Final
Quality Assurance Project Plan for Site Inspections of Fire Fighting Foam Usage at Various Air Force Bases in the Eastern United States

January 2016

Submitted to:
Air Force Civil Engineer Center
3515 General McMullen Suite 155
San Antonio, Texas 78226-2018

Submitted by:
U.S. Army Corps of Engineers
Savannah District
100 W. Oglethorpe Avenue
Savannah, Georgia 31401-3640

Prepared by:
Aerostar SES LLC
1006 Floyd Culler Court
Oak Ridge, TN 37830-8022
under
Contract No. W912HN-15-C-0022

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Acronyms and Abbreviations

%R	percent recovery
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
6:2-FTS	6:2 Fluorotelemer Sulfonate
8:2-FTS	8:2 Fluorotelemer Sulfonate
AFB	Air Force base
AFCEC	Air Force Civil Engineer Center
AFFF	aqueous film forming foam
ANGB	Air National Guard base
ARB	Air Reserve base
ARS	Air Reserve station
ASL	Aerostar SES LLC
CAS	Chemical Abstract Service
CCL	contaminant candidate list
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	conceptual site model
CWA	Clean Water Act
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DoDI	Department of Defense instruction
DOT	Department of Transportation
DPT	direct push technology
DQI	data quality indicator
DQOs	data quality objectives
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ERPIMS	Environmental Resources Program Information Management System
FOSA	perfluorooctanesulfonamide
GPS	Global Positioning System
HAZWOPER	hazardous waste operations and emergency response
HDPE	high density polyethylene
ICAL	initial calibration
ICV	initial calibration verification
ID	inside diameter
IDW	investigation-derived waste
JB	joint base
JBLE	Joint Base Langley-Eustis
LC-MS-MS	liquid chromatography and tandem mass spectrometry
LCS	Laboratory Control Sample
LDPE	low-density polyethylene
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MDL	method detection limit

mg/kg	milligrams per kilogram
mL	milliliter
MS	matrix spike
MSD	matrix spike Duplicate
N/A	not applicable
ND	not detected
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OWS	oil/water separator
PA	preliminary assessment
PAL	project action limits
PFAS	per- and polyfluorinated alkyl substance
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFC	perfluorinated compounds
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PFDS	perfluorodecanesulfonic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFPA	perfluoropentanoic acid
PFTeA	perfluorotetradecanoic acid
PFTriA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PHA	provisional health advisory
POC	point of contact
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QL	quantitation limit
QSM	*Quality Systems Manual*
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
RPD	relative percent difference
SDWA	Safe Drinking Water Act
SOP	standard operating procedure
UCMR	Unregulated Contaminant Monitoring Rule
UFP	Uniform Federal Policy
UHPLC	ultra high performance liquid chromatography
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USCS	Unified Soil Classification System

INTRODUCTION

This quality assurance project plan (QAPP) presents the activities and associated quality objectives for site inspections of aqueous film forming foam (AFFF) release areas identified during preliminary assessment (PA) research activities to determine if a confirmed release of per- and polyfluorinated alkyl substance (PFAS) has occurred in groundwater, soil, surface water, and sediment in concentrations greater than the United States Environmental Protection Agency (EPA) provisional health advisory (PHA) values or other applicable state or Federal standards. The installations and planned initial site inspections include

- Air Force Plant 6, Georgia (3 sites);
- Air Force Research Lab, Rome, New York (4 sites);
- Avon Park Air Force Range, Florida (8 sites);
- Burlington Air National Guard Base (ANGB), Vermont (4 sites);
- Dobbins Air Reserve Base (ARB), Georgia (8 sites);
- Dover Air Force Base (AFB), Delaware (12 sites);
- Hanscom AFB, Massachusetts (4 sites);
- Homestead AFB, Florida (6 sites);
- Joint Base Andrews (JBA), Maryland (10 sites);
- Joint Base Charleston (JBC), South Carolina (12 sites);
- Joint Base Langley-Eustis (JBLE)-Eustis, Virginia (3 sites);
- JBLE-Langley, Virginia (6 sites);
- Joint Base McGuire-Dix-Lakehurst (JBMDL), New Jersey (33 sites);
- Moody AFB, Georgia (8 sites);
- Niagara Falls Air Reserve Station (ARS), New York (5 sites);
- Robins AFB, Georgia (34 sites);
- Seymour Johnson AFB, North Carolina (6 sites);
- Shaw AFB, South Carolina (8 sites);
- Tyndall AFB, Florida (10 sites); and
- Westover ARB, Massachusetts (4 sites).

Niagara Falls will begin with a PA because no previous investigations have been conducted to identify sites.

This is a general QAPP to provide program-level information for site investigation and release determination activities at each installation. Aerostar SES LLC (ASL) has prepared this QAPP for submittal to the Air Force Civil Engineer Center (AFCEC) under United States Army Corps of Engineers (USACE) Savannah District Contract No. W912HN-15-C-0022. The scope of the contract is to

- Conduct reconnaissance site visits at each of the 20 installations, review available data to determine additional information needs for the sites best-suited for further investigation, and determine potential human exposure and/or off-site migration. The visits will be coordinated with the point of contact (POC) at each installation, the Air Force, and USACE Savannah District. Sites selected during the reconnaissance site visits will be based on the results of the final PA report provided by AFCEC or completed during this effort. Areas to be evaluated include
    - Aircraft maintenance hangars, including associated oil water separators (OWS);
    - AFFF lagoons/ponds;
    - Fire stations;
    - Identified AFFF spill sites; and
    - Crash sites.

- During the reconnaissance site visits, identify the location and method of obtaining appropriate samples.
- Prepare and submit a separate work plan (as an addendum to this QAPP) for each of the 20 installations from the information gathered during the reconnaissance site visits. QAPP addenda will be submitted in draft, draft final, and final form. All Air Force and USACE comments will be resolved and incorporated as appropriate. The appropriate regulatory agencies will get 30 days for review and comment. All regulatory agency comments will be resolved and incorporated as appropriate.
- Select sample locations that will provide the most useful information. For each site where borings are installed, a representative composite sample will be collected for the entire area evaluated for each depth sampled. The composite sample will be submitted to the laboratory for geotechnical analyses of soil physiochemical properties, including soil potential of hydrogen (pH), particle size analysis, and total organic carbon content at a minimum.
- Prepare and submit a report in draft, draft final, and final form for the site inspections at each of the 20 installations. All Air Force and USACE comments will be resolved and incorporated as appropriate. The appropriate regulatory agencies will get 30 days for review and comment. All regulatory agency comments will be resolved and incorporated as appropriate. Each site reports within an installation report will, at a minimum, contain the following information:
    - Site description (current/former use and location),
    - Geology/hydrology,
    - Site map,
    - Conceptual site model,
    - Potentiometric surface,
    - Sampling points,
    - Sample analytical results,
    - Validation report of the analytical sampling results, and
    - Recommendations for further actions at the site.
- The analytical results for each installation will be prepared in the United States Air Force (USAF) Environmental Resources Program Information Management System (ERPIMS) format and submitted. All USAF comments will be addressed and a final ERPIMS data package submitted.

This QAPP has been prepared to ensure

- The site investigation objectives and data quality objectives (DQOs) for this project are clearly identified,
- The field sampling protocols are documented and reviewed in a consistent manner, and
- The data collected are scientifically valid and defensible.

This QAPP complies with the general Uniform Federal Policy (UFP) QAPP in accordance with the July 2009 AFCEC (formerly the Air Force Center for Engineering and the Environment) memorandum detailing the implementation of the UFP QAPP on Air Force restoration projects. This memorandum states that the UFP QAPP will replace the formerly required work plan, field sampling plan, and QAPP on all new Air Force projects. The UFP QAPP integrates all technical and quality aspects for the lifecycle of the project, including planning, implementation, assessment, and decision-making. A general accident prevention plan (APP) for the project will be provided under separate cover. After this QAPP has been approved, installation-specific work plan addenda and site-specific safety and health plans will be prepared.

BACKGROUND

PFASs are a class of synthetic compounds formed from carbon chains with fluorine attached. The chemical structure of PFASs gives them unique properties, such as thermal stability and the ability to repel water and oil, that make them useful components in consumer and industrial products, including nonstick cookware, food packaging, waterproof clothing, fabric stain protectors, lubricants, paints, and firefighting foams, such as AFFF.

PFASs are under increased scrutiny from the regulatory community because they are environmentally persistent, tend to bioaccumulate in living organisms, and have demonstrated some toxicity in laboratory animals.[1] The EPA issued the Contaminant Candidate List 3 (CCL 3) in October 2009. CCL 3 identified chemicals or chemical groups not subject to any national primary drinking water regulations, that are known or anticipated to occur in public water systems, and that may require regulation under the Safe Drinking Water Act (SDWA).[2] Two PFASs, perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), were identified on CCL 3. Six PFASs (Table 1) are included in the EPA Proposed Unregulated Contaminant Monitoring Rule 3 (UCMR 3), which requires public water systems to monitor for these chemicals from 2013 through 2015.[3] The UCMR is the primary source of occurrence and exposure information used by the EPA to determine whether to regulate a contaminant.

Table 1 Polyfluorinated Contaminants Included in the EPA UCMR 3

Contaminant	CAS Registry Number
Perfluorooctanesulfonic acid (PFOS)	1763-23-1
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorohexane sulfonic acid (PFHxS)	355-46-4
Perfluoroheptanoic acid (PFHpA)	375-85-9
Perfluorobutane sulfonic acid (PFBS)	375-73-5

CAS = Chemical Abstract Service

The EPA has developed PHAs for PFOS [0.2 micrograms per liter (µg/L)] and PFOA (0.4 µg/L) to protect against potential risk from exposure to these chemicals through drinking water.[4] Table 2 summarizes the current Federal regulatory advisory and screening values.

Table 2 Federal Regulatory Guidance Values for PFOS and PFOA in Drinking Water and Soil

United States Environmental Protection Agency (EPA) Guidance Values	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)
Provisional Drinking Water Health Advisory Values (EPA Office of Water)	0.2 µg/L	0.4 µg/L
Residential Soil Screening Level (EPA Region 4)[a]	6 mg/kg	16 mg/kg

Footnotes:
[a] http://http://www.epa.gov/sites/production/files/2014-04/documents/factsheet_contaminant_pfos_pfoa_march2014.pdf
µg/L = microgram per liter
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram

Initially, regulatory activity was primarily driven by concern over potential contamination near PFAS manufacturing facilities. However, this concern has expanded to include other types of sites, such as firefighting training locations. Regulatory interest has focused on two PFASs: PFOS and PFOA, both which have been identified in historically used AFFF. Large quantities of AFFF have been released into the environment as a result of fire training exercises, fire suppression activities, and tank and pipeline leaks and releases. AFFF concentrate contains fluorocarbon surfactants to meet required performance standards [Department of Defense (DoD) Military Specification MIL-F-24385F (SH), Amendment 1, August 5, 1984]. The surfactants provide the AFFF with the low surface tension needed to enable film formation on top of the fuel to help suffocate the fire. Historically, most AFFF contained both PFOS and PFOA. Manufacturers now use a different process to produce fluorosurfactants for AFFF. However, current AFFF agents may still contain trace levels of perfluorocarboxylic acids, such as PFOA.

From the early 1970s until 2002, the DoD purchased and used AFFF containing PFOS and/or PFOA for firefighting and firefighting training. Older training facilities were often unlined and were not constructed to prevent infiltration of firefighting foams and combustion products into the environment. Per DoD Instruction (DoDI) 4715.18, “Emerging Contaminants,” (DoD, 2009)[5] and the Interim AF Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and BRAC Installations (USAF, 2012),[6] in the absence of an applicable legal driver, the USAF may confirm a possible release of an emerging contaminant such as PFAS, followed by delineation, if a reasonable basis exists to suspect a potential release associated with USAF activities at an installation, an exposure pathway exists for the probable contamination to threaten public health, and/or potential for off-site migration is likely.

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[5] Department of Defense (DoD). 2009. DoD Instruction Number 4715.18, Emerging Contaminants (ECs). Certified current through June 11, 2016.

[6] United States Air Force. 2012. Interim Air Force Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and BRAC Installations. August 27.

QAPP Worksheet #1 & 2: Title and Approval Page
UFP-QAPP Manual Section 2.1
(EPA 2106-G-05 Section 2.2.1)

Rev 0, Date: 01/19/2016

Site Name/Project Name: Site Investigation of Fire Fighting Foam Usage at Various Air Force Bases in the Eastern United States
Site Location: Eastern United States
Contract Number: W912HN-15-C-0022

Review Signatures:
Aerostar SES LLC (ASL)
1006 Floyd Culler Court
Oak Ridge, Tennessee 37830

ASL Project Manager: Brian Odom, PG
Bodom@specproenv.com

Signature

ASL Quality Control Manager:
Jeff Williams, PE
Jwilliams@specproenv.com

Jeffrey C Williams
Signature

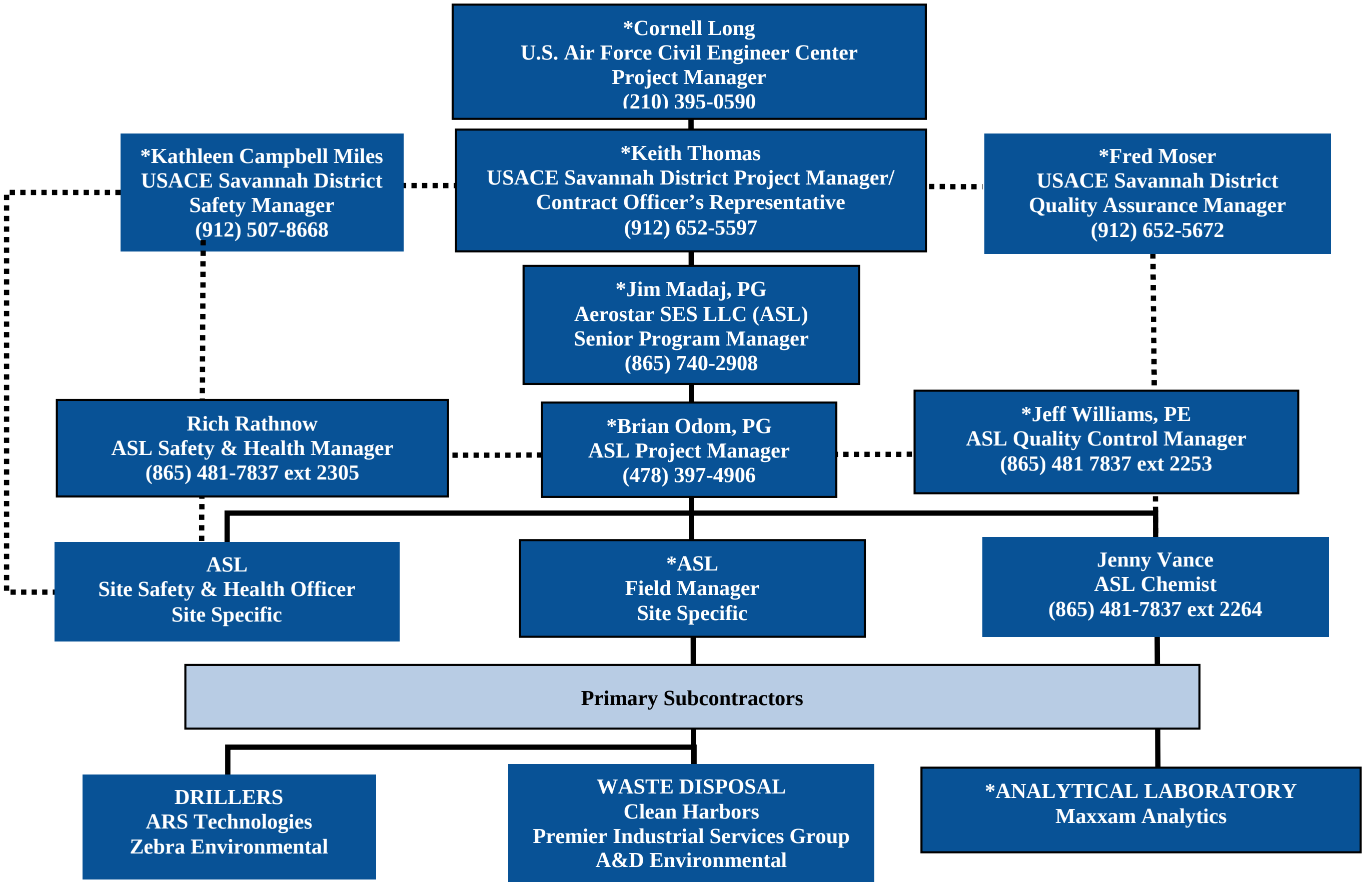
USACE Savannah District:
100 W. Oglethorpe Avenue
Savannah, Georgia 31401-3640
Technical Lead: Fred Moser
Fred.Moser@usace.army.mil

Fred E. Moser
Signature

Relevant Plans and Reports from Previous Investigations:
To be included in the installation-specific QAPP addenda.

QAPP Worksheet #3 & 5: Project Organization and QAPP Distribution
(UFP-QAPP Manual Section 2.3 and 2.4)
(EPA 2106-G-05 Section 2.2.3 and 2.2.4)

Rev 0, Date: 01/19/2016



*Denotes QAPP recipient ______Lines of Authority _ _ _ _ _ _ _ Lines of Communication

QAPP Worksheet #4, 7 & 8: Personnel Qualifications and Sign-off Sheet
(UFP-QAPP Manual Sections 2.3.2 – 2.3.4)
(EPA 2106-G-05 Section 2.2.1 and 2.2.7)
Rev 0, Date: 01/19/2016

Organization: Aerostar SES LLC (ASL)

Name	Project Title/Role	Education/ Experience	Specialized Training/ Certifications	Signature/Date*
Jim Madaj, PG	Program Manager/Plans and administers ASL's overall environmental program. Develops and oversees execution of the strategic plan. Responsible for performance, cost/schedule control, estimating, quality, and safety management in accordance with the PWS, contract requirements, and applicable laws/regulations. Approves staff assignments and oversees project managers on task orders. Responsible for monthly progress and cost reporting and change management in response to USACE needs.	See resume in Appendix A.		
Brian Odom, PG	ASL Project Manager/Responsible for the overall execution of the project from initiation through completion. The ASL project manager will be accountable for all subcontract activities and is responsible for coordinating the project with the USACE.	See resume in Appendix A.	• Professional Geologist license in North Carolina, Georgia, Tennessee, Kentucky, and Florida • 40 hour HAZWOPER • HAZWOPER Supervisor Training • Construction Quality Management for Contractors, USACE	
Jeff Williams, PE	ASL Quality Control Manager/Responsible for ensuring the overall project quality, specifically the outgoing project plans and reports, and ensuring that each project deliverable meets quality standards. The QA/QC manager coordinates with the project team to evaluate status, procedures, and nonconformance from a quality program standpoint.	See resume in Appendix A.		
Rich Rathnow	ASL Health & Safety Manager/Oversees all health and safety aspects of projects that are reported to him.	See resume in Appendix A.		
Jenny Vance	ASL Project Chemist/Reviews all analytical data before it can be released.	See resume in Appendix A.		

Name	Project Title/Role	Education/ Experience	Specialized Training/ Certifications	Signature/Date*
Site Specific	ASL site safety and health officer			
Site Specific	ASL field supervisor			

Notes: Signatures indicate personnel have read and agree to implement this QAPP as written.

ASL = Aerostar SES LLC
HAZWOPER = Hazardous Waste Operations and Emergency Response
PE = Professional Engineer
PG = Professional Geologist
PWS = performance work statement
USACE = United States Army Corps of Engineers

QAPP Worksheet #6: Communication Pathways
(UFP-QAPP Manual Section 2.4.2)
(EPA 2106-G-05 Section 2.2.4)

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Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Regulatory agency interface	AFCEC, USACE	Brian Odom	(912) 756-5243 bodom@specproenv.com	Is the primary point of contact for regulatory interface. Contact will be made by ASL project manager through telephone or electronic mail and a record will be retained detailing the correspondence.
Stop work because of safety issues	AFCEC, USACE, ASL, subcontractors	On-site personnel	Site-specific	On-site personnel must notify the ASL site safety and health officer*, who notifies the ASL project manager (verbal, electronic), who notifies USACE (verbal, electronic).
Stop work because of quality issues	AFCEC, USACE, ASL, subcontractors	On-site personnel	Site-specific	On-site personnel must notify the ASL field manager*, who notifies the ASL QC manager, who will contact the ASL project manager (verbal, electronic), who notifies AFCEC and USACE (verbal, electronic).
QAPP changes prior to fieldwork	ASL	Jeff Williams	(865) 481-7837 ext. 2253 jwilliams@scf-llc.com	Notify the ASL project manager, who notifies AFCEC and USACE (verbal, electronic).
QAPP changes during project execution	ASL	ASL field manager	Site-specific*	Will notify the ASL project manager, who notifies AFCEC and USACE.
Field corrective actions	ASL	ASL field manager	Site-specific*	Field corrective actions will be developed by the ASL project manager and ASL QC manager within 24 hours and will be communicated to the ASL field manager, who will communicate corrective actions to the field team.
Sample receipt variances	Maxxam	Paul Henige	(650) 576-7765	Will notify the ASL chemist within 24 hours of sample receipt, who will then notify the ASL project manager.
Laboratory quality control variances	Maxxam	Paul Henige	(650) 576-7765	Will notify the ASL chemist and ASL QC manager within 24 hours of variance. If quality control variances contradict the minimum requirements of the DoD *Quality Systems Manual*, then the ASL QC manager and ASL project manager will contact AFCEC and USACE (COR and technical lead) to discuss and receive approval for the variances within 7 days of notice of variance.

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, documentation, etc.)
Analytical corrective actions	ASL	Jenny Vance	(865) 483-7904 jvance@aerostar.net	Will respond to issue from laboratory with potential corrective action (verbal, written, or electronic) within one week of notification.
Data verification issues (incomplete records)	ASL	Jenny Vance	(865) 483-7904 jvance@aerostar.net	The ASL chemist will resolve any data verification issues with the contract laboratory within one week of issue being identified.
Data validation issues, noncompliance with procedures	ASL	Jenny Vance	(865) 483-7904 jvance@aerostar.net	The ASL chemist will resolve any data validation issues with the contract laboratory within one week of issue being identified.
Data review corrective actions	ASL	Jenny Vance	(865) 483-7904 jvance@aerostar.net	The ASL chemist will communicate necessary data review corrective actions with the contract laboratory within one week of corrective actions.

* Because the ASL field managers and site safety and health officers may be different for each installation, they will be identified in the installation-specific work plan addenda.

AFCEC = Air Force Civil Engineer Center
COR = contract officer’s representative
QAPP = quality assurance project plan
USACE = United States Army Corps of Engineers
ASL = Aerostar SES LLC
ext. = extension
QC = quality control

QAPP Worksheet #9: Project Planning Session Summary
(UFP-QAPP Manual Section 2.5.1 and Figures 9-12)
(EPA 2106-G-05 Section 2.2.5)

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Notes and minutes from the scoping sessions/site visits for each facility will be included in the site-specific QAPP addenda.

Date of planning session:
Location:
Purpose:

QAPP Worksheet #10: Conceptual Site Model
(UFP-QAPP Manual Section 2.5.2)
(EPA 2106-G-05 Section 2.2.5)
Rev 0, Date: 01/19/2016

The preliminary conceptual site model (CSM) for each site will be developed and presented in the installation-specific work plan addenda. The CSMs at a minimum will include the following information presented in table format.

Facility Profile	Physical Profile	Release Profile	Land Use and Exposure Profile	Ecological Profile
Installation Description: • Years of operation • Total area occupied by base (acres) • Investigation area (acres) • Description of historical activities on base • Installation mission Area History: • Location(s) on base • Activities conducted at the site • Years of operation • Frequency of operation	Area Site Characteristics: • Total area (acres) Topography: • General topography across base • Topography in vicinity of area • Approximate elevation Vegetation: • General overview of vegetation at the area • Stressed vegetation Surface Water: • Presence of streams, lakes, playas, oceans, etc. • Drainage pathways Soils: • Primary soil makeup (sand, silt, clay, etc.) Geology: • Formation information and name • Depth intervals Hydrogeology: • Aquifer formation name • Depth to groundwater • Saturated thickness • Confined, unconfined, and/or perched aquifer • Groundwater flow direction • Hydraulic gradient, hydraulic conductivity, and seepage velocity (if known) Meteorology: • Average annual precipitation • Wet and dry seasons • Average temperature / climate	Contaminants of Potential Concern: • PFASs primary concern • As determined from previous reports • Note historical contaminants (chlorinated solvents, fuels, etc.) associated with the area Media of Potential Concern: • Soil, groundwater, surface water, and sediment Confirmed AFFF Releases: • Per area training records • Dates of AFFF release / use • Quantities of AFFF used (if known) Primary Releases from Area: • Infiltration into groundwater (unconsolidated material, fracture flow, etc.) • Direct discharge into stormwater sewer collection system • Direct discharge into drains, plumbing infrastructure, and outfall locations • Adsorption to soil matrix near source Secondary Releases: • Soil excavations and disposal • Pump and treat systems discharges	Current Land Use: • Area-specific information Future Land Use: • Potential development • Land use restrictions Potential Receptors: • Surface water bodies • Municipal groundwater wells • Private groundwater wells • Humans • Biota	Potential Ecological Receptors: • High-quality rivers, streams, lakes, etc. • Inland and marine plant species, fish, birds, insects, soil invertebrates, and mammals that inhabit or migrate through the site • Associated threatened and endangered species Threatened and Endangered Species: • Listed threatened and endangered species

AFFF = aqueous film forming foam

PFASs = per- and polyfluorinated alkyl substances

QAPP Worksheet #11: Project/Data Quality Objectives
(UFP-QAPP Manual Section 2.6.1)
(EPA 2106-G-05 Section 2.2.6)
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Data quality objectives were developed using EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

Step 1: State the Problem
PFASs are synthetic fluorinated compounds that are widely used to make everyday products more resistant to heat, stains, grease, and water. They are also used as components in firefighting foams. These chemicals were used by the United States military, including the USAF, at sites where personnel used AFFF to extinguish fires. For this project, the term PFAS refers to the specific compounds listed in EPA’s UCMR 3 and listed in Table 1 (PFOS, PFOA, PFNA, PFHxS, PFHpA, and PFBS).

The chemical structures of PFASs make them very resistant to breakdown in the environment. Because of their persistence, bioaccumulation potential, and toxicity, PFASs have a potential impact on human health and the environment. Therefore, investigation activities are necessary to determine if potential releases of PFASs have occurred and to confirm the presence of these compounds at identified sites at USAF installations.

Step 2: Identify the Goals of the Study
The objectives of this study are to

- Determine if a confirmed release of PFASs has occurred at sites selected for site investigation;
- Determine if PFASs are present in groundwater, soil, or surface water/sediments at the site in concentrations exceeding the EPA PHAs; and
- Identify potential receptor pathways with immediate impacts to human health.

In accordance with *Interim AF Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and BRAC Installations*” (USAF, August 2012), a release will be defined if concentrations exceeding the following are identified:

PFOS:	0.2 µg/L in groundwater and/or surface water
	5.0 mg/kg in soil and/or sediment
PFOA:	0.4 µg/L in groundwater and/or surface water
	12 mg/kg in soil and/or sediment

Step 3: Identify Information Inputs
The following data and informational needs for the site inspections are required to achieve the project goals:

- Collection of historical and site-specific information through document reviews, site scoping visits, and post scoping conference calls;
- Soil boring advancement;
- Sampling of existing monitoring wells, installation/sampling of temporary groundwater monitoring wells, or groundwater sampling using direct push technology (DPT) equipment;
- Collection of soil, sediment, surface water, and groundwater samples; and
- Laboratory analysis of soil, sediment, surface water, and groundwater samples for PFASs by high-performance liquid chromatography with tandem mass spectrometry (LC-MS-MS).

Step 4: Define the Boundaries of Data Collection
Review of historical documents (including PA reports), site scoping visits, and post scoping conference calls will be used to identify the sampling locations. Sampling will be limited to facilities where use is documented and targeted to areas where PFASs were used, stored, or handled.

Laboratory analysis for the samples collected will be conducted for approximately 18 compounds. It should be noted that there are potentially a variety of analytical suites for PFASs based on regional regulatory requirements. The basic suite of compounds include, but are not limited to,

- Perfluorooctanesulfonic acid (PFOS),
- Perfluorohexanesulfonic acid (PFHxS),
- Perfluorooctanoic acid (PFOA),
- Perfluoroheptanoic acid (PFHpA),
- Perfluorononanoic acid (PFNA),
- Perfluorobutanesulfonic acid (PFBS),
- Perfluorobutanoic acid (PFBA),
- Perfluoropentanoic acid (PFPA),
- Perfluorohexanoic acid (PFHxA),
- Perfluorooctanesulfonamide (FOSA),
- Perfluorodecanoic acid (PFDA),
- Perfluorodecanesulfonic acid (PFDS),
- Perfluoroundecanoic acid (PFUnA),
- Perfluorododecanoic acid (PFDoA),
- Perfluorotridecanoic acid (PFTriA),
- Perfluorotetradecanoic acid (PFTeA),
- 6:2 Fluorotelomer sulfonate (6:2 FTS), and
- 8:2 Fluorotelomer sulfonate (8:2 FTS).

Step 5: Develop the Analytical Approach
Sampling of soil, sediment, surface water, and groundwater at potential source areas and along migration pathways is necessary to determine if PFASs are present. LC-MS-MS will be used to analyze the samples. If a release of PFASs is confirmed (see Step 2), the concentrations of those constituents will determine if further actions are necessary. Worksheet 15 identifies the project action limits (PALs) and method reporting limits for determining PFASs presence in soil, sediment, surface water, and groundwater for PFOS and PFOA. The remaining PFASs do not have established PALs.

Step 6: Specify Performance or Acceptance Criteria
The following performance and acceptance criteria will be used during site investigation activities:

- The ASL field manager for each installation will complete a daily standardized PFAS personal protective equipment (PPE)/equipment checklist in the PFC protocol standard operating procedure (SOP). The quality assurance (QA) manager will review and accept the final checklist.
- The field manager will verify that field procedures defined in the QAPP and installation-specific work plan are followed during fieldwork. The QA manager or designee will verify field procedures are conducted appropriately through field audits. Any deviations will be promptly addressed and documented.
- The laboratories will adhere to analytical performance/acceptance criteria per method as detailed in the *Quality Systems Manual* (QSM) V5.0 (DoD, July 2013) and defined on Worksheet 12.
- The LC-MS-MS method will provide acceptable detection limits to confirm presence of PFASs at concentrations defined in Step 5 and Worksheet 15.

- EPA Stage 2B data verification will be conducted on 100 percent of the data by an experienced chemist to assess the data usability. The data usability will then be evaluated by USACE and AFCEC for final approval. Data completeness of 90 percent usable data is required.
- The site investigation reports will be reviewed and accepted by USACE and AFCEC.

Step 7: Develop the Detailed Plan for Obtaining Data

Sampling plans may be revised based upon installation-specific research and scoping. The final detailed sampling approach will be in Worksheets #13, #14/16, #17, #18, and #20 of the installation-specific work plan addenda. Additional sites may be added, if necessary, as an addendum to this plan.

QAPP Worksheet #12: Measurement Performance Criteria
(UFP-QAPP Manual Section 2.6.2)
(EPA 2106-G-05 Section 2.2.6)
Rev 0, Date: 01/19/2016

Project Laboratory: Maxxam Analytics International Corporation
Matrix: Groundwater/Soil
Analytical Group or Method: PFC by LC-MS-MS
Concentration Level: Low

Data Quality Indicator (DQI)	Quality Control (QC) Sample or Measurement Performance Activity	Measurement Performance Criteria
Overall precision	Field duplicates	RPD ≤ 30% or difference between analytical results < LOQ
Analytical accuracy/bias (laboratory)	Laboratory control samples	70-130% recovery, 30% RPD
Analytical precision/accuracy/bias (matrix interference)	Matrix spike and matrix spike duplicates	70-130% recovery, 30% RPD
Overall accuracy/bias (contamination)	Equipment blanks	No target analyte concentrations ≥ 1/2 LOQ
Sensitivity	LOQ verification sample (spiked at LOQ)	Recovery within ±50% of LOQ
Completeness	See Worksheet #34	See Worksheet #34

≤ = less than or equal to
% = percent
± = plus/ minus
RPD = relative percent difference
≥ = greater than or equal to
< = less than
LOQ = limit of quantitation

QAPP Worksheet #13: Secondary Data Uses and Limitations
(UFP-QAPP Manual Section 2.7)
(EPA 2106-G-05 Chapter 3: QAPP Elements for Evaluating Existing Data)

Rev 0, Date: 01/19/2016

The following worksheet will be included in the installation-specific work plan addenda and will identify data used to generate the installation-specific work plan addenda (previous environmental sampling reports, interviews with former fire chiefs, etc.).

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use

QAPP Worksheet #14/16: Project Tasks & Schedule
(UFP-QAPP Manual Section 2.8.2)
(EPA 2106-G-05 Section 2.2.4)
Rev 0, Date: 01/19/2016

Activity	Responsible Party	Planned Start Date*	Planned Completion Date*	Deliverable(s)	Deliverable Due Date*
Installation scoping visits	ASL	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
QAPP addendum/SSHP	ASL	See schedule	See schedule	QAPP addendum and SSHP	See schedule
Mobilization/demobilization	ASL and subcontractors	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
Soil boring advancement/ abandonment	ASL and subcontractors	See schedule	See schedule	Field notes and boring logs (included in site investigation report)	See schedule
Sample collection – surface soil	ASL	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
Sample collection – subsurface soil	ASL and subcontractors	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
Sample collection – sediment	ASL and subcontractors	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
Sample collection – surface water	ASL and subcontractors	See schedule	See schedule	Field notes (included in site investigation report)	See schedule
Sample collection – groundwater from existing monitoring wells	ASL	See schedule	See schedule	Field notes, monitoring well diagram, and field measurements (included in site investigation report)	See schedule
Temporary monitoring well installation and sampling	ASL and subcontractors	See schedule	See schedule	Field notes, monitoring well diagrams, and field measurements (included in site investigation report)	See schedule
Analyses	Maxxam	See schedule	See schedule	Report of analyses/data package (included in Site Investigation Report)	See schedule
Validation	ASL	See schedule	See schedule	Validation summary (included in site investigation report)	See schedule
Environmental Resources Program Information Management System (ERPIMS) data submittal	ASL	See schedule	90 days after sampling completed	Successful submittal of ERPIMS data for each installation and receipt of AFCEC ERPIMS data loading notification	90 days after sampling completed
Site investigation report	ASL	See schedule	See schedule	Site investigation report	See schedule

*The project schedule is provided in **Appendix B**.

PFC Release Determination, Delineation, and Remediation - Site Investigation

To meet the project goals defined in Worksheet #11, site inspections will be initiated at 20 installations as identified in Table 3. The site investigation will include site reconnaissance to determine the scope of sampling activities at the installations as well as the collection of soil, sediment, surface water, and groundwater samples to confirm if a release of PFASs has occurred. The specific procedures for implementing site inspections will be documented in 20 installation-specific work plans. The approach to conducting site inspections will include the activities identified in this worksheet and described below. Fieldwork will be conducted in accordance with the standard operating procedures (SOPs) provided in Appendix C.

Table 3 Air Force Facilities with Identified PFAS Sites

Facility, Location	Facility, Location
Air Force Plant 6, Georgia (3 sites)	JBLE-Eustis, Virginia (3 sites)
Air Force Research Lab, Rome, New York (4 sites)	JBLE-Langley, Virginia (6 sites)
Avon Park Air Force Range, Florida (8 sites)	Joint Base McGuire-Dix-Lakehurst (JBMDL), New Jersey (33 sites)
Burlington Air National Guard Base, Vermont (4 sites)	Moody AFB, Georgia (8 sites)
Dobbins ARB, Georgia (8 sites)	*Niagara Falls Air Reserve Station, New York (5 sites)
Dover AFB, Delaware (12 sites)	Robins AFB, Georgia (34 sites)
Hanscom AFB, Massachusetts (4 sites)	Seymour Johnson AFB, North Carolina (6 sites)
Homestead AFB, Florida (6 sites)	Shaw AFB, South Carolina (8 sites)
Joint Base Andrews, Maryland (10 sites)	Tyndall AFB, Florida (10 sites)
Joint Base Charleston, South Carolina (12 sites)	Westover ARB, Massachusetts (4 sites)

*Niagara Falls will begin with a Preliminary assessment because no previous investigations have been conducted to identify sites.
AFB = Air Force base
ARB = Air Reserve base
JBLE = Joint Base Langley Eustis

Reconnaissance Site Visits

Site surveys will be conducted at each installation to develop the sampling plan for environmental sampling activities for each of the 20 installations. The site surveys will be conducted to

- Verify site locations from the PA reports,
- Select proposed locations for sampling at each identified site on the facility, and
- Coordinate site access at each of the 20 installations.

The information to be collected during the site surveys includes, but is not limited to,

- Current site conditions;
- Access routes;
- Monitoring well inventory documenting condition;
- Conditions affecting the investigation approach (utilities, structures, etc.);
- Equipment and personnel requirements for investigation;
- Escort requirements;
- Dig permit process;
- Traffic considerations (including both vehicular and aircraft traffic);
- Well construction requirements; and
- Site restoration requirements.

Note: Sufficient time must be allotted for coordinating permits and approval where required. Federal Aviation Administration (FAA) and other airfield or restricted area access permits may require weeks or months to obtain.

Mobilization/Demobilization

Prior to site mobilization, ASL will coordinate with the POC for each installation to obtain utility clearances and dig permits.

- **Site Specific Regulations** – Fieldwork will be on a variety of installation types, including active -airfields. All personnel must become familiar with and comply with site-specific regulations. All required badges, passes, and vehicle permits will be acquired with the proper authority.
- **Site Access –** ASL will coordinate with installation POCs to ensure that access onto sites will not be restricted during the proposed work schedule.
- **Utility Clearances and Dig Permits –** Prior to the commencement of drilling activities, embedded service lines shall be located and protected. Drilling operations will not begin until all underground hazards have been located. Utility maps will be requested detailing utilities and other infrastructure at each site to assist with utility location.

After these activities are complete and proper coordination has been made with AFCEC, USACE, and the POCs, ASL will mobilize to the site(s). Demobilization will occur after all site activities are completed and the sites have been restored to their original condition.

Environmental Sampling

To confirm releases of PFASs, soil, sediment (where applicable), surface water (where applicable), and groundwater sampling will be conducted at the preselected sites at each of the 20 installations. The goal of site-specific sampling is to determine the presence or absence of PFASs in media of concern. Investigation requirements at each installation will vary based upon site layout and access, in-place remedies, and other unforeseen factors that will be identified during scoping activities and detailed in installation-specific work plans. SOPs (Appendix C) applicable to each installation/site should be reviewed prior to implementation of field activities and consist of

- ASL SOP-001 – “Logbooks,”
- ASL SOP-002 – “Groundwater Sampling,”
- ASL SOP-003 – “Pump Operation,”
- ASL SOP-004 – “Surface Water Sampling,”
- ASL SOP-005 – “Water Level and Well Depth Measurements,”
- ASL SOP- 006 – “Field Measurement of Dissolved Oxygen,”
- ASL SOP- 007 – “Field Measurement of pH,”
- ASL SOP-008 – “Field Measurement of Oxidation Reduction Potential,”
- ASL SOP-009 – “Field Measurement of Specific Conductance,”
- ASL SOP-010 – “Field Measurement of Temperature,”
- ASL SOP-011 – “Field Measurement of Turbidity,”
- ASL SOP-012 – “Sediment Sampling,”
- ASL SOP-013 – “Soil Sampling,”
- ASL SOP–015 – “Field Equipment Cleaning and Decontamination,”
- ASL SOP-016 – “Shipping Samples,”
- ASL SOP-017 – “Sample and Evidence Management,”
- ASL SOP-018 – “Field Sampling Quality Control,”
- ASL SOP-019 – “Monitoring Well Installation/Abandonment,”
- ASL SOP-020 – “Management of Investigation Derived Waste (IDW),”
- ASL SOP-026 – “Global Positioning Systems (GPS),”
- ASL SOP-028 – “Field Sampling Protocols to Avoid Cross-Contamination at Perfluorinated Compounds (PFCs) Sites,” and
- ASL SOP-029 – “Providing Contaminant-Free Source Water at Perfluorinated Compounds (PFCs) Sites.”

A total of 188 sites have been identified at 20 installations for sampling. Table 4 details the installations and includes a count of associated release sites. The number of sites at each installation may be changed as information is gathered from the PA reports and initial site visits. AFCEC and USACE approval of the sites will be required. A total of 1,863 samples will be collected. These samples should be used where most beneficial across all 20 Air Force installations. Sample media can include soil, groundwater (from existing monitoring wells, existing Air Force or residential wells, newly installed temporary wells, or direct push sampling), surface water, or sediment.

Table 4 Preliminary PFAS Release Determination Sampling Summary

Installation	**Identified Sites**	**Soil Borings (4 per site)**	***Soil Samples**	**Sediment Samples**	**Surface Water Samples**	***Groundwater Samples**
Air Force Park 6, Georgia	3	12	12	3	3	9
Air Force Research Lab Rome, New York	4	16	16	4	4	12
Avon Park Air Force Range, Florida	8	32	32	8	8	24
Burlington Air National Guard Base, Vermont	4	16	16	4	4	12
Dobbins ARB, Georgia	8	32	32	8	8	24
Dover AFB, Delaware	12	48	48	12	12	36
Hanscom AFB, Massachusetts	4	16	16	4	4	12
Homestead AFB, Florida	6	24	24	6	6	18
JB Andrews, Maryland	10	40	40	10	10	30
JB Charleston, South Carolina	12	48	48	12	12	36
JB Langley Eustis – Eustis, Virginia	3	12	12	3	3	9
JB Langley Eustis– Langley, Virginia	6	24	24	6	6	18
JB McGuire-Dix-Lakehurst, New Jersey	33	132	132	33	33	99
Moody AFB, Georgia	8	32	32	8	8	24
Niagara Falls Air Reserve Station, New York	5	20	20	5	5	15
Robins AFB, Georgia	34	136	136	34	34	102
Seymour Johnson AFB, North Carolina	6	24	24	6	6	18
Shaw AFB, South Carolina	8	32	32	8	8	24
Tyndall AFB, Florida	10	40	40	10	10	30
Westover ARB, Massachusetts	4	16	16	4	4	12
Subtotals	188	752	752	188	188	564
*Quality Assurance/Quality Control (QA/QC) Samples			76	19	19	57
TOTALS			828	207	207	621

*Assume 4 soil samples, 3 groundwater samples, 1 surface water, 1 sediment sample per site and an additional 1 for every 10 samples analyzed as QA/QC samples.
Note: This table is preliminary and the actual number of samples from each media for each area will be in the installation-specific work plan addenda.

AFB = Air Force base	ARB = Air Reserve base
JB = joint base	

PFAS Sampling Considerations

Given the low detection limits associated with PFAS analysis and the many potential sources of trace levels of PFASs, field personnel are advised to err on the side of caution by strictly following protocols to help mitigate the potential for false detections of PFASs. A list of prohibited and acceptable clothing/equipment for sampling at PFAS sites is included in Table 5. Specific details and procedures related to sampling for analysis of PFASs can be found in ASL SOP-028 (Appendix C). In addition, an SOP to provide contaminant free source has been included as ASL SOP-029.

Table 5 Summary of Prohibited and Acceptable Items for Sampling of PFAS

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials	HDPE materials
Low density polyethylene (LDPE) materials	Acetate liners
	Silicon tubing
Waterproof field books	Loose paper (non-waterproof)
Plastic clipboards, binders, or spiral hard cover notebooks	Aluminum field clipboards or with Masonite
	Sharpies®, pens
Post-It Notes	
Chemical (blue) ice packs	Regular ice
Field Clothing and PPE	
New cotton clothing; synthetic water-resistant, waterproof, or stain-treated clothing; clothing containing Gore-Tex™	Well-laundered clothing, defined as clothing that has been washed 6 or more times after purchase, made of natural fibers (preferably cotton)
Clothing laundered using fabric softener	No fabric softener
Boots containing Gore-Tex™	Boots made with polyurethane and polyvinyl chloride (PVC)
Tyvek®	Cotton Clothing
No cosmetics, moisturizers, hand cream, or other related products as part of personal cleaning/showering routine on the morning of sampling	**Sunscreens** - Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, baby sunscreens that are "free" or "natural" **Insect repellents** - Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics **Sunscreen and insect repellent -** Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon®-lined caps	Unlined polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade® and Powerade®) to be brought and consumed only in the staging area

Soil Boring Advancement/Abandonment and Soil Sample Collection

To determine if PFASs have been released in the investigation areas, borings will be advanced to the depth of the water saturated/unsaturated soil interface to collect soil samples. Soil boring locations will be selected based upon site assessments and site reconnaissance and will be biased toward potential source areas, known spill locations, and downgradient migration pathways. Proposed soil boring locations will be presented in site-specific work plan addenda.

Soil cores will be collected continuously, visually screened for evidence of impacts (discoloring or staining), and logged by a qualified professional in accordance with the Unified Soil Classification System (USCS). Discrete soil samples will be collected at intervals based upon site assessments and field observations (visual evidence of impacts). Samples selected for laboratory analysis will be analyzed at a minimum for the suite of 18 PFASs detailed in Worksheet #11.

Soil samples will be collected in accordance with ASL SOP-13, “Soil Sampling” (Appendix C). Borings will be abandoned in accordance with the state-specific regulatory requirements. Soil sample collection will be recorded in the field log and on soil sample collection forms, and boring logs will be recorded on USACE drilling log forms (Appendix D). A summary of proposed soil samples will be provided in the installation-specific work plan addenda.

Monitoring Well Sampling
Existing monitoring wells at each installation will be used wherever applicable to collect groundwater samples for the sites. Temporary groundwater monitoring wells will be installed as needed based upon site reconnaissance, review of installation-specific data, and/or reports showing groundwater flow. The monitoring wells will be installed by state-licensed drilling contractors in accordance with state-specific requirements and ASL SOP-19, “Monitoring Well Installation” (Appendix C). Where site conditions and state regulations allow, temporary monitoring wells will be installed using a direct-push drill rig. Elsewhere, a hollow stem auger or sonic rig will be used to advance the borehole for the well. Proposed monitoring well locations will be presented in the installation-specific work plan addenda.

Monitoring wells will be constructed with 1-inch inside diameter (ID) polyvinyl chloride (PVC) casing. The PVC will be flush-threaded and have a threaded bottom cap installed. Well screens will be 1-inch ID factory-cut 0.01-inch slotted pipe (slot size may need to be adjusted based on individual site lithology and installation method). Actual screen lengths, screen types, and total well depths will be specified in the installation-specific work plan addenda and adjusted as necessary in the field based on site-specific conditions. Boring logs and monitoring well completion diagrams will be generated for each well on forms provided in Appendix D.

Prior to initiating groundwater sampling activities, static water levels will be collected from existing and newly installed monitoring wells at each site to evaluate the direction of groundwater flow. Water level measurements will be recorded to the nearest 0.01 foot from the top of casing in monitoring wells using an electronic water level indicator. Wells in which water levels are measured will be documented in the installation-specific work plan addenda.

Groundwater samples will be collected from existing monitoring wells and newly installed temporary wells to determine the presence or absence of PFASs within groundwater at each site. Existing monitoring wells will be purged and sampled using low flow purging and sampling techniques in accordance with ASL SOP-002, “Groundwater Sampling” (Appendix C). During purging, water quality parameters [pH, specific conductance, temperature, oxidation reduction potential (ORP), and turbidity] will be measured using a water quality meter or combination of meters. Well purging will be considered complete when stabilization of water quality parameters is achieved, as indicated in ASL SOP-002. After achieving stabilization, the appropriate sample containers will be filled using direct fill sampling techniques. Groundwater samples will be analyzed at a minimum for the 18 PAFS parameters detailed in

Worksheet #11. Purge records, water quality parameters, and sampling details will be recorded on groundwater sample forms (Appendix D). Proposed groundwater sample locations and specific sampling equipment to be used will be presented in the installation-specific work plan addenda.

Sediment Sampling

Sediment samples will be collected, as applicable, to determine the presence or absence of PFASs within surface water bodies. A sample will be considered a sediment sample if it is collected within a surface water body or drainage feature; otherwise, it will be considered a soil sample. Sediment samples will be collected in accordance with ASL SOP-012, "Sediment Sampling," (Appendix C) and will be analyzed, at a minimum, for the 18 PFASs identified in Worksheet #11. Sample collection will be recorded in the field log and on sample collection forms (Appendix D). Proposed sediment sample locations and specific equipment to be used during sample collection will be in the installation-specific work plan addenda.

Surface Water Sampling

Surface water samples will be collected, as applicable, to determine the presence or absence of PFASs within surface water bodies. Surface water samples may be collected from any flowing or free-standing water present at the site. Surface water will be analyzed, at a minimum, for the 18 PFASs identified in Worksheet #11. Surface water samples will be collected in accordance with ASL SOP-004, "Surface Water Sampling," (Appendix C). Sample collection will be recorded in the field log and on sample collection forms (Appendix D). Proposed surface water sample locations and specific equipment to be used during sample collection will be in the installation-specific work plan addenda.

Surveying

Handheld global positioning system (GPS) units will be used for surveying during fieldwork in accordance with ASL SOP-026, "Global Positioning Systems." The measurement point on the monitoring well casing will be marked for future reference with a survey reference point.

Investigation-Derived Waste Management

Investigation-derived waste (IDW) will consist of soil cuttings from soil boring advancement, purge and decontamination water, disposable PPE, and other household type trash. All IDW will be managed in accordance with ASL SOP-020, Investigation Derived Waste Management," as modified in accordance with installation and/or local regulatory requirements. It is anticipated that PPE and other trash will be placed in plastic bags and placed into sanitary trash containers and disposed of at a sanitary landfill. It is assumed that soil and water IDW will be containerized in Department of Transportation (DOT)-approved 55-gallon drums pending characterization. Based upon characterization results, IDW will be transported off site and disposed at the appropriate facility. Waste characterization analyses will be based upon specific state and disposal facility requirements and will be presented in the installation-specific work plan addenda.

Field Documentation

A field logbook will be maintained for documentation of pertinent field activities from each activity during the investigation (sampling and surveying) in accordance with ASL SOP-001, "Logbooks." Field sheets and other forms to be used to document pertinent information associated with the field activities are in Appendix D. In addition, digital photographs will be recorded to document significant observations during activities. Photographs will only be taken in accordance with the restrictions and permitting requirements of each installation. Field documentation—including field notes, photographs, and other forms (sampling forms, etc.)—will be in the site investigation reports for each facility.

Health and Safety

Fieldwork during the site investigation will be conducted in accordance with the general APP (submitted under separate cover) and the installation-specific SSHPs.

Data Management

The purpose of data management is to ensure that all necessary data are accurate and readily accessible to meet the analytical and reporting objectives of the project. The analytical results will be provided by the laboratory in the ERPIMS lab submittal electronic data deliverable (EDD) format. Laboratory EDDs will be loaded to the ERPTools X software, where they will be checked and supplemented with field-derived data. Final ERPIMS submittal will be complete after all data in ERPTools X have completed table, group, and submittal checks and final review by the AFCEC ERPIMS staff.

QAPP Worksheet #15a: Action Limits and Laboratory-Specific Detection/Quantitation Limits

(UFP-QAPP Manual Section 2.6.2.3 and Figure 15) (EPA 2106-G-05 Section 2.2.6)
Rev 0, Date: 01/19/2016

Laboratory: Maxxam Analytics International Corporation
Matrix: Aqueous
Analytical Method: PFAS by LC-MS-MS, EPA 537 (modified)
Concentration Level: Low

				Analytical Method[1]		Achievable Laboratory Limits[2]	
Analyte	**Acronym**	**CAS Number**	**Project Action Limit (µg /L)**	**MDLs (µg /L)**	**Method QLs (µg /L)**	**LODs (µg /L)**	**LOQs (µg /L)**
Perfluorobutanoic acid	PFBA	375-22-4	N/A	0.0066	0.02	0.014	0.02
Perfluoropentanoic acid	PFPA	2706-90-3	N/A	0.0036	0.02	0.010	0.02
Perfluorohexanoic acid	PFHxA	307-24-4	N/A	0.0046	0.02	0.010	0.02
Perfluoroheptanoic acid	PFHpA	375-85-9	N/A	0.0047	0.02	0.010	0.02
Perfluorooctanoic acid	PFOA	335-67-1	0.4	0.0053	0.02	0.014	0.02
Perfluorononanoic acid	PFNA	375-95-1	N/A	0.0046	0.02	0.010	0.02
Perfluorodecanoic acid	PFDA	335-76-2	N/A	0.0066	0.02	0.014	0.02
Perfluoroundecanoic acid	PFUnA	2058-94-8	N/A	0.0037	0.02	0.010	0.02
Perfluorododecanoic acid	PFDoA	307-55-1	N/A	0.0057	0.02	0.014	0.02
Perfluorotridecanoic acid	PFTriA	72629-94-8	N/A	0.0034	0.02	0.010	0.02
Perfluorotetradecanoic acid	PFTeA	376-06-7	N/A	0.0052	0.02	0.014	0.02
Perfluorobutane sulfonate	PFBS	375-73-5	N/A	0.0019	0.02	0.007	0.02
Perfluorohexane sulfonate	PFHxS	355-46-4	N/A	0.0040	0.02	0.010	0.02
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.2	0.0033	0.02	0.010	0.02
Perfluorodecane sulfonate	PFDS	335-77-3	N/A	0.0043	0.02	0.010	0.02
Perfluorooctane sulfonamide	FOSA	754-91-6	N/A	0.0058	0.02	0.014	0.02
6:2 Fluorotelomersulfonate	6:2-FTS	27619-97-2	N/A	0.0065	0.02	0.14	0.02
8:2 Fluorotelomersulfonate	8:2-FTS	39108-34-4	N/A	0.0055	0.02	0.014	0.02

[1] Analytical MDLs and QLs are those documented in validated methods.

[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. Laboratory Generated Limits are subject to change, the laboratory will use the most current limits at the time of analysis.

µg/L = micrograms per liter CAS = Chemical Abstract Service LOD = limit of detection LOQ = limit of quantitation MDL = method detection limit QL = quantitation limit

QAPP Worksheet #15b: Action Limits and Laboratory-Specific Detection/Quantitation Limits (UFP-QAPP Manual Section 2.6.2.3 and Figure 15) (EPA 2106-G-05 Section 2.2.6)

Rev 0, Date: 01/19/2016

Laboratory: Maxxam Analytics International Corporation
Matrix: Soil, Sediment
Analytical Method: PFAS by LC-MS-MS
Concentration Level (if applicable): Low to High

Analyte	Acronym	CAS Number	Project Action Limit (mg/kg)	Analytical Method[1] MDLs (mg/kg)	Analytical Method[1] Method QLs (mg/kg)	Achievable Laboratory Limits[2] LODs (mg/kg)	Achievable Laboratory Limits[2] LOQs (mg/kg)
Perfluorobutanoic acid	PFBA	375-22-4	N/A	0.000011	0.001	0.0004	0.001
Perfluoropentanoic acid	PFPA	2706-90-3	N/A	0.00013	0.001	0.0004	0.001
Perfluorohexanoic acid	PFHxA	307-24-4	N/A	0.00011	0.001	0.0004	0.001
Perfluoroheptanoic acid	PFHpA	375-85-9	N/A	0.00014	0.001	0.0004	0.001
Perfluorooctanoic acid	PFOA	335-67-1	16.0	0.000060	0.001	0.0002	0.001
Perfluorononanoic acid	PFNA	375-95-1	N/A	0.000084	0.001	0.0002	0.001
Perfluorodecanoic acid	PFDA	335-76-2	N/A	0.00014	0.001	0.0004	0.001
Perfluoroundecanoic acid	PFUnA	2058-94-8	N/A	0.00013	0.001	0.0004	0.001
Perfluorododecanoic acid	PFDoA	307-55-1	N/A	0.00013	0.001	0.0004	0.001
Perfluorotridecanoic acid	PFTriA	72629-94-8	N/A	0.00020	0.001	0.0004	0.001
Perfluorotetradecanoic acid	PFTeA	376-06-7	N/A	0.00018	0.001	0.0004	0.001
Perfluorobutane sulfonate	PFBS	375-73-5	N/A	0.00017	0.001	0.0004	0.001
Perfluorohexane sulfonate	PFHxS	355-46-4	N/A	0.00013	0.001	0.0004	0.001
Perfluorooctanesulfonic acid	PFOS	1763-23-1	6.0	0.00012	0.001	0.0004	0.001
Perfluorodecane sulfonate	PFDS	335-77-3	N/A	0.00017	0.001	0.0004	0.001
Perfluorooctane sulfonamide	FOSA	754-91-6	N/A	0.00012	0.001	0.0004	0.001
6:2 Fluorotelomersulfonate	6:2-FTS	27619-97-2	N/A	0.00016	0.001	0.0004	0.001
8:2 Fluorotelomersulfonate	8:2-FTS	39108-34-4	N/A	0.00018	0.001	0.0004	0.001

[1] Analytical MDLs and QLs are those documented in validated methods.

[2] Achievable MDLs and QLs are limits that an individual laboratory can achieve when performing a specific analytical method. Laboratory Generated Limits are subject to change, the laboratory will use the most current limits at the time of analysis.

mg/kg = milligrams per kilogram CAS = chemical abstract system LOD = limit of detection LOQ = limit of quantitation MDL = method detection limit QL = quantitation limit

QAPP Worksheet #17: Sampling Design and Rationale
(UFP-QAPP Manual Section 3.1.1)
(EPA 2106-G-05 Section 2.3.1)
Rev 0, Date: 01/19/2016

Sampling activities will be conducted at approximately 188 sites identified as potential PFAS release sites in the PA reports for 20 installations. Soil, groundwater, and surface water/sediment (as applicable) samples will be collected from each area to determine if a release of PFASs has occurred. In accordance with Step 4 (Define the Boundaries of Data Collection) of the DQOs established in Worksheet #11, sample locations will target areas with the potential for the highest concentrations of the following 18 PFASs:

Chemical Name	CAS Number
Perfluorooctanesulfonic acid (PFOS)	1763-23-1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4
Perfluorooctanoic acid (PFOA)	335-67-1
Perfluoroheptanoic acid (PFHpA)	375-85-9
Perfluorononanoic acid (PFNA)	375-95-1
Perfluorobutanesulfonic acid (PFBS)	375-73-5
Perfluorobutanoic acid (PFBA)	375-22-4
Perfluoropentanoic acid (PFPA)	2706-90-3
Perfluorohexanoic acid (PFHxA)	307-24-4
Perfluorooctanesulfonamide (FOSA)	754-91-6
Perfluorodecanoic acid (PFDA)	335-76-2
Perfluorodecanesulfonic acid (PFDS)	335-77-3
Perfluoroundecanoic acid (PFUnA)	2058-94-8
Perfluorododecanoic acid (PFDoA)	307-55-1
Perfluorotridecanoic acid (PFTriA)	72629-94-8
Perfluorotetradecanoic acid (PFTeA)	376-06-7
6:2 Fluorotelomer sulfonate (6:2 FTS)	27619-97-2
8:2 Fluorotelomer sulfonate (8:2 FTS)	39108-34-4

CAS = Chemical Abstract Service

Sample locations may include, but are not limited to,

- Groundwater from the center of the suspected release area and downgradient,
- Surface and subsurface soil from the center of the suspected release area, and
- Surface water and/or sediment from drainage and surface water features downgradient of the suspected release areas.

Information inputs from the preliminary conceptual site model (Worksheet #10) of the installation-specific work plan addenda will be the basis for sample design at each suspected release area. Details of installation-specific sampling design and rationale will be in the installation-specific work plan addenda.

QAPP Worksheet #18: Sampling Locations and Methods
(UFP-QAPP Manual Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.1 and 2.3.2)
Rev 0, Date: 01/19/2016

Sampling locations and methods will be presented in the installation-specific work plan addenda. As discussed on Worksheet #14/16, sample methodologies will strictly follow the protocols ASL SOPs (Appendix C) to help mitigate the potential for false detections of PFASs. A list of prohibited and acceptable clothing/equipment for sampling at PAFS sites is included in Table 5 on Worksheet #14/16.

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

(UFP-QAPP Manual Section 3.1.2.2)
(EPA 2106-G-05 Section 2.3.2)
Rev 0, Date: 01/19/2016

Laboratory for PFAS Analysis: Maxxam Analytics International Corporation
Sample Delivery Method: EDDs (analytical data packages, electronic data)

Analyte/ Analyte Group	Matrix	Method/ SOP	Accreditation Expiration Date	Container(s) (number, size, and type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
PFC	Water	EPA 537 (modified)/ CAM SOP-00894	5/31/2017	(1) 250 mL HDPE bottle with an unlined cap	< 6°C	28 days to extract	45 days for analysis	10 business days
PFC	Soil	CAM SOP-00894	5/31/2017	(1) 250 mL HDPE wide mouth bottle with an unlined lid	< 6°C	28 days to extract	45 days for analysis	10 business days

< = less than °C = Celsius EPA = United States Environmental Protection Agency
HDPE = high density polyethylene mL = milliliters PFC = perfluorinated compound
SOP = standard operating procedure

Maxxam Analytics International Corp. is an off-site laboratory that is certified by Perry Johnson Laboratory Accreditation Inc., as United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) compliant.

Name of Laboratory:	Maxxam Analytics International Corp.
Address:	6740 Campobello Road Mississaugua ON, L5N 2L8, Canada
Contact:	Paul Henige
Telephone Number:	650-631-7571
Mobile Number:	650-576-7765

Accrediting Authority:	Perry Johnson Laboratory Accreditation Inc.
Accreditation Number:	66912
Effective Date:	04/18/2015
Expiration Date:	05/31/2017

Accreditation Scope: Clean Water Act (CWA) & Resource Conservation and Recovery Act (RCRA)/Comprehensive Environmental Response, Compensation, and Liability Act CERCLA) & Toxicology

Back Up Lab: None
Sample Delivery Method: Next Day Air via UPS/FedEx

QAPP Worksheet #20: Field QC Summary
(UFP-QAPP Section 3.1.1 and 3.1.2)
(EPA 2106-G-05 Section 2.3.5)
Rev 0, Date: 01/19/2016

The following QC samples (and collection frequencies) will be collected during field activities:

- Site investigation,
    - One field duplicate sample for every 10 field samples in each media (1:10 or 10 percent), and
    - One rinseate sample and one trip blank sample for each sampling day.
- One field blank sample per lot of laboratory-provided “PFAS-free” deionized water, and
- One matrix spike (MS)/matrix spike duplicate (MSD) sample for every 20 field samples (1:20 or 5 percent).

The field QC summary for the individual facilities will be in each installation-specific work plan addenda.

QAPP Worksheet #21: Field SOPs
(UFP-QAPP Manual Section 3.1.2)
(EPA 2106-G-05 Section 2.3.2)

Rev 0, Date: 01/19/2016

Standard Operating Procedure No. or Reference[1]	Subject	Originating Organization	SOP option or Equipment Type (if SOP provides different options)	Modified for Project? Y/N	Comments
ASL SOP-001	“Logbooks”	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-002	“Groundwater Sampling”	ASL	Bladder Pump, Peristaltic Pump, Electric Submersible Pump, Bailer	Y	Incorporates PFC protocols.
ASL SOP-004	“Surface Water Sampling”	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-005	“Water Level and Depth Measurements”	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-006	“Field Measurement of Dissolved Oxygen”	ASL	N/A	N	
ASL SOP-007	“Field Measurement of pH”	ASL	N/A	N	
ASL SOP-008	“Field Measurement of Oxidation Reduction Potential”	ASL	N/A	N	
ASL SOP-009	“Field Measurement of Specific Conductance”	ASL	N/A	N	
ASL SOP-010	“Field Measurement of Temperature”	ASL	N/A	N	
ASL SOP-011	“Field Measurement of Turbidity”	ASL	N/A	N	
ASL SOP-012	“Sediment Sampling”	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-013	“Soil Sampling”	ASL	Macrocore sampler, hand auger	Y	Incorporates PFC protocols.
ASL SOP-015	Drilling, development, and heavy equipment decontamination	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-016	“Shipping Samples”	ASL	N/A	N	
ASL SOP-017	Sample handling and custody	ASL	N/A	Y	Incorporates PFC protocols.
ASL SOP-018	Field sampling quality control	ASL	N/A	N	Incorporates PFC protocols.

Standard Operating Procedure No. or Reference[1]	**Subject**	**Originating Organization**	**SOP option or Equipment Type (if SOP provides different options)**	**Modified for Project? Y/N**	**Comments**
ASL SOP-019	Temporary monitoring well/groundwater sample point installation	ASL	DPT	Y	Incorporates PFC protocols.
ASL SOP-020	“Management of Investigation Derived Waste (IDW)”	ASL	N/A	Y	Modified in accordance with facility requirements
ASL SOP-025	Corrective actions	ASL	N/A	N	
ASL SOP-026	“Global Positioning Systems (GPS)”	ASL	N/A	N	
ASL SOP-028	“Field Sampling Protocols to Avoid Cross-Contamination at Perfluorinated Compound Sites”	ASL	N/A	N	
ASL SOP-029	Protocol to provide source water free of perfluorinated compounds	ASL	N/A	N	

Notes:

[1] ASL SOPs included as Appendix C.

ASL = Aerostar SES LLC
DPT = direct push technology
N/A = not applicable
PFC = Perfluorinated Compounds
SOP = standard operating procedure

QAPP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection
(UFP-QAPP Manual Section 3.1.2.4)
(EPA 2106-G-05 Section 2.3.6)

Rev 0, Date: 01/19/2016

Field Equipment	Activity	SOP Reference	Title or Position of Responsible Person	Frequency	Acceptance Criteria	Corrective Action
Water quality meter (DO, temperature, pH, ORP, and specific conductivity meter)	Calibration, testing, and inspection	Manufacturer's user guide	Field team leader	Daily, before groundwater monitoring	Most units: Verification of calibration passes if result is within ±20% certified/ expected value	Troubleshoot problem(s), repeat calibration. If check fails again, obtain new unit and calibrate new unit for use. Document in field logbook.
Turbidity meter	Calibration, testing, and inspection	Manufacturer's user guide	Field team leader	Daily, before groundwater monitoring	Most units: Verification of calibration passes if result is within +20% certified/ expected value	Troubleshoot problem(s), repeat calibration. If check fails again, obtain new unit and calibrate new unit for use. Document in field logbook.
Water level meter	Inspection, testing	Operator's manual	Field team leader	Daily	Functioning properly	Clean probe; replace battery; return to supplier/ manufacturer for repair.
Photoionization detector	Calibration, inspection, maintenance	Operator's manual	Field team leader	Daily	In accordance with operator's manual	Recalibration or return to supplier/ manufacturer for repair.
Sampling pump	Inspection, maintenance	Operator's manual	Field team leader	Daily	Functioning properly	Clean pump and/or trouble shoot or return to supplier/ manufacturer for repair.

Note: Field quality audits will be conducted on a subset of the sites and will include inspection of the field equipment calibration records.

± = plus/ minus
DO = dissolved oxygen
pH = potential of hydrogen
% = percent
ORP = oxidation reduction potential

QAPP Worksheet #23 Analytical SOPs
(UFP-QAPP Manual Section 3.2.1)
(EPA 2106-G-05 Section 2.3.4)
Rev 0, Date: 01/19/2016

SOP #	Title, Date, and URL (if available)	Definitive or Screening Data	Matrix/Analytical Group	SOP Option or Equipment Type	‡Modified for Project? (Y/N)
CAM SOP-00894	"Preparation and Analysis of Perfluorinated Compounds," 11/07/14 - Rev.0	Definitive	Groundwater/Soil/PFAS	LC-MS-MS	Y (calibration curve)

Note: SOPs from Maxxam Analytics International Corporation will be forwarded to the government upon request.

Maxxam Analytics International Corp. is an off-site laboratory that is certified by Perry Johnson Laboratory Accreditation Inc., as United States Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) compliant.

Department of Defense Environmental Laboratory Accreditation Program (DoD- ELAP)
Environmental Laboratory Accreditation

Name of Laboratory:	Maxxam Analytics International Corp.	**Accrediting Authority:**	Perry Johnson Laboratory Accreditation Inc.
Address:	6740 Campobello Road Mississaugua ON, L5N 2L8, Canada	Accreditation Number:	66912
Contact:	Paul Henige	Effective Date:	09/29/2011
Telephone Number:	650-631-7571	Expiration Date:	05/31/2017
Mobile Number:	650-576-7765	**Accreditation Scope:**	CWA & RCRA/CERCLA & Toxicology

QAPP Worksheet #24: Analytical Instrument Calibration
(UFP-QAPP Manual Section 3.2.2)
(EPA 2106-G-05 Section 2.3.6)
Rev 0, Date: 01/19/2016

Maxxam Analytics International Corporation

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
LC-MS-MS	Minimum 5 point calibration	5 point daily	Unlabeled analytes ≤ 25% from target (lowest standard ≤ 30%) Analyte retention time is ≤2% from internal Signal to noise > 5	Instrument maintenance Instrument parameters adjusted (re-optimization) Standards reanalyzed	Instrument operator	CAM SOP-00894

≤ = less than or equal to
> = greater than
SOP = standard operating procedure
% = percent
LC-MS-MS = liquid chromatography – tandem mass spectrometry

Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) compliant. Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) Environmental Laboratory Accreditation

Name of Laboratory: Maxxam Analytics International Corp.
Address: 6740 Campobello Road
Mississaugua ON, L5N 2L8, Canada
Contact: Paul Henige
Telephone Number: 650-631-7571
Mobile Number: 650-576-7765

Accrediting Authority: Perry Johnson Laboratory Accreditation Inc.
Accreditation Number: 66912
Effective Date: 09/29/2011
Expiration Date: 05/31/2017
Accreditation Scope: CWA & RCRA/CERCLA & Toxicology

QAPP Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection
(UFP-QAPP Manual Section 3.2.3)
(EPA 2106-G-05 Section 2.3.6)
Rev 0, Date: 01/19/2016

Maxxam Analytics International Corporation

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
Liquid chromatography – tandem mass spectrometry (LC-MS-MS)	Ion source injector column UHPLC pump	EPA 537 (modified)	Leaks LC column performance MS sensitivity/ selectivity	Daily	Passing ICAL	Recalibrate Reinject affected samples Reanalyze affected samples	Instrument operator	CAM SOP-00894
	Planned maintenance		Tuning mass calibration/ resolution replace consumables	Mass spectrometer (biannually) UHPLC pump (annually)	Meets original manufacturer's performance specifications	N/A	Contracted third party service provider	

[1] Laboratory standard operating procedures are subject to revision and updates during duration of the project, lab will use the most current revision of the SOP at the time of analysis.

EPA = Environmental Protection Agency
N/A = not applicable
UHPLC = ultra-high performance liquid chromatography
ICAL = initial calibration
SOP = standard operating procedure

Department of Defense Environmental Laboratory Accreditation Program (DoD- ELAP) Environmental Laboratory Accreditation

Name of Laboratory:	Maxxam Analytics International Corp.
Address:	6740 Campobello Road Mississaugua ON, L5N 2L8, Canada
Contact:	Paul Henige
Telephone Number:	650-631-7571
Mobile Number:	650-576-7765
Accrediting Authority:	Perry Johnson Laboratory Accreditation Inc.
Accreditation Number:	66912
Effective Date:	09/29/2011
Expiration Date:	05/31/2017
Accreditation Scope:	CWA & RCRA/CERCLA & Toxicology

QAPP Worksheet #26 & 27: Sample Handling, Custody, and Disposal
(UFP-QAPP Manual Section 3.3)
(EPA 2106-G-05 Section 2.3.3)
Rev 0, Date: 01/19/2016

Sampling Organization: Aerostar SES LLC (ASL)
Laboratory: Maxxam Analytics International Corporation (Maxxam)
Method of sample delivery (shipper/carrier): Overnight UPS and/or Overnight FedEx
Number of days from reporting to sample disposal: In accordance with lab certification requirements

Activity	Organization and Title or Position of Person Responsible for the Activity
Sample labeling	ASL – field manager and sampling team
Chain-of-custody form completion	ASL – field manager and sampling team
Packaging	ASL – field manager and sampling team
Shipping coordination	ASL – field manager and sampling team
Sample receipt, inspection, and login	Maxxam, sample receiving
Sample custody and storage	ASL (field manager) and Maxxam
Sample disposal	Maxxam

ASL = Aerostar SES LLC

QAPP Worksheet #28: Analytical Quality Control and Corrective Action

(UFP-QAPP Manual Section 3.4 and Tables 4, 5, and 6)
(EPA 2106-G-05 Section 2.3.5)
Rev 0, Date: 01/19/2016

Matrix: Groundwater/Soil
Analytical Group: PFAS
Concentration Level: Low
Analytical Method/SOP Reference: EPA 537 (modified)/CAM SOP-00894
Analytical Organization: Maxxam Analytics International Corporation

QC Sample	Frequency and Number	Method / SOP Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
Method blank	1/batch (20 samples)		If sufficient sample is available, reanalyze samples. Qualify data as needed. Report results if sample results >10x blank result or sample results ND.	Analyst / section supervisor	Accuracy/bias-contamination	No target compounds >1/2 RL; no common lab contaminants > RL.
LCS	1/batch (20 samples)		If sufficient sample is available, reanalyze samples. Qualify data as needed.	Analyst / section supervisor	Accuracy/bias	Laboratory % recovery control limits
Surrogates	Every sample and standards		Check calculations and instrument performance; recalculate, reanalyze.	Analyst / section supervisor	Accuracy/bias	Laboratory % recovery control limits
MS/MSD	1/batch (20 samples)		Determine root cause; flag MS/ MSD data; discuss in narrative.	Analyst / section supervisor	Accuracy/bias/ precision	Laboratory % recovery / RPD control limits
Results between DL and LOQ	N/A	Apply "J" qualifier to results between DL and LOQ.	N/A	Analyst / section supervisor	Accuracy	Same as acceptance limits

> = greater than
DL = detection limit
LCS = laboratory control sample
MS = matrix spike
N/A = not applicable
RL = reporting limit
% = percent
DQI = data quality indicator
LOQ = limit of quantitation
MSD =matrix spike duplicate
ND = not detected
RPD = relative percent difference
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Matrix: Soil, Aqueous
Analytical Group: PFAS
Concentration Level: Low
Analytical Method/SOP Reference EPA 537 (modified)/CAM SOP-00894
Analytical Organization: Maxxam Analytics International Corporation

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
ICAL	Daily	± 25% of true value for native analytes (± 30 of true value for lowest standard)	Correct problem, then repeat ICAL.	Analyst	Laboratory accuracy	± 25% (except for lowest standard ≤ 30%)
ICV	1 per ICAL, analyzed after ICAL, before field samples	± 25% of true value for native analytes	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.	Analyst	Laboratory accuracy	± 25% of true value for native analytes
CCV	After every 10th sample and at the end of the run	± 25% of true value for native analytes	Correct problem and reanalyze all affected samples since the last acceptable CCV.	Analyst	Laboratory accuracy	± 25% of true value for native analytes
MB	1 per 20 samples or one for each extraction batch	<1/2 LOQ and < 1/10 amount measured in any sample or <1/10 of regulatory limit	The source of the contamination is investigated and eliminated before proceeding with further analysis. If required, prep again and reanalyze MB and all samples processed with contaminated blank.	Analyst/prep analyst	Acceptable level or absence of interference/ contamination	<1/2 LOQ, and <1/10 amount measured in any sample or < 1/10 of regulatory limit

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LCS	1 per 20 samples or one for each extraction batch	%Recovery = (Calculated Value/True Value) *100% Native analyte recoveries 70-130%	Source of poor recovery is investigated and eliminated before proceeding with further analysis. If necessary, prep again and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes.	Analyst/prep analyst	Laboratory accuracy/ method bias in ideal matrix	%Recovery = (Calculated Value/True Value) *100%
MS	1 per 20 samples or one for each extraction batch	%Recovery = (Calculated Value - Sample Value/True Value) *100% Native analyte recoveries 70-130%	If the recoveries indicate that the problem is procedure-related, re-extraction and reanalysis are required. If the recoveries indicate that the failures are matrix-related, refer to blank spike as a measure of method performance in clean matrix. The project chemist will be contacted and a decision will be made to either report the data as is with a notation in the analytical narrative or the samples should be re-extracted and reanalyzed.	Analyst/prep analyst	Precision and accuracy in field samples	%Recovery = (Calculated Value - Sample Value/True Value) *100%

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MSD	1 per 20 samples or one for each extraction batch	RPD between duplicates ≤ 30%	Source of poor RPD is investigated and eliminated before proceeding with further analysis. Check for heterogeneity in samples.	Analyst/prep analyst	Precision in field samples	RPD between duplicates ≤ 30%

< = less than
% = percent
CCV = continuing calibration verification
ICAL = initial calibration
LCS = laboratory control sample
MB = method blank
MSD = matrix spike duplicate
QC = quality control
SOP = standard operating procedure
≤ = less than or equal to
± = plus/ minus
DQI = data quality indicator
ICV = initial calibration verification
LOQ = limit of quantitation
MS = matrix spike
prep = preparation
RPD = relative percent difference

Department of Defense Environmental Laboratory Accreditation Program (DoD-ELAP) Environmental Laboratory Accreditation

Name of Laboratory: Maxxam Analytics International Corp.
Address: 6740 Campobello Road
Mississaugua ON, L5N 2L8, Canada
Contact: Paul Henige
Telephone Number: 650-631-7571
Mobile Number: 650-576-7765

Accrediting Authority: Perry Johnson Laboratory Accreditation Inc.
Accreditation Number: 66912
Effective Date: 09/29/2011
Expiration Date: 05/31/2017
Accreditation Scope: CWA & RCRA/CERCLA & Toxicology

QAPP Worksheet #29: Project Documents and Records
(UFP-QAPP Manual Section 3.5.1)
(EPA 2106-G-05 Section 2.2.8)

Rev 0, Date: 01/19/2016

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other
• Field logbooks • Chain-of-custody forms • Sample labels • Shipping records • Variance request forms • Sample location coordinates	• Field logbooks • Chain-of-custody forms • Variance request forms	• Laboratory sample receipt logs • Chain-of-custody form • Standard traceability logs • Instrument calibration logs • Instrument maintenance logs • Sample preparation worksheets/logs • Sample analysis worksheets/run logs • Chromatograms/raw data/ instrument printouts • Sample results/Form 1s • QC sample results • Telephone/e-mail logs • Corrective action documentation	• Laboratory data review checklists • Corrective action documentation • Data validation report • ERPIMS error logs	• Telephone/e-mail logs • Corrective action documentation

QAPP Worksheet #31, 32 & 33: Assessments and Corrective Action
(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)
(EPA 2106-G-05 Section 2.4 and 2.5.5)
Rev 0, Date: 01/19/2016

Assessments

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions	Person(s) Responsible for Monitoring Effectiveness of Corrective Actions
Field quality control audit	Once	Internal	ASL	ASL quality control manager or designee	ASL field manager	ASL field manager	ASL QC manager
Analytical quality control audit	Once	Internal	ASL	ASL quality control manager or designee	Laboratory project manager	Laboratory project manager	ASL QC manager

Assessment Findings and Corrective Action

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response
Field quality control audit: operational readiness review	Checklist or logbook entry	ASL field manager	Immediately to within 24 hours of review	Checklist or logbook entry	ASL project manager
Field quality control audit: deviations from QAPP	Logbook or field change request	ASL project manager and regional lead	Immediately to within 24 hours of deviation	Logbook or field change request	ASL project manager
Analytical quality control audit: laboratory technical systems/ performance	E-mail followed by deficiency report	ASL project manager, ASL chemist, and Maxxam project manager	Immediately to within 24 hours of deviation	Corrective action report	ASL project manager and ASL chemist

Quality Control Management Reports Table

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Quality control audit	Once	Prior to beginning sample analyses	ASL quality control manager or designee	ASL project manager
Data validation report	As performed	Up to 30 business days after receipt of data package	ASL project manager	Contents summarized in installation-specific investigation report
Laboratory technical systems/ performance audits	As per QSM V 5.0	Per certification requirements	Maxxam project manager	ASL project manager and laboratory coordinator
Laboratory DoD ELAP Recertification*	Per certification or every two years	May 2017	Maxxam project manager	ASL project manager and laboratory coordinator
Variance request form	As required per variance/field change	Prior to field change if feasible	ASL project manager	AFCEC project manager

Note: ***The project laboratory was accredited for EPA Method 537 (modified for nonpotable water and soil) as part of its DoD ELAP accreditation. This is equivalent to the LC-MS-MS method.

ASL = Aerostar SES LLC
ELAP = Environmental Laboratory Accreditation Program
DoD = Department of Defense
QSM = *Quality Systems Manual*

QAPP Worksheet #34: Data Verification and Validation Inputs
(UFP-QAPP Manual Section 5.2.1 and Table 9)
(EPA 2106-G-05 Section 2.5.1)

Rev 0, Date: 01/19/2016

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

LOD = limit of detection
QAPP = quality assurance project plan
SOP = standard operating procedure
LOQ = limit of quantitation
QC = quality control

QAPP Worksheet #35: Data Verification Procedures
(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)

Rev 0, Date: 01/19/2016

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Field logbooks	Field notes will be reviewed periodically to determine completeness, appropriateness, ease of understanding, etc., of information recorded. Upon completion of fieldwork, logbooks will be placed in the project files.	Internal	ASL project manager or designee
Chain-of-custody forms	Chain-of-custody forms will be reviewed against the samples packed in the specific cooler prior to shipment. Original chain-of-custody forms will be sent with the samples to the laboratory while a copy is retained for the project files.	Internal	ASL field manager or designee
Sample receipt and logins	Sample receipt and login summaries will be reviewed to determine potential receipt issues that may impact data quality and for consistency with the chain-of-custody forms.	Internal and external	ASL project chemist; Maxxam project manager (or designee)
Laboratory analytical data package prior to release	Data packages will be reviewed/verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	External	Maxxam project manager (or designee)
Laboratory analytical data package	Data packages will be reviewed by the project chemist. The data will undergo Level 2B/IV validation protocol.	Internal	ASL project chemist or designee
Data validation report	Data validation reports will be reviewed by the ASL project manager and the quality control manager.	Internal	ASL project manager or designee
Electronic data	Electronic laboratory data and field data will be reviewed for consistency with the hard copy information.	Internal	ASL database manager or designee

ASL = Aerostar SES LLC

QAPP Worksheet #36: Data Validation Procedures
(UFP-QAPP Manual Section 5.2.2)
(EPA 2106-G-05 Section 2.5.1)
Rev 0, Date: 01/19/2016

Data Validator: DataChek

The sample data will be validated following the logic identified in *The Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (EPA, June 2008).

Qualifier	Definition
R	The sample results are rejected because of serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.
U	The analyte was analyzed for but was not detected above the reported sample quantification limit.
B	The reported concentration is less than 5 times the concentration reported in an associated field or lab blank.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. J- denotes a low bias for the sample results and J+ for a high bias.
UJ	The material was analyzed for but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

Data Validation Reason Codes

During the review process, a data validation reason code will be added to each of the reviewer's qualifiers to allow the user to identify which results were qualified and the reason(s) for the qualifiers.

Reason Code	Definition
01	Sample received outside of 4+/-2 degrees Celsius
01A	Improper sample preservation
02	Holding time exceeded
02A	Extraction
02B	Analysis
03	Instrument performance – outside criteria
03A	BFB
03B	DFTPP

Reason Code	Definition
03C	DDT and/or Endrin % breakdown exceeds criteria
03D	Retention time windows
03E	Resolution
04	Initial calibration results outside specified criteria
04A	Compound mean RRF QC criteria not met
04B	Individual % RSD criteria not met
04C	Correlation coefficient >0.995
05	Continuing calibration results outside specified criteria
05A	Compound mean RRF QC criteria not met
05B	Compound % D QC criteria not met
06	Result qualified as a result of the 5x/10x blank correction
06A	Method or preparation blank
06B	ICB or CCB
06C	ER
06D	TB
06E	FB
07	Surrogate recoveries outside control limits
07A	Sample
07B	Associated method blank or LCS
08	MS/MSD/duplicate results outside criteria
08A	MS and/or MSD recovery not within control limits (accuracy)
08B	% RPD outside acceptance criteria (precision)
09	Post digestion spike outside criteria (GFAA)
10	Internal standards outside specified control limits
10A	Recovery
10B	Retention time
11	Laboratory control sample recoveries outside specified limits
11A	Recovery
11B	% RPD (if run in duplicate)
12	Interference check standard

Reason Code	Definition
13	Serial dilution
14	Tentatively identified compounds
15	Quantification
16	Multiple results available; alternate analysis preferred
17	Field duplicate RPD criteria is exceeded
18	Percent difference between original and second column exceeds QC criteria
19	Professional judgment was used to qualify the data
20	Pesticide cleanup checks
21	Target compound identification
22	Radiological calibration
23	Radiological quantification
24	Reported result and/or lab qualifier revised to reflect validation findings

% = percent
BFB = bromofluorobenzene
DDT = dichlorodiphenyltrichloroethane
ER = equipment rinseate
GFAA = graphite furnace atomic absorption
LCS = laboratory control sample
MSD = matrix spike duplicate
RPD = relative percent difference
RSD = relative standard deviation
%D = percent difference
CCB = continuing calibration blank
DFTPP = decafluorotriphenylphosphine
FB = field blank
ICB = initial calibration blank
MS = matrix spike
QC = quality control
RRF = relative response factor
TB = trip blank

QAPP Worksheet #37: Data Usability Assessment
(UFP-QAPP Manual Section 5.2.3 including Table 12)
(EPA 2106-G-05 Section 2.5.2, 2.5.3, and 2.5.4)

Rev 0, Date: 01/19/2016

Identify personnel (organization and position/title) responsible for participating in the data usability assessment:

Project Manager: ASL project manager
Project QC Manager: ASL QC manager
Geologist/Hydrogeologist: ASL field manager
Project Chemist: ASL lab coordinator
Data Validator: DataChek

Summarize the data usability assessment process—including statistics, equations, and computer algorithms—that will be used to analyze the data.

Field Measurements – Accuracy of the field measurements will be assessed using daily instrument calibration, calibration check, and analysis of blanks. Precision will be assessed based on reproducing the readings of a single sample.

Field data completeness will be calculated using the following equations:

Sample Collection:

$$\text{Completeness} = \frac{\text{Number of Sample Points Sampled}}{\text{Number of Sample Points Planned}} \text{ X 100 percent}$$

Field Measurements:

$$\text{Completeness} = \frac{\text{Number of Valid Field Measurements Made}}{\text{Number of Field Measurements Planned}} \text{ X 100 percent}$$

Laboratory Data – Laboratory results will be assessed for compliance with required precision, accuracy, completeness, and sensitivity.
Precision – The precision of the laboratory analytical process will be determined through LCS analyses. The standard deviation of these measurements over time will provide confidence that implementation of the analytical protocols was consistent and acceptable. These measurements will establish the precision of the laboratory analytical process. Investigative sample matrix precision will be assessed by comparing the analytical results between the MS/MSD for organic analysis and laboratory duplicate analyses for inorganic analysis.

The RPD will be calculated for each pair of duplicate analysis using the following equation. This precision measurement will include variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity.

$$\text{RPD} = \frac{S - D}{\frac{(S + D)}{2}} \text{ X } 100$$

Where

S = first sample value (original or MS value)
D = second sample value (duplicate or MSD value).

Accuracy – The accuracy of the laboratory analytical measurement process will be determined by comparing the percent recovery for the LCS versus its documented true value.

Investigative sample accuracy will be assessed for compliance with the established QC criteria described earlier in this QAPP using the analytical results of method blanks, reagent/preparation blank, MS/MSD samples, and field blank. The percent recovery (%R) of matrix spike samples will be calculated using the following equation. This accuracy will include variables associated with the analytical process, influences related to sample matrix interferences, and sample heterogeneity.

$$\%R = \frac{A-B}{C} \times 100$$

Where

A = The analyte concentration determined experimentally from the spiked sample
B = The background level determined by a separate analysis of the unspiked sample
C = The amount of the spike added

Completeness – Data completeness of laboratory analyses will be assessed for compliance with the amount of data required for decision making. The completeness is calculated using the following equation.

$$\text{Completeness} = \frac{\text{Number of Valid Laboratory Measurements Made}}{\text{Number of Laboratory Measurements Planned}} \times 100 \text{ percent}$$

Sensitivity – Achieving method detection limits depends upon sample preparation techniques, instrument sensitivity, and matrix effects. It is important to monitor instrument sensitivity through calibration blanks and low concentration standards to ensure consistent instrument performance. It is also critical to monitor the analytical method sensitivity through analysis of method blanks, calibration check samples, LCSs, etc.

Project Completeness – The evaluation of planned versus actual data will determine project completeness. Consideration will be given for project changes and alterations during implementation. All data not flagged as rejected by the review, verification, validation, and assessment processes will be considered valid. Overall, the project completeness will be assessed relative to media, analyte, and area of investigation.

Appendix A

Aerostar SES LLC Project Team Resumes

Jim Madaj, PG, Senior Program Manager

Years with SES Group
17 Years

Total Years of Experience
33 Years

Employee Title
Senior Program Manager

Office
Oak Ridge, TN

Academic Background

- B.S., Geology, University of Oklahoma, 1985

Professional Geologist:

- Alabama #0612
- Georgia #PG001805
- Kentucky #KY-2420
- Mississippi #624
- Tennessee #0516
- Texas #5147

Professional Training

- OSHA 40-Hour HAZWOPER and 8-Hour Refreshers
- OSHA 8-Hour Confined Space for Attendant/Entry
- OSHA 8-Hour Hazardous Waste Supervisor
- OSHA 10-Hour Construction Safety and Health
- USACE Construction Quality Management for Contractors
- Lead Awareness (Title 29 CFR 1910.1025)
- Georgia Soil and Water Conservation Committee (GASWCC), Level II, Level 1B, Level 1A
- Hazardous Materials Handling
- Respirator Fit Test
- Bloodborne Pathogens
- First Aid/CPR/AED

As Senior Program Manager, Mr. Madaj has responsibility for all company environmental programs, personnel and resources. He previously served for 12 years as Senior Program Manager, Senior Project Manager, and technical advisor for sister company, SES LLC, and for over 4 years as General Manager/Senior Program Manager of sister company, SCF. During the past 13 years he has primarily managed base-wide environmental programs for the U.S. Army Corps of Engineers (USACE) Savannah District since 2004, and at Fort Campbell for the USACE Nashville District since 2002. He has managed 13 major indefinite delivery indefinite quantity (IDIQ) task order contracts valued at approximately $150M since 2002 for these and other Department of Defense clients and private customers.

Program Management

2004–Present: Basewide Environmental Support (BEST) Contracts, USACE–Savannah District; W912HN-04-D-0019 ($3M), W912HN-07-D-0012 ($15M), W912HN-10-D-0001 ($40M), W912HN-11-D-0024 ($9.9M), W912HN-12-D-0021 ($9.9M), W912HN-13-D-0023 ($9.9M). Seven consecutive IDIQ contracts valued at $97M with general environmental construction and remediation scopes of work comprising compliance, restoration, conservation, and pollution prevention—supporting programs primarily at bases throughout the Savannah District including multiple task orders at Hunter Army Airfield, Fort Stewart, and Fort Gillem, Georgia; and Fort Bragg, North Carolina. Providing services driven by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA), activities have included interim removal actions, corrective measures studies (CMS), corrective action plans, multimedia sampling, underground storage tank (UST) removal, and waste management planning. Since 2012, installation environmental management support has been provided to the Defense Logistics Agency (DLA) at Fort Belvoir, Virginia—overseeing installation support to assist in program management-related functions and provision of financial expertise to DLA's Restoration Team in the annual estimating and reporting of future environmental liabilities.

2011–Present: Waste Management and Small Arms Range Support, Naval Facilities Engineering Command Southeast (NAVFAC SE) Area of Responsibility; Contracts N69450-11-D-0056 ($4M), N69450-14-D-0013 ($4M). Program Manager for two follow-on IDIQ contracts to provide hazardous waste management and release support, small arms shooting range clearance and remediation services, and site investigations and evaluations within the NAVFAC SE region.

2002–Present: USACE, Nashville District; Contracts DAW62-02-D-0009, W912P5-04-D-0016 ($3M), W912P5-04-D-0004 ($14 M), W912P5-11-D-0004 ($10M). Provided CERCLA/RCRA support to Fort Campbell, Kentucky and Tennessee, for over 13 years under consecutive contracts totaling approximately $30M. Typical projects have included: emergency response; spill remediation; well installation and abandonment; best management practices and sinkhole improvements; landfill maintenance, repairs, and construction support; UST removal and line leak testing; aboveground storage tank (AST) integrity testing and replacement; remediation of oil pits, lubrication racks, oil-water separators, and other petroleum, oil, and lubricant remediation; site investigations; human health and ecological risk assessments; CMSs; RCRA permit support; free product delineation and recovery; and contaminant removal in residential areas. Responsibilities include coordination with USACE–Nashville District and Fort Campbell personnel, allocating resources for simultaneous projects, review of reports to ensure technical accuracy, and ensuring that projects are completed on time and within budget.

2013–Present: UT-Battelle, Fort Campbell Energy Management Program, Fort Campbell, KY. Providing energy management and process engineering support to Fort Campbell through integration of existing monitoring and communication systems and the design and management of system engineering projects including reliability, logistics, system requirements, evaluation measurements, work-processes, optimization methods, and energy management tools as related to energy consumption and efficiency.

2006–Present: UT-Battelle, Long Term Monitoring and Natural Attenuation Field Support, Dover Air Force Base (AFB). DE. Providing evaluation of suspected problems associated with past waste disposal and spill sites. Ongoing tasks assessed under this technical assistance subcontract to Oak Ridge National Laboratory are: semi-annual and annual natural attenuation monitoring at multiple sites; and quarterly long-term monitoring at three sites on Base.

2006–2011: UT-Battelle Environmental Services, Fort Stewart, GA; Contract 4200000214 ($5M). Eight tasks were issued under this blanket subcontract for projects that included storage tank compliance, low-impact development construction and enhancements, and environmental pilot landfill studies on Fort Stewart.

2005–2009: Tank Program Support, Robins AFB, GA. SES served as the UST and AST contractor at Robins AFB for over four years, ensuring that the installation was in compliance with Georgia tank regulations as well as federal requirements specified in 40 CFR 112 and 280. The scope included vapor recovery system design and installation, tank maintenance, technical support, and well monitoring.

Project Management

2014–Present: Vapor Intrusion Mitigation, Fort Gillem, GA. Project Manager on a task for the USACE savannah District to provide rapid response services to the Army BRAC program at Fort Gillem, Georgia. Working with the Army, the Urban Redevelopment Agency of the City of Forest Park, the Georgia Environmental Protection Division, and EPA Region IV, SCF is conducting a high profile, highly visible vapor intrusion study and installing vapor intrusion mitigation systems in residential and commercial structures. Based on vapor intrusion air monitoring results from a local daycare facility, SCF was asked to respond immediately to install a temporary vapor mitigation system. Working around the business's schedule, SCF was able to install and start-up the mitigation system in less than 15 days from NTP.

2013–Present: Site Investigations of Fire Fighting Foam Usage at Various U.S. AFBs. Project Manager responsible for providing program-level information for screening-level investigation of potential sites where perfluorinated compounds (PFCs) may be found related to Air Force-mediated aqueous film forming foam (AFFF) environmental release. Supports concurrent management of field work and reporting for investigations at 10 AFBs throughout the United States. Most of the field work has occurred on active Air Force airfields which added to the logistical requirements of the project. Duplicate groundwater samples were also collected to prove the effectiveness of a PFC screening device that Air Force Civil Engineering Center (AFCEC) would like to use to speed screening for PFCs at all of their bases in the future.

2010–2012: Joint Base Lewis-McChord (JBLM) Planning Support, WA. As Project Manager provided studies and analysis capability to support planning, execution and evaluation of the impact of Joint Base requirements at JBLM. Objective was to provide the Joint Base, which became fully operational in 2010, with technical support on strategic planning and change management with a focus on preparation and refinement of Joint Base execution plans and evaluation of the efficiency of JB directed changes.

2006: CMS for Solid Waste Management Unit (SWMU) 170Z11, Fort Campbell, KY. Project Manager for the CMS of a former lubrication rack site where free product and dissolved groundwater contaminants were a concern. Directed development of site-specific, qualitative cleanup goals to address the contamination and protect human health and the environment. Evaluated five remedial alternatives, and ultimately selected passive skimmers as the most cost-effective remedial strategy to meet remedial goals.

2005–2006: Tank Support, Robins AFB, GA. Project Manager responsible for evaluating and installing Stage 1 vapor recovery at three locations, correcting tank deficiencies at 30 locations, performing tank vapor and interstitial monitoring at 90 wells in 17 different locations, and providing Robins AFB with technical support as needed. Ensured that all specifications were met, and coordinated with the Robins AFB Contracting Officer and Environmental Management Resources Division.

2005: Oil-Water Separator Directory, Fort Campbell, KY. Project Manager responsible for confirming active or closure status of oil-water separators at more than 100 sites across Fort Campbell. Directed the update of information and photographic documentation in the directory to ensure accurate listings.

2005: Review of Land Use Controls, Fort Stewart, GA. Project Manager completed a five-year review of existing documentation for nine sites at Fort Stewart to determine the effectiveness of corrective actions and institutional controls. Directed site visits and research for three inactive landfills, four closed explosives ordnance disposal sites, a former fire training area, and a tanker purge station to determine whether chosen remedies had functioned as intended and whether exposure assumptions were still valid. Provided technical review of the final report.

2004–2005: Interim Action and CMS at SWMU 39, Fort Stewart, GA. Project Manager responsible for an interim action at a site used for vehicle service. A pilot study was conducted using multi-phase extraction to remediate both waste oil and solvent contamination as an interim measure. The CMS evaluated several options, including the following remedial technologies: passive skimmer pumps, active skimmer pumps, multi-phase extraction, and excavation of the area containing free product. In addition, the in situ groundwater remediation technologies evaluated in the study were monitored natural attenuation, hydrogen peroxide injection, bacteria injection, oxygen injection, hydrogen injection, and soil vapor extraction.

2003–2005: Investigation, Risk Assessment, and CMS for the Old Hospital Complex Site at Fort Campbell, KY. As Project Manager, was responsible for directing the collection of over 600 soil samples and a subsequent human health risk assessment and CMS for a 70 acre site contaminated with pesticides and semi-volatile organic compounds (SVOCs).

2004: AST Repairs, Fort Campbell, KY. Project Manager responsible for oversight and coordination with facility representatives during repairs of large ASTs used for bulk fuel storage at three separate sites. The work included repairs to piping and structural supports, interior tank cleaning, and welding repairs. Much of this project involved confined space entry for personnel in up to Level C personal protective equipment.

2004: Removal of 33 Heating Oil Tanks within the Main Cantonment Area and Campbell Army Airfield, Fort Campbell, KY. Project Manager responsible for allocating resources and oversight during removal of 33 USTs containing heating oil (6 tanks in Kentucky, 27 tanks in Tennessee). Directed the excavation and removal of tanks and contaminated soil and performed confirmatory sampling in accordance with Kentucky and Tennessee requirements. The removal action was completed ahead of schedule. Recommended clean closure for 28 tank sites. The remaining five tanks will require further action to meet cleanup criteria.

2004: Convault Replacement, Fort Campbell, KY. Project Manager for the time-critical removal and replacement of an 18,000 pound AST supplying fuel to the generator for runway lights at Fort Campbell. Under Mr. Madaj's leadership, the fieldwork was completed ahead of schedule and the use of a temporary tank ensured no interruption in generator use.

2003-2006: Free Product Recovery at Campbell Army Airfield, Fort Campbell, KY. Project Manager for an ongoing product recovery effort at the Campbell Army Airfield. Directed the installation of a solar-powered product recovery pump, which automatically seeks the oil-water interface. The unit is portable and was used for pockets of groundwater contamination and hard to reach areas. Because groundwater can fluctuate as much as 20 feet at the airfield, the automatically adjusting pump reduced the monitoring and maintenance that would have been required with fixed pumps.

2003: Removal of Small Arms Ammunition at Fort Campbell, KY. Project Manager for the removal of buried small arms ammunition. Provided oversight for the unexploded ordnance (UXO) subcontractor and coordinated all activities with Fort Campbell personnel. Directed project personnel during excavation and removal of 3240 rounds of 0.3- caliber and five rounds of 0.5-caliber ammunition which was transported to the Clean Harbors Colfax facility in Louisiana, with all appropriate hazardous waste manifest documentation. Following the removal action, UXO specialists conducted a sweep of the area to confirm removal.

2002: Phase 4 RCRA Facility Investigation (RFI) at Campbell Army Airfield for Bravo Parking Apron and SWMU 41, Fort Campbell, KY. Project Manager for an RFI involving the installation of two groundwater monitoring wells at SWMU 41 and the completion of three soil gas surveys at Campbell Army Airfield used to delineate the extent of subsurface fuel contamination. The results were included in a human health risk assessment. Coordinated all field activities and provided technical review of final reports.

2002: RFI at SWMU 27, Open Burn/Open Detonation Unit, Fort Campbell, KY. Project Manager responsible for an RFI to determine whether residual contamination from explosives was present at the site. The task included developing and sampling 16 existing wells, and collecting 35 surface soil samples and 21 subsurface samples from seven geoprobe borings. The groundwater and soil samples were analyzed for volatile organic compounds (VOCs), SVOCs, energetics, sulfites, nitrates/nitrites, and total phosphorous. All field efforts were coordinated with UXO specialists to ensure that all project activities were conducted in a safe manner.

2001–2002: Oil-water Separator Removal, Fort Campbell, KY. As Project Manager, provided oversight during the removal of 42 oil-water separators. Removal activities included demolition of below ground structures and associated influent and effluent piping. Pits were overexcavated, and confirmatory samples were collected and analyzed for VOCs, SVOCs, RCRA 8 metals, and polychlorinated biphenyls (PCBs).

2000–2002: UST Investigation, Fort Stewart, GA. Project Manager responsible for oversight to determine the extent of contamination related to UST and heating oil tanks at Fort Stewart. Project activities included installation of groundwater monitoring wells as well as soil and groundwater sampling to determine the extent of VOC and polycyclic aromatic hydrocarbon (PAH) contamination.

2001: Various Projects Involving Fuel Releases at the Campbell Army Airfield, Fort Campbell, KY. Project Manager responsible for addressing fuel releases to soil and groundwater near Pumphouses 1 and 2, and Hangar 3 at the Campbell Army Airfield. Free product recovery at the two pumphouses was performed using vapor extraction and skimmer pumps. Over the first 11 weeks, over 11,000 gallons of fuel were recovered.

2000: Investigation of Oil Pit Sites at SWMU 149, Fort Campbell, KY. Project Manager for the investigation of 40 suspected oil pits used for vehicle maintenance fluids. Project activities included verification of the presence of oil pits, removal of contaminated soil from two of the sites, installation of groundwater monitoring wells, and soil sampling. Interfaced with client representatives to determine remedial options.

<u>2000: Pumphouse 1 Fuel Reconnaissance and Pipeline Repair, Fort Campbell, KY</u>. Project Manager for pipeline repair activities near Pumphouse 1. Tracer testing on the active fuel line near the pumphouse indicated the presence of a fuel leak. Project activities included excavation to 8 ft. to expose the pipeline in the suspected leak area. Sampling was performed to determine appropriate method of disposal.

<u>1999–2001: RFI and Corrective Action, Skeet Range, Fort Campbell, KY</u>. Project Manager for RFI activities to characterize surface soil, sediment, and surface water contamination. Surface soil, surface water, and sediment samples were collected and analyzed for Target Compound List (TCL) PAHs and Target Analyte List (TAL) metals. Responsible for project management, client interface, technical direction, and oversight during the removal of the top 18 inches of soil from the site.

<u>1999–2000: Update Generic Work Plan and Sampling and Analysis Plan, Fort Campbell, KY</u>. Project Manager responsible for revision of the Fort Campbell Generic Work Plan and Standard Sampling and Analysis Plan to reflect changes in regulatory requirements and a better understanding of site conditions.

<u>1999–2000: Fort Campbell Pumphouse RFI, Fort Campbell, KY</u>. Project Manager responsible for groundwater and soil sampling activities to determine the presence or absence of fuel contamination. Two groundwater wells were installed and surface and subsurface soil samples were collected and analyzed for TCL VOCs and SVOCs, TAL metals, total petroleum hydrocarbons (TPH), and geotechnical parameters. Provided project management and technical oversight for these activities.

<u>1999–2001: Post Exchange (PX) Service Station RFI and CMS, Fort Campbell, KY</u>. Project Manager for Phase II and III RFIs to delineate the extent of soil and groundwater contamination, determine the future movement of contaminants, assess potential risks to human health and the environment, and determine the requirements for corrective action. Served as technical advisor when drilling activities unexpectedly encountered a large subterranean cave. Responsible for project management, client interface, and technical direction. Provided oversight for the CMS to evaluate and select appropriate remedial action methods.

<u>1999: Fort Campbell 801st Oil Pit RFI, Fort Campbell, KY</u>. Project Manager over the RFI at SWMUs 134, 135, 136, and 137 to determine the presence or absence of groundwater contamination due to past practices at the motor pool. Performed a field investigation, installed two monitoring wells, and conducted soil and groundwater sampling for TCL VOC and SVOC, PCB, and TAL metals analyses. Responsible for project management, client interface, and technical direction and oversight.

<u>1998–1999: Lockheed Martin Energy Systems, Inc.–Hazardous Waste Remedial Action Program (LMES-HAZWRAP); Fort Campbell Master RFI, Fort Campbell, KY</u>. Project Manager for several RFIs and confirmatory sampling investigations at Fort Campbell ranging from UST removals to complex RFIs that delineate/investigate complex underground fuel distribution systems. Attended meetings with state and federal regulatory agencies to expedite the review and approval of submitted plans and reports.

Previous Experience

Ogden Environmental and Energy Services Company, Inc., 1995–1998
Science and Technology, Inc., 1991–1995
Oak Ridge, Tennessee
Senior Hydrogeologist

<u>1991–1998: LMES-HAZWRAP, Oak Ridge, TN</u>. Provided full-time technical support to HAZWRAP. Assisted in the effort to identify, control, and remediate environmental contamination resulting from past methods of storage, handling, and disposal of hazardous waste at military bases nationwide. Prepared statements of work; reviewed business and technical proposals; reviewed work plans and technical reports; interacted with

subcontractors, clients, and regulators; provided technical consulting support to the project manager; and provided technical oversight of fieldwork. Ensured quality of all deliverables for CERCLA and UST projects. Acted as a technical lead for the Air National Guard's Rapid Response UST Program. Supervised preparation of environmental assessment plans, environmental assessment reports, and corrective action plans. Trained personnel for environmental fieldwork, including drill rig supervision and sample collection techniques. U.S. Department of Defense facilities included McConnell AFB, Loring AFB, Columbus AFB, Chanute AFB, Tinker AFB, Mountain Home AFB, Fresno Air Terminal, and New York Air National Guard. Managed a rapid response investigation at McGhee Tyson Air National Guard Base, Tennessee. Prepared work plans, sampling and analysis plans, quality assurance plans, health and safety plans, and final reports. Maintained projects within budget and schedule constraints and interfaced with clients and regulatory agencies.

NUS Corporation, 1988–1991
Tucker, Georgia
Project Manager

Planned, conducted, and supervised project assignments. He estimated and scheduled work to meet completion dates and budgets, directed assistants, reviewed progress and evaluated results, made changes in methodology, and designed equipment. Designed cost-effective approaches to define the extent of contamination at various hazardous waste sites and developed remedial options. Developed site safety plans for all field personnel according to NUS directives as well as Occupational Safety and Health Administration, National Institute for Occupational Safety and Health, and other health and safety guidelines. Other duties included field team leader for well drilling and sampling on numerous hazardous waste site investigations. Prepared drilling bid specifications and supervised subcontractors in the drilling and installation of groundwater monitoring wells. Designed and implemented environmental sampling programs, coordinated field activities and managed sampling teams, and conducted site investigations/inspections. Prepared site investigation and hydrogeologic reports for the EPA. Specific National Priorities List sites included National Southwire Aluminum, Kentucky; Lakeland Tanning, Florida; Zellwood Delisting Project, Florida; Valley Sanitation Landfill, Kentucky; Amnicola Dump, Tennessee; Southwire, Georgia; Beckwith Dump, South Carolina; Ringold Chemical, North Carolina; and Caldwell Systems, North Carolina.

Tinker Air Force Base, 1987–1988
Midwest City, Oklahoma
Hydrogeologist

Responsible for asbestos surveys and asbestos abatement at multiple sites.

Association of Central Oklahoma Governments, Water Resources Division, 1986–1987
Oklahoma City, Oklahoma
Hydrogeologist

Completed water resource studies to determine whether water supply resources were sufficient for surrounding populations.

U.S. Geological Survey, Water Resources Division, 1982–1986
Oklahoma City, Oklahoma
Hydrologic Technician

Conducted hydrogeologic and surface water studies at sites in Oklahoma and surrounding states.

Professional Memberships/Affiliations

- Sustaining member of Society of American Engineers (SAME)

Honors/Awards

- Received the “Award for Individual Excellence for exceptional individual professionalism, dedication, and loyalty demonstrated in support of the Installation Restoration Program at Fort Campbell, Kentucky, during the period of October 1, 2000, through September 30, 2001” presented by the Fort Campbell Environmental Restoration Staff, June 27, 2001.

Brian Odom, P.G., Project Manager

Years with SES Group
9 Years

Total Years Experience
25 Years

Employee Title
Project Manager

Office
Richmond Hill, Georgia

Academic Background
- B.S., Geology, Auburn University, 1999

Professional Geologist
- Florida #2488
- Georgia #1858
- Kentucky #2412
- North Carolina #2119
- Tennessee #5137

Professional Training
- OSHA 40-Hour HAZWOPER and 8-Hour Refreshers
- OSHA Confined Space Safety
- OSHA 10-Hour Construction Safety and Health, Scaffolding Safety Overview, Excavation Safety Overview, and Electrical Safety Course Level 1
- OSHA HAZWOPER Supervisor
- Georgia Level 1A Land Disturbance Qualified Personnel
- USACE Construction Quality Management for Contractors
- Design, Chemical Cleaning, Disinfection, and Redevelopment of Water Wells
- Operations Security (OPSEC)
- CPR/First Aid/AED/BBP

Mr. Odom has over 15 years of experience as a geologist, site supervisor, and project manager on Department of Defense (DoD) and commercial environmental investigation, remediation, and construction projects. In particular, he has extensive experience in underground/aboveground storage tank (UST/AST) compliance activities involving inspections, demolitions, removal and closure, integrity testing, restoration and rehabilitations. Between 2005 and 2010 Mr. Odom managed the underground/ aboveground storage tank (UST/AST) compliance program at Robins Air Force Base (AFB), ensuring that tank installation was in compliance with all state and federal requirements.

Mr. Odom has been actively involved in investigations involving Environmental Protection Agency (EPA) emerging contaminants and investigations and remediation within complex geological environments. His remediation experience includes petroleum hydrocarbons, chlorinated solvents, metals, and polycyclic aromatic hydrocarbon (PAH) contamination. This work has included major excavation projects, soil and groundwater treatment system construction, and in-situ remediation of groundwater contamination.

Mr. Odom also has over eight years of sustainment, restoration and modernization (SRM) construction project management experience to upgrade mechanical, electrical, and structural building infrastructure, working in fully functioning U.S. Air Force medical facilities throughout the southeastern U.S. and California.

Experience Highlights

2014–Present: Corrective Action Management, Fort Bragg, NC. Project Manager on the demolition and reconstruction of a pre-treatment system at a C-130 aircraft wash facility; a survey of all facilities potentially contaminated with perfluorinated compounds (PFCs), and further investigation through groundwater and soil sampling; and installation of back flow prevention assemblies at sites requiring cross-contamination prevention.

2014–Present: Removal and Replacement of Piping at Smoke Bomb Hill AAFES Service Station, Fort Bragg, NC. Project Manager/Geologist responsible for the removal and replacement of over 500 feet of underground fuel pipelines, 10 dispenser sumps, and four tank sumps.

2014–Present: Remedial Investigation and Interim Remedial Action, Trap and Skeet Range, Fort McPherson, GA. Project Manager overseeing the delineation of the extent of PAH and lead contamination at a former trap and skeet range. This project also includes excavation, stabilization, and disposal of lead and PAH impacted soils above regulatory levels and site restoration to prepare for sale of the property.

2013–Present: Product Recovery System Pilot Study, Bulk Fuel Farm Facility Building 7009, Hunter Army Airfield, GA. Project manager responsible for the installation and operation of a pilot study needed to design a final remedy to remove free product from under the bulk fuel farm.

2013–2015: Site Investigations of Fire Fighting Foam Usage at Various U.S. AFBs. Project manager responsible for providing program-level information for screening-level investigation of potential sites where

PFCs may be found related to Air Force-mediated aqueous film forming foam (AFFF) environmental release. This project involves simultaneously managing field work and reporting for investigations at 10 AFBs located throughout the United States. Most of the field work has occurred on active Air Force airfields, adding to the logistical requirements of the project. Duplicate groundwater samples were also collected to prove the effectiveness of a PFC screening device that Air Force Civil Engineering Center (AFCEC) would like to use to speed screening for PFCs at all of their bases in the future.

2011–2013: Repair of Mechanical and Electrical Building Infrastructure Systems, Vandenberg AFB, CA. Project Manager responsible for the multiple AHU, boiler, domestic hot water, and building automation system (BAS) upgrade in an occupied clinic. Included design and replacement of AHU #1, 3, 5, 6, and 7, boiler 1 and 2, replacement of a hot water converter with two domestic hot water boilers, and the complete clinic BAS system. BAS installation included changing out antiquated variable air volume boxes in areas where asbestos abatement was required. All work was completed during down days, weekends, holidays, and nights to avoid interruption to the facility's mission.

2012–2014: Groundwater Investigation Services, Redstone Arsenal, AL. Project Manager to provide groundwater investigation services during a two-year period of performance in support of Shaw Environmental's Performance-Based Management Contract. Twelve single overburden groundwater monitoring wells, 26 single overburden/bedrock interface groundwater monitoring wells, and 82 single, nested, or multi-zone deep bedrock groundwater monitoring wells with surface casings were installed in an epikarst geologic environment using Rotosonic, ODEX, dual walled reverse circulation, dual walled air rotary, and conventional air rotary drilling methods. Drilling was conducted in active test ranges, former test ranges, and in areas where chemical munitions were manufactured and had been tested in the past. Screened well zones were selected by installing and logging reactive borehole liners and conducting wireline packer testing and open borehole geophysics (natural gamma, 3-arm caliper, optical televiewer, acoustical televiewer, fluid resistivity and temperature, and hydrophysical testing). Colloidal borescope flowmeter surveys were performed on newly installed monitoring well screens as well as on older monitoring well screens throughout Redstone Arsenal. A large portion of the work was conducted in areas where dense non-aqueous phase liquid (DNAPL) was present—therefore water was treated as hazardous during drilling, geophysical, and well installation operations.

2012–2013: Repair of Mechanical Building Infrastructure System, Edwards AFB, CA. Project Manager responsible for the recommissioning of the current BAS to provide improved performance and energy conservation of the existing air handling unit (AHU) and associated variable air volumes (VAVs).

2011–2014: Delineation Sampling and Soil Excavation Interim Measures SWMU-46, Fort Gordon, GA. Project Manager/Geologist responsible for coordinating personnel and resources. The project consists of delineation of PAH and metals contamination in soil and groundwater, ecological and human health risk assessments, and removal of approximately 20,000 cubic yards of soil and debris.

2011–2013: Repair of Heating, Ventilation and Air Conditioning (HVAC) Systems and BAS, Eglin AFB, FL. Project Manager responsible for the AHU and BAS upgrade in an occupied 600,000 sq. ft. hospital and seven associated "out" buildings. Included design and replacement of AHU #3 in Building 2825, replacement of AHU#1 in Building 2530 and associated condensing unit and outside air damper, and the complete hospital BAS system as well as the BAS controls in seven other facilities and their connection to the main hospital system so that utilities could be managed from a single location. All BAS controls conversions were completed within nine months with much of the BAS installation completed at night to avoid interruption to the facility's mission. Project contributed to the facility receiving its *Energy Star* award.

2011–2012: Repair of Emergency Power System, Patrick AFB, FL. Project Manager responsible for the replacement of the main electrical distribution and emergency power systems in an occupied medical facility.

Replaced two existing 455kW generators, two diesel fuel day tanks, fuel pipelines, eight automatic transfer switches (ATSs), paralleling switchgear, and six distribution panel boards with one 500kW generator, one diesel fuel day tank, welded stainless steel fuel pipelines, two ATSs, switchgear, and eight higher capacity distribution panelboards. Two 3-ton split fan coil units with air cooled condensing units were installed in the Emergency Power Building to remove humidity and ensure a longer life span for the equipment. A monitoring system for the new generator and day tanks was installed in the Facility Manager's office.

2011–2012: Air Rotary Deep Bedrock Monitoring Well Installation, Redstone Arsenal, AL. Project Manager/Technical Lead responsible for installing deep bedrock wells at Redstone Arsenal in support of Shaw Environmental's Performance-Based Management Contract.

2011: DPT Borings, Borehole Drilling, and Monitoring Well Installation, Redstone Arsenal, AL. Project Manager/Technical Lead responsible for installing temporary wells, collecting groundwater samples from temporary wells, installing overburden, overburden/bedrock interface, and shallow bedrock wells at Redstone Arsenal in support of Shaw Environmental's Performance-Based Management Contract.

2010–2012: Disposal of Contaminated Soil from Excavation at Special Operations Forces Joint Intelligence Brigade Building and AVTEG Annex, Fort Bragg, NC. Project Manager responsible for coordinating personnel and resources during the removal and proper disposal of 4,800 tons (3,700 cu. yds.) of petroleum contaminated soil prior to building construction.

2010–2011: Repair Infrastructure Systems for Buildings 1040 and 1060, Shaw AFB, SC. Project Manager responsible for waterproofing the exterior of Buildings 1040 and 1060, removing the low slope gravel roof on Building 1060 and replacing it with a pitched truss standing seam metal roof, repairing leaks to the roof of Building 1040, replacing all exterior windows and doors on Building 1060 to meet anti-terrorism force protection (ATFP) requirements, upgrading the BAS, replacing an AHU, two chillers and a boiler, and replacing and relocating the air compressor and vacuum systems.

2010–2013: Corrective Action Plan (CAP) Part B and Free Product Extraction at Underground Storage Tank (UST) Site 15, Fort Gordon, GA. Project Manager/Geologist responsible for the installation of soil borings and groundwater monitoring wells used to delineate free petroleum product and petroleum contamination in soil and groundwater. One surfactant injection and free product extraction event was performed to remove residual free product.

2010–2011: Dunnage Pit Excavation at the Former Ammunition Supply Point, Fort Bragg, NC. Project Manager responsible for coordinating personnel and resources during the removal and proper disposal of 17,000 cubic yards of buried ammunition debris and soil. The project followed an expedited schedule to clear the site for construction.

2010–2011: Stryker Golf Course Pro Shop Debris Excavation, Install Shredder at Incinerator Site, and Upgrade Paint Spray Booth, Fort Bragg, NC. Project Manager responsible for coordinating personnel and resources. The project consists of the removal and proper disposal of debris from the basement of a former building that was covered with a parking lot, demolition of an incinerator, and installation of a bulk paper shredder and a paint spray booth.

2010–2011: Repair of Building Envelope Systems and Emergency Power System at the Medical Facility, Robins AFB, GA. Project Manager responsible for waterproofing the clear story and roof system replacement at Building 207 and upgrading the emergency power system at Building 700.

2009–2011: Grease Trap Maintenance and Repairs and Installation/Upgrading of Back-flow Protection Assemblies and Devices, Fort Bragg, NC. Project Manager responsible for the installation, replacement, or repair of 461 insufficiently protected drinking water systems and repair of 33 grease traps throughout Fort Bragg.

2010: Well Installation for Site 08 Tobacco Road Gas Station, Fort Gordon, GA. Project Manager/Geologist responsible for the installation of seven groundwater monitoring wells at the Army and Air Force Exchange Service (AAFES) station.

2009–2010: Repair of Exterior Building Envelope Systems at the Medical Facility, Hurlburt Field, FL. Project Manager responsible for waterproofing of four Buildings, 91020, 91041, 91042, and 91049 at the Medical Facility. Waterproofing consisted of replacing caulk in all joints and window perimeters, applying water repellent to all block, repairing leaks in metal roofs, and recoating roofs with an elastomeric coating.

2009–2010: Oil Water Separator Inspections and Removal, Robins AFB, GA. Project Manager/Geologist responsible for coordinating personnel and resources during the project. Tasks included performing regulatory compliance inspections on every oil water separator (OWS) at Robins AFB. Two OWSs were removed and one OWS was abandoned in place. Vapor monitoring was performed at all USTs at Robins AFB.

2009–2010: Plugging and Abandonment of Observation Wells, Fort Campbell, KY. Project Manager/Geologist responsible for properly plugging and abandoning 26 observation wells screened into overburden and bedrock. Installed grout plugs in wells that contained voids to keep grout from escaping through the void spaces.

2009–2010: Replacement of the UST and Pipeline System at the AAFES Station, Robins AFB, GA. Project Manager/Geologist responsible for the replacement of five 10,000 gallon USTs with three 15,000 gallon USTs while keeping the service station open during the entire project. Pipelines and dispenser sumps were also replaced.

2009–2010: Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Former Skeet Range, Fort Gordon, GA. Project Manager/Geologist responsible for the delineation of PAH and metals contamination in soil and groundwater.

2008–2010: Free Product Delineation and Removal at UST Site 15, Fort Gordon, GA. Project Manager/Geologist responsible for the installation of soil borings and groundwater monitoring wells used to delineate free petroleum product in groundwater. Free product was removed by quarterly vacuum extraction events.

2008–2010: Electrical Distribution System Upgrade at the Medical Facility, Tyndall AFB, FL. Project Manager responsible for replacing transformers, dual voltage load panels, antiquated load panels, repair grounding connections in electrical rooms, install transient voltage surge suppression systems, remove abandoned generator controls, and performed a short circuit coordination study.

2008–2009: Replacement of Roofing Systems on Multiple Buildings at the Medical Facility, Moody AFB, GA. Project Manager responsible for the replacement of the metal roofs at Buildings 893, 905, and 909 with new standing seam metal roof systems.

2008–2009: Phase I Environmental Baseline Survey and Phase II Soil and Groundwater Investigation of the Bulk Fuel Farm, Two Hazardous Waste Storage Areas, and Georgia Army National Guard Joint Forces Headquarters Construction Footprint, Naval Air Station Atlanta, GA. Project Manager/Geologist responsible for the Phase I Environmental Baseline Survey, Phase II Soil and Groundwater Investigation, and additional investigation required to delineate semi-volatile organic compound and pesticide contamination discovered during the Phase II Investigation. Project was part of a Base Realignment and Closure (BRAC) land transfer between the US Navy and Georgia National Guard which required an expedited schedule to facilitate the design of the Joint Force Headquarters Building.

2008–2009: Tank Support and Permanent Tank Closure, Robins AFB, GA. Project Manager/Geologist responsible for coordinating personnel and resources during the project. Tasks included performing regulatory compliance inspections on every tank at Robins AFB, correcting tank deficiencies, and providing technical support to the Robins AFB Tank Program Manager to ensure regulatory compliance was maintained. One UST was replaced with an aboveground storage tank (AST) on the active airfield in accordance with Georgia closure requirements. Closure documents were prepared and submitted to Georgia Environmental Protection Division.

2008: Permanent Tank Closure, Robins AFB, GA. Project Manager/Geologist responsible for coordinating personnel and resources during the project. One UST was replaced with an AST at Building 230 in accordance with Georgia closure requirements. Closure documents were prepared and submitted to Georgia Environmental Protection Division.

2007–2011: Comprehensive Site Assessment and Corrective Action at POL Point 2, Fort Bragg, NC. Project Manager/Geologist responsible for the investigation and cleanup of petroleum contamination which originated from 13 USTs. This project included fully delineating the benzene, toluene, ethylbenzene, and xylenes (BTEX) contamination, writing the Comprehensive Site Assessment Report, negotiating with state regulators to satisfy state regulations while protecting the interest of the client, designing an chemical oxidation and enhanced aerobic bioremediation injection to reduce BTEX contamination below state gross contaminant levels, writing the Underground Injection Control Permit Application, and writing and implementing the site's CAP.

2007–2009: Remedial Action Pilot Studies at the Combined Support Maintenance Shop (CSMS), Camp Blanding Joint Training Center, FL. Project Manager/Geologist responsible for the design and implementation of two pilot studies directed at reducing chlorinated solvent contamination. The pilot studies included an enhanced anaerobic injection and building and operating an air sparging and soil vapor extraction system. Performance monitoring and reporting was conducted along with a groundwater investigation to eliminate some of the data gaps at the CSMS.

2007–2008: Heating and Control Systems Upgrade, Robins AFB, GA. Project Manager responsible for adding hot water heating capacity and optimizing the chilled water system in Building 700, integration of all of the medical facility's direct digital controls, and upgrade lighting in all mechanical rooms in Building 700.

2007–2008: HVAC, Electrical, and Control Systems Upgrade, Eglin AFB, FL. Project Manager responsible for the replacement of the AHU that serves the Labor and Delivery floor of Building 2825, the Direct Digital Controls (DDCs) which control the medical facility's Central Energy Plant, and the complete upgrade of the electrical system which serves the Medical Logistics Area of building 2825.

2007: Purge Propane from Propane/Air Plant, Fort Stewart, GA. Project Manager responsible for the removal of propane from six 30,000 gallon capacity propane tanks to ensure the safety of demolition crews. Liquid propane was purged from the tanks with the remaining vapor removed during a burn-off operation. Due to the high profile location of the tanks near the main gate, proper coordination was essential to the success of the project. Piping was dismantled between the tanks and a natural gas pipeline feeding Fort Stewart. Flanges were installed to ensure no inadvertent releases of natural gas into the environment.

2006–2008: Tank Support and Permanent Tank Closure, Robins AFB, GA. Project Manager/Geologist responsible for coordinating personnel and resources. Tasks included performing regulatory compliance inspections on every tank at Robins AFB, correcting tank deficiencies, and providing technical support to the

Robins AFB Tank Program Manager to ensure regulatory compliance was maintained. One UST was replaced with an AST at Building 255 in accordance with Georgia closure requirements. Closure documents were prepared and submitted to Georgia Environmental Protection Division. One aboveground Fuel Recovery System was replaced and a containment pad constructed to house the new system at Building 190 to remedy excess fuel entering the oil water separator and comply with current regulations.

2007: Campbell Army Airfield Free Product Investigation, Fort Campbell, KY. Project Manager/Geologist responsible for coordinating personnel and resources during installation of 20 groundwater monitoring wells used to delineate free-product contamination in the subsurface at Campbell Army Airfield in support of Shaw Environmental's Performance-Based Contract.

2007: Lube Rack Investigation, Fort Campbell, KY. Project Geologist responsible for soil sampling to determine the presence or absence of contamination in support of Shaw Environmental's Performance-Based Contract.

2006: Ash Pond 2 Closure and Pond 3 Subgrade Development at Georgia Power's Plant Arkwright, Macon, GA. Safety Officer and Site Superintendent responsible for oversight of the field crew during removal of over 120,000 cubic yards of fly ash and associated water from Ash Pond 2. The ash was dried and transported to Pond 3, where it was consolidated and graded in preparation for a final clay cap. Because the two ponds were located ¾ mile from each other, SES, formerly STEP Inc., constructed a temporary haul road, and installed silt fence, culverts, ditches and check dams to protect sensitive wetland areas from excessive sediment. The project was completed within budget and ahead of schedule.

2006: Campbell Army Airfield Free Product Study, Fort Campbell, KY. Project Geologist during an investigation to determine extent of free product contamination in the subsurface at Campbell Army Airfield. Work included oversight of drilling and sampling teams during installation of soil borings and monitoring/extraction wells.

2005–2006; Tank Support, Robins AFB, GA. Project Manager responsible for coordinating personnel and resources. Tasks included evaluating and installing Stage 1 vapor recovery at three locations, correcting tank deficiencies at 30 locations, performing tank vapor and interstitial monitoring at 90 wells in 17 different locations, and providing Robins AFB with technical support as needed.

2005: Hurricane Katrina Emergency Response, Gulfport, Wiggins, Saucier, and Lyman, MS. Regulatory Specialist during cleanup and removal of 92 damaged transformers from four cities in Mississippi as part of the Hurricane Katrina relief effort. Within one day of receiving project requirements, mobilized with a 12-person team. Work included removal of transformers, oil spill cleanup, and removal of contaminated soil. Responsible for preparation of spill cleanup and decontamination records, and authored final report.

2005: Bryan Village CAP B, Fort Stewart, GA. Project Geologist responsible for analyzing mobile laboratory data during DPT groundwater sampling to ensure proper placement of new monitoring wells. Slug testing and groundwater sampling of existing monitoring wells was also conducted.

2005: Confirmatory Sampling at 160th Special Operation Aviation Regiment Area, Fort Campbell, KY. Project Geologist responsible for soil and groundwater sampling to determine the presence or absence of contamination after reports of petroleum odors during a geotechnical investigation.

Previous Experience

Shaw Environmental and Infrastructure (formerly IT Corporation), 2000–2005
Knoxville, Tennessee

Scientist II (E06)

Site Supervisor for the Moody AFB Total Environmental Restoration Contract (TERC) project in Valdosta, GA:

- Supervised and directed all field activities on a RCRA facility investigation at a DoD installation with a $5.5 to $8.0 million annual budget.
- Directed daily communication with U.S. Air Force, Army, Army Corps of Engineers, and commercial clients.
- Direct onsite supervision of drilling activities using Directional, Rotosonic, Mini Rotosonic, Air Rotary, Hollow Stem Auger, and DPT in clay, silt, flowing sands, gravel, and limestone at RCRA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites.
- Supervised drilling activities in unexploded ordinance (UXO), chemical warfare material (CWM), and low-level radiation contaminated sites.
- Supervised the installation of over 700 groundwater monitoring, soil vapor monitoring, injection, piezometer, groundwater extraction, and soil vapor extraction wells.
- Supervised the installation of two 850 feet long 6-inch diameter horizontal extraction wells that were screened at a depth of 60 feet below ground surface.
- Performed passive and active remedial injections of oxygen releasing compound (ORC), hydrogen releasing compound (HRC), sodium lactate, dehalococcoides spp. (DHC) microbial organisms, emulsified oil substrate (EOS), diammonium phosphate (DAP) and potassium permanganate (KMnO4).
- Utilized mobile laboratories and membrane interface probes (MIP) for real-time groundwater and soil contaminant plume delineation.
- Performed slug, pump, and step drawdown tests.
- Conducted injection and soil vapor extraction pilot tests.
- Supervised the construction of one groundwater treatment system, upgrades to two groundwater treatment systems, the construction of two groundwater recirculation systems, the upgrade to one groundwater recirculation system, the construction of a waste storage facility, and the construction of a concrete decontamination pad with a sump piped to waste storage tanks.
- Created maps and located positions using a Trimble global positioning satellite survey unit.
- Utilized technical writing skills through report writing and the creation of tables, figures, topographic maps, and geologic cross sections.
- Wrote scopes of work and procured drilling, electrical, mechanical, and waste removal contractors.
- Conducted daily site safety meetings and completed health and safety paperwork for a RCRA facility investigation site.
- Coordinated the removal of investigative and remedial derived wastes from Moody AFB field operations (hazardous and non-hazardous).
- Operated tractors, backhoes, forklifts, bulldozers, and excavators.
- Moody AFB received the Commander-in-Chief’s Installation Excellence Special Recognition Award from the DoD during tenure as Site Manager.

Scientist (E04) and Senior Assistant Engineer/Scientist (E03)

- Assistant Site Supervisor, Lead Field Geologist, and Site Health and Safety Officer for the Moody AFB TERC Project in Valdosta, GA.
- Staff Geologist for the Redstone Arsenal TERC Project in Huntsville, Alabama.

Briggs and Stratton Corporation, 1998–1999
Auburn, Alabama

Assembly Worker/Equipment Operator

Assembled Briggs and Stratton small air-cooled engines. In addition, served on the communication team in the employee involvement program.

City of Foley, 1990–1998
Foley, Alabama
Maintenance Worker/Equipment Operator

Served as a maintenance worker and equipment operator for the City of Foley. Duties included maintaining all of the city's athletic fields and swimming pools. In addition, maintained and operated front-end loaders, tractors, and backhoes.

Professional Memberships/Affiliations

- Sustaining Member of Society of American Military Engineers (SAME)

Honors/Awards

- Received Shaw Environmental's *Presidents Award* for contribution to the OMAHA TERC II program reaching 1500 days with no lost time accidents.
- Received Shaw Environmental's *Presidents Award* for contribution to the OMAHA TERC II program reaching 1,000,000 hours with no lost time accidents.
- Received letter of commendation from the U.S. Army Corps of Engineers, Omaha District, Project Manager for contribution to the Moody AFB Environmental Restoration Program
- Received letter of commendation from the Moody AFB Environmental Restoration Element Chief for contribution to Moody AFB receiving the Commander-in-Chief's *Installation Excellence Special Recognition Award*.

Jeff Williams, PE, Sr. Project Manager/Engineer

Years with SES Group
23 Years

Total Years of Experience
37 Years

Employee Title
Senior Project Manager/Civil Engineer

Office
Oak Ridge, TN

Academic Background
- B.S., Civil Engineering, University of Tennessee, 1983

Registrations
- **Professional Engineer:**
  Georgia, #028348 (12-31-02)
  Kentucky, #15560 (8-10-88)
  Tennessee, #19235 (8-11-87)

Certifications
- Level II Certified Design Professional, State of Georgia

Professional Training
- OSHA 40-Hour Hazardous Waste Operations (HAZWOPER) and 8-Hour Refreshers
- USACE Construction Quality Management
- Radiological Worker I and II
- OSHA 8-Hour Hazardous Waste Supervisor
- OSHA 30-Hour Construction Safety and Health
- Hazard Communication
- Operations Security (OPSEC)
- Bloodborne Pathogens
- First Aid/CPR/AED

Mr. Williams' 37-year career represents a diverse background in the environmental, geological, geotechnical, and engineering disciplines. Previously working in the same capacity for sister companies, he was a Senior Project Manager for five years with SES Construction and Fuel Services (SCF), and for the preceding 18 years with SpecPro Environmental Services (SES). He has conducted environmental and hydrological assessments for the U.S. Department of Defense (DoD), U.S. Department of Energy (DOE), industrial and commercial facilities, and residential subdivisions. For the past nine years he has been almost exclusively dedicated to project management of tasks awarded by the U.S. Army Corps of Engineers (USACE) under indefinite delivery/indefinite quantity (IDIQ) contracts. Additionally, he performs corporate quality control (QC) oversight on all underground and aboveground storage tank (UST/AST) removals and closures and AST installations on Fort Campbell for the USACE Nashville District, ensuring a quality service that is executed safely, on time and within budget.

Mr. Williams has performed data acquisition, analyses, and modeling for potential soil, groundwater, and surface water contamination and environmental remediation designs for USTs, storm water, and waste disposal facilities. He has also completed data acquisition and designs for erosion control and storm water collection, containment, chemical treatment, and discharge facilities; land use plans; topographic mapping; and engineering surveying. Mr. Williams has performed surveying for site plans, topographic surveys, construction layouts, and as-built drawings using electronic field data collection and has produced topographic maps using AutoCAD software for more than 100 projects and thousands of acres. His erosion control design experience includes ditches, culverts, earthen dams, riverbank stabilization, and storm conveyances along roads. He has also designed roadways in subdivisions, incorporating the appropriate drainage structures.

During his career, Mr. Williams has designed over 10 landfills ranging in size from 15 to 150 acres, to contain: hazardous waste, construction/demolition debris, and Resource Conservation and Recovery Act (RCRA) Subtitle C and D waste. He has also designed over 100 surface mine permits, and has a thorough knowledge of Bureau of Land Management, Department of the Interior, Office of Surface Mining, and state regulations in Tennessee, Kentucky, and Nevada. In addition to solid waste and mining permits, he has also prepared National Pollutant Discharge Elimination System (NPDES) permits. His remedial design experience includes addressing contamination at airfields, petroleum, oil, and lubricant facilities, and fuel distribution sites. In many cases, he has also supervised the implementation of the remediation. He has managed numerous remediation tasks in Tennessee, Kentucky, and Georgia, and is familiar with remedial regulations and wastewater permitting in those states. His managerial experience includes supervision of project teams and monitoring project performance.

Mr. Williams has performed engineering design and construction supervision for coal mines, landfills, subdivisions, and drainage control structures at sites in California, Georgia, Kentucky, Nevada and Tennessee.

Jeff Williams, PE, Sr. Project Manager/Engineer

Experience Highlights

2014–Present: Vapor Intrusion Investigation and Mitigation, Offsite Properties, Fort Gillem, GA. Project Manager on a task involving the forensic analysis of groundwater, soil, soil vapor, and air contaminant data (within and adjacent to off-site houses and structures) overlying and near a groundwater plume that developed due to past usage of areas within Fort Gillem. The project is reviewing and evaluating existing data for data gaps; collecting additional data; designing and implementing individual building vapor control mitigation systems as required; along with the operation and monitoring of these systems. The investigation has resulted in the installation of a mitigation system in a daycare facility, church, and one home. The forensic analysis has determined in most offsite structures, a complete vapor intrusion pathway (from groundwater plume to indoor air) does not exist and that no mitigation is required.

2014–Present: Ozone Depleting Substance (ODS) Compliance, Fort Jackson, SC. Project Manager for a task to update the installation's ODS inventory of equipment containing in excess of 50 lbs. of ODS, and to ensure compliance with all applicable regulations. Also assisting with the implementation of a more effective recordkeeping system, and with training of personnel identified as essential to maintaining compliance.

2014–Present: Sampling and Corrective Action at Fuel Pipeline A Areas, Well Abandonment and Removal of Tanks at the Turner Job Corps Area at Former Turner Air Force Base (AFB), GA. Project Manager overseeing a follow-on task for additional soil and groundwater sampling and reporting for three remaining sub-sites that will require the installation of four additional wells at Site A4. A total of 15 groundwater wells will then be sampled for the four sites. Soil samples will be taken from 12 soil borings—including four borings used to install the four groundwater monitoring wells at A4. The task also includes the removal of 37 Formerly Used Defense Sites (FUDS) eligible heating oil tanks, used in conjunction with former buildings within the cantonment area of the former Turner AFB. A geophysical survey was done to assist in locating these tanks. In addition, monitoring wells will be abandoned that are no longer needed at sites receiving previous No Further Action Required status from the Georgia Environmental Protection Division UST Management Program. The project removed the tanks and sampling data allowed recommendation of No Further Action at six tank sites. Additional soil and groundwater investigations recommended No Further Action at one site along the pipeline with further investigations recommended for one site along the pipeline.

2012–Present: Remedial Action at Site A11J, Former Turner AFB, GA. Project Manager overseeing the delineation of the extent of contamination at the site of a 25,000-gallon fuel UST and to revise the Corrective Action Plan (CAP)-Part B and provide the approach for site closure in accordance with the Georgia EPD UST Management Program.

2014–2015: Methane Feasibility Study, Landfill 3, Fort Jackson, SC. Project Manager overseeing a methane feasibility study at Landfill #3, an inactive, former 70-acre sanitary landfill that used the trench and fill style of operation between 1974 and 1994. The study reviewed historical information, measured the volume of methane from each well and determined the potential for methane harvesting or flaring; evaluated whether prescribed burns of the non-capped landfill area posed a safety threat by evaluating sub-surface concentrations in that area; determined if methane migration posed a threat to populated areas that included an elementary school and day care centers; and if methane threatened (or will threaten) populated areas, and what mitigation measures need to be implemented. The study determined the methane currently being generated was not an imminent threat to the nearby receptors and the methane gas being generated was not sufficient to recommend the capital cost to support a methane reuse project over the service life of a typical reuse project

2012–2014: Remedial Action at Site A, Former Turner AFB, GA. Project Manager overseeing the installation of three new monitoring wells at 11 separate sites and amendment of the existing CAP-A and/or CAP-B based on results of additional investigation at Site A, a former fuel distribution center. The investigation resulted in the Georgia EPD approving No Further Action status at nine of eleven sites along the pipeline and determining the probable locations for the 37 heating oil tanks thought to be present.

2013—2015: Storm Water Conveyance System Survey of Military Family Housing and Well Head Protection Plan and Evaluation for Shaw AFB, Sumter, SC. Project Manager overseeing the surveying and mapping efforts to update the Municipal Separate Storm Sewer System (MS4) GIS data base relating to storm water conveyance systems and updating the Well Head Protection Plan to include all of the elements required by the South Carolina Department of Health and Control (SCDHEC) and the U.S. Environmental Protection Agency. As part of the task, the efficiency and projected life of air strippers was determined that are used with several base wells, along with recommendations for future treatment.

2012–2013: Methane Evaluation and Utilization Study, Fort Stewart, GA. Project Manager on project to address public safety as it relates to possible methane migration from the South Central Landfill at Fort Stewart and evaluating the technical and economic feasibility of collecting the landfill gas (LFG) from the landfill and using the LFG as a fuel source at the Installation. Field testing determined the presence and concentration of landfill gas and modeling determined the LFG production estimates using the Environmental Protection Agency's Landfill Gas Emissions Model (LandGEM). Evaluation determined there was an inadequate gas volume and methane concentration to use as a fuel source, and recommended further evaluation and design to control LFG migration to protect public safety.

2012–Present: CAP Part A and Part B, AAFES Victory Shoppette, Fort Stewart, GA. Project Manager overseeing the delineation of the extent of petroleum contamination at the site of piping replacement to revise the CAP-Part A and CAP-Part B and provide the approach for site closure in accordance with the Georgia Environmental protection Division (EPD) UST Management Program. After the extent of contamination was determined, groundwater monitoring has demonstrated the contaminants of concern were at acceptable levels and a No Further Action status was granted by the Georgia EPD UST Management Program.

2011–2012: Kelley Hill Debris Removal, Fort Benning, GA. Senior Engineer on the designs for removal activities of 16,500 cubic yards of debris from a highly eroded area at a closed inert landfill and subsequent site restoration that incorporated improved storm water management, grading and re-establishment of groundcover.

2011–2012: Land Use Controls at the 4th Infantry Brigade Combat Team (IBCT) Complex, Fort Stewart, GA. Project Manager on the installation of 11,300 feet of 6-foot high security fencing around four separate wetland areas within the IBCT complex.

2010–2012: Storm Water, Erosion and Sediment Controls at Mirror Lake, Fort Gordon, GA. Project Manager upgrading the existing water control system through repair to the standpipe and outlet pipe system at Mirror Lake, to properly convey storm water in compliance with state and federal regulations.

2010–2013: Interim Remedial Action at USTs 208 and 209, Fort Stewart, GA. Project Manager responsible for a 24-hour enhanced fluid recovery event at one extraction point (monitor well 42-13) at which 76 gallons of petroleum hydrocarbons were removed. A semi-annual sampling event took place to determine groundwater flow direction and free product was measured in monitor well 42-13 at a thickness of 0.95 feet. Conducted excavation to remove free product and petroleum contaminated soil, and quarterly groundwater monitoring. The site received a no-further-action-status from the Georgia EPD and the site wells were plugged and abandoned.

2010–Present: MS4 Non-Compliant Post Construction Best Management Practices (BMP) Corrective Actions, Fort Stewart, GA. Project Manager on in-stream seasonal monitoring, compliance and flood plain modeling, and BMP and/or maintenance recommendations. The monitoring and modeling has resulted in recommendations for the implementation of BMP upgrades to four areas of the storm water system.

2010–2012: UST CAP Part A, Victory Shoppette, Fort Stewart, GA. Project Manager on the preparation of a CAP Part A at site of four USTs at the active gas station: facility renovations included relocation of the gasoline pumps and removal and closure of the former pump islands. Results of associated soil sampling indicated that soil and groundwater contamination existed. Installed eleven soil borings using direct push technology and obtained a total of 22 soil samples using a Geoprobe. Groundwater monitoring wells were installed at eight of the soil borings, and groundwater sampled for benzene, toluene, ethylbenzene, xylenes (BTEX), polynuclear aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH) gasoline range organics (GRO) and diesel range organics (DRO). The extent of the petroleum contamination was determined.

2010–2011: Detention Pond Study, Fort Bragg, NC. Project Manager on the design of a flow control structure to provide peak flow reduction and short-term storage for runoff to improve water quality by reducing sediment traveling downstream.

2010–2011: Curb Washrack and Tank Curb Implementation for Pollution Prevention, Fort Stewart, GA. Project Manager at installation of rollover curbing at 12 locations, all either washrack or tanker containment sites, on Fort Stewart. Some motor pools received both tanker containment curbing and washrack rollover curbing, and other motor pools only received one or the other. In addition, a concrete pad was constructed near a loading ramp at Building 720 at Hunter Army Airfield (HAAF).

2009–2012: Sediment Removal from Wilkerson Lake, Fort Gordon, GA. Project Manager on a $2.6 million effort to remove sedimentation from the seven-foot deep Wilkerson Lake and two 10-feet wide culverts draining into the lake. Twenty soil borings were drilled to determine thickness of the sediment and to characterize it for disposal. Access roads were constructed in the lake in order to perform the sediment removal. Approximately 26,000 cubic yards of sedimentation were removed.

2009–2010: Curb Washrack Implementation and Hazardous Waste Satellite Covers, Fort Stewart, GA. Project Manager responsible for ongoing installation of concrete drive-over curbing to divert storm water away from washracks and providing secondary containment at tanker parking areas, and the procurement and installation of Hazardous Waste Satellite Covers (Lockers) at Fort Stewart and HAAF.

2009: UST Removal, Fort Stewart, GA. Field manager responsible for removal of two unregistered 5,000-gallon USTs 5-J1 and 5-J2 at Building 1330 in Fort Stewart. Approximately 14,000 gallons of surface water were removed from the area first; the water was stored in an on-site, rented storage tank until analysis verified the water to be acceptable for disposal. Soil was removed from the area using a track hoe, and placed in plastic-lined roll-offs. The area was backfilled with #57 stone and rolled in with a drum roller. The roll-off containers were staged in an off-site area until characterization analysis determined the soil acceptable for landfill disposal. Because soil concentrations above the groundwater table were below the GUST-9 detection limits, “Clean Closure, No Further Action Required” was recommended for this UST system.

2008–2009: Soil Remediation and FY08 Groundwater Monitoring, HAAF, GA. Field manager responsible for remediation and monitoring efforts at the former Pumphouse #2 site, an old aviation-gas fuel island that once held ten 25,000-gallon USTs, all since removed. Tasks included: excavating and stockpiling the uncontaminated soil; removing the contaminated soil; applying Oxygen Release Compound® (ORC®) to the excavation floor and four side walls; backfilling the excavation site; re-installing three groundwater monitoring wells that were within the excavation area; and conducting groundwater monitoring at the site.

2008–2009: Time Critical Removal Action (TCRA), Fort Stewart, GA. Project Manager for TCRA to extend security fencing and signage at the Hero Road Trench Area Munitions Response Site in Fort Stewart. SES cleared brush from the proposed fence line and installed approximately 1,122 linear feet of 7-feet high, chain-link fence, one 20-foot wide double swing gate to allow vehicular access to the site, and five permanent warning signs.

2007–2009: Abandonment of 22 Monitoring Wells at the Victory Shoppette Site, Fort Stewart, GA. Project Manager responsible for abandonment of 22 monitoring wells at a busy service station. Four of the wells were installed in the tank-pit backfill and were not normal monitoring wells which were abandoned by pulling the well materials from the ground, allowing the cavity to fill and plugging and sealing the surface; the remaining 18 wells were abandoned according to state of Georgia regulations. This was a follow-on project from an annual storage tank assessment project.

2007–2009: Low Impact Development Projects, Fort Stewart, GA. Project Manager responsible for design and construction of two low impact development projects. Designed and supervised construction of a retrofit for the Soldiers Services Center, by eliminating an unsightly storm water retention pond close to the building and routing storm water drainage to another retention basin, allowing a recreation area next to the building. Removed sediment accumulation from several storm water conveyance systems. Designed and replaced several storm water culverts that allowed for needed storm water conveyance and upgrading due to installation infrastructure development. Designed and constructed a channel system to provide additional storm water retention, thus reducing flooding impacts downstream. Total cost of projects was $3.2 million.

2007–2008: Remedial Action for UST CAP Part B, Fort Stewart, GA. Project Manager overseeing a remedial action to treat benzene-contaminated groundwater at a former UST site at an active automobile service station in a residential area on Fort Stewart, Georgia. *ORC Advanced*® was applied through direct push technology at three locations as a means of accelerating contaminant degradation at the site. SES installed three groundwater wells and conducted semi-annual well sampling from these and twelve existing wells to monitor the treatment. The ORC treatment was successful with benzene levels reduced to within acceptable limits and the 15 wells were subsequently closed with No Further Action required.

2006–2007: South Central Landfill, Fort Stewart, GA. Project Manager responsible for responding to a methane migration problem associated with an old landfill near a heavily used tank trail. Directed a geophysical survey and exploratory trenches to delineate the boundaries of an old disposal area. When sanitary debris was found outside the landfill boundary, was responsible for removal of over 50,000 tons of waste and appropriate disposal into an active waste cell. Conducted a pilot study to determine the most appropriate technology for installing an impervious barrier to prevent methane gas from migrating off the prescribed southern boundary of the landfill. A less permeable barrier, using compacted borrow soil, was installed. Total project cost was $1.1 million.

2005–2006: Solid Waste Management Unit (SWMU) 149 Oil Pits, USACE-Nashville District, Fort Campbell, KY. Project Manager for a $200,000 site investigation of four suspected oil pit sites, where waste oil was disposed using a French drain seepage pit. Obtained utility clearances and required digging permits for each site prior to removal action. At each site, all surface and subsurface oil pit structures and contaminated soils encountered were removed and disposed, confirmatory samples were collected, the excavations were backfilled, and the sites were restored to blend with the surrounding terrain. The data obtained from the confirmatory sampling were used in conducting a data screening assessment for each site where a removal action occurred. The screening assessments were conducted in accordance with the approved work plan. Results indicated that all remaining concentrations were below cleanup standards and No Further Action was recommended. The methodology used saved the client time and money by eliminating the investigative, delineation, and corrective measures phases by remediating the site at the time contamination was found.

2004: Permanent Tank Closure, Robins AFB, GA. Project Manager responsible for the removal of two USTs in accordance with Georgia closure requirements. Work included disposal of tank contents, soil and groundwater sampling, drilling soil borings, removal of existing vapor monitoring wells, and determining action levels based on the distance to nearby water wells and groundwater pollution susceptibility. Prepared all closure documentation to support No Further Action at both sites.

2004: Hemmitt Tanker Pad Construction, Fort Campbell, KY. Project Manager for the installation of a new reinforced concrete pad, complete with a secondary containment system, for the new Hemmitt tanker parking facility. The project included a topographic survey to determine existing site elevations and site preparation, including grubbing, grading, filling, and compacting as needed. Managed installation of the 8-in. reinforced concrete pad measuring approximately 141ft. x 61ft.; secondary containment curbing (three sides) and rollover (one side) was constructed to meet regulatory requirements, and control joints were sealed with fuel-resistant caulking. Five galvanized static ground connection rods were installed with the pad.

2004: Sinkhole Verification, Fort Campbell, KY. Project Manager of a task to verify the existence of over 90 sinkholes that were referenced in historical documents at Fort Campbell. Visited each site to assess whether storm water flowed into the sinkholes, photographed each area, installed markers, and collected survey data using global positioning system equipment.

2004: Bryan Village CAP-A, Fort Stewart, GA. Lead Engineer and field team member during installation of four groundwater wells, well sampling, and soil sampling around a former tank pit where fuel-related contamination had been detected in the groundwater. Performed the majority of fieldwork at night to minimize disruption to the active fueling facility. Provided peer review of the work plan and other project documents.

2003–2004: UST Removal at Wright Army Airfield, Fort Stewart, GA. Project Manager and Engineer for the removal of a 2,000 gallon UST used for heating oil. Directed fieldwork during tank and line removal, and collected soil samples in accordance with Georgia requirements. Completed all fieldwork, including capping the lines and removing the tank and associated equipment, in just two days, well ahead of schedule. Prepared all permanent closure documentation and project report.

2003: SWMUs 12 and 15, Fort Campbell, KY. QC Manager for a project involving the application of hydrogen release compound (HRC) into the subsurface in an effort to remediate trichloroethylene (TCE) and benzene contamination. HRC was pumped into injection points through hollow-stem rods. Periodic samples were collected to determine the effectiveness of the HRC treatment. Responsible for QC review of project documents, logbooks, and field procedures.

2003: Old Hospital Complex Investigation, Fort Campbell, KY. Sampling team member responsible for collecting over 600 soil samples on a 70-acre site. The samples were shipped to the laboratory and analyzed for metals, volatile organic compound (VOC), semi-volatile organic compound (SVOC), and pesticide contamination. Conducted a QC review of the project document and all laboratory data.

2003: Oil Pit Removal, Fort Campbell, KY. Project Manager for a follow-on task to remove additional oil pits at Fort Campbell. Responsible for preparation of project reports. Provided oversight of fieldwork to remove oil pits 149B and 149O in Tennessee and oil pits 149S, 149T, 149U, and 149V in Kentucky. Surface and subsurface oil pit structures were removed as well as all contaminated soil. Confirmatory samples were collected.

2003: Removal and Permanent Closure of USTs at Hunter Army Airfield, Fort Stewart, GA. Project Manager for permanent closure of five USTs in accordance with state of Georgia requirements. Tanks ranged in size from 500 to 12,000 gallons and contained diesel fuel, used oil, and anti-freeze. Responsible for oversight of the removal of all tanks and ancillary equipment. Tanks were recycled and confirmatory samples were collected (soil and groundwater). All removal activities were completed in less than two weeks.

2002–2003: SWMU 146 Bioremediation, Fort Campbell, KY. As QC Manager, reviewed logbooks, field procedures, and project documents during this project to determine whether ORC® would accelerate bioremediation in groundwater at SWMU 146. ORC was applied at the site in October 2002 to mitigate total petroleum hydrocarbon (TPH)-EPH contamination. The ORC was sprayed as slurry on the bottom and sidewalls of an excavated area, which was subsequently backfilled with #57 limestone, restored to blend with the surrounding topography, and monitored for one year to determine the effectiveness of the treatment.

2002: Y-12 Boneyard/Burnyard Project, National Security Complex (Y-12), Oak Ridge, TN. Project engineer responsible for oversight during the removal of approximately 80,000 cubic yards of low-level radioactive waste. Coordinated with radiation control personnel during all sampling activities.

2002: SWMU 11 Investigation, Fort Campbell, KY. Project Manager for the investigation of a suspected landfill site. Eighty trenches were excavated to determine whether buried debris was present over the 40-acre area. Responsible for surveying and preparation of the work plan and health and safety plan. Interviewed knowledgeable utility personnel to determine likely areas of debris. Established the boundaries of an existing three-acre landfill and prepared the final drawings.

2002: Landfill 17, Fort Campbell, KY. Project engineer for the restoration of the vegetative cover at Landfill 17. Restoration was necessary because of erosion damage and debris settlement. Responsible for surveying and verifying that the final design provided positive drainage for the site. Fill material was brought in, graded, and seeded to re-establish vegetation.

2002: SWMU 27 Investigation, Fort Campbell, KY. Project engineer during a RCRA facility investigation at the Open Burn/Open Detonation site. Worked closely with unexploded ordnance (UXO) personnel and conducted UXO screenings prior to all soil and groundwater sampling events. Surveyed soil samples and provided peer review of project reports.

2001–2002: Oil Pit/Lube Rack Removals, Fort Campbell, KY. Project Manager for the removal of 12 oil pits and one lube rack in the Main Cantonment area of Fort Campbell. Prepared the work plan, health and safety plan, and final project reports. Responsible for managing the field crew, surveying excavation areas and sampling locations, collecting confirmatory soil samples, and coordinating the off-site disposal of contaminated soil.

2000: Drakes Creek Dredging, Hendersonville, TN. Project Engineer and QC Manager responsible for the initial soundings of the Drakes Creek area to determine sediment thickness. Performed the initial topographic verification before dredging activities began. Project was conducted to restore the Drakes Creek embankment and activities included dredging to a depth of five feet, installation of geotubes to contain the dredged material, and restoration of the site using bioengineering and conventional techniques.

2000: Mousetail Landing, Perry County, TN. Project Engineer for the initial site reconnaissance and topographic survey. Identified additional erosion that required redesign efforts. Project activities included the protection of the shoreline and an exposed Indian Burial Mound using geotextile and Class B riprap.

1999–2003: Groundwater Summary Report, Fort Campbell, KY. QC Manager responsible for final report review. The annual report summarized analytical data that had been collected from over 140 wells at various SWMUs, one area of concern, and the Campbell Army Airfield.

1999–2000: Knoxville Streambank Protection, Knoxville, TN. Project Engineer responsible for the initial topographic verification of pre-construction conditions. Project activities included the installation of 20,000 tons of Class B riprap and geotextile fabric to protect the shoreline near Neyland Drive. The effort was completed over 3 months ahead of schedule, and protected 2,275 feet of shoreline.

1999–2000: Wastewater Treatment Plant Demolition and Characterization, Fort Campbell, KY. Project Engineer for the characterization and demolition of an abandoned wastewater treatment plant located in the northwest corner of the Old Clarksville Base area of Fort Campbell. Surveyed and mapped sampling locations, conducted soil sampling, and assisted in writing/editing project reports.

1999–2000: Drain Line Replacement at Areas of Concern A and D, Fort Campbell, KY. Project Engineer for the Phase II drain line replacement at Areas of Concern A and D at Fort Campbell. Responsible for sampling of the contaminated soils beneath the old pipes that were removed and for placing the new pipes on grade to achieve gravity flow. Assisted in writing/editing the reports and providing as-built drawings for the new drain lines.

1998–2000: Subsurface Investigation of SWMU 149 Oil Pits, Fort Campbell, KY. Project Engineer for confirmatory sampling at two oil pits within SWMU 149 at Fort Campbell to confirm the presence of TPH, SVOCs, and polychlorinated biphenyls (PCBs). The effort required trenching and excavating soil at SWMUs 149A and 149F. Responsible for soil sampling to confirm the presence of contamination within the pits, guiding the removal of the oil pit at SWMU 149A, and writing/editing the reports.

1998: Streambank Protection at Decatur, Hardin, Perry, and Wayne Counties, TN. Project Engineer for streambank protection on the Tennessee River. Work included the installation of erosion controls, excavation and restoration of the existing stream channel, installation of geotextile, clearing, and grubbing. Responsible for the redesign of approximately 3000 feet of streambank on the Tennessee River at Clifton Marina, along with the construction stakeout, placement of over 12,000 tons of stone, and 6,200 sq. ft of geotextile for erosion control next to the campground. Produced the construction layout for storm water drainage piping, with inlet grates on the downstream side of the earthen portion of Center Hill Dam.

1998: Land Between the Lakes Landfill, Tennessee Valley Authority (TVA) Golden Pond, KY. Project Engineer for redesigning the final grade of the supplemental cover for a non-permitted landfill at Land Between the Lakes. The landfill, which was constructed in 1984, pre-dated permitting requirements, but the State of Kentucky directed that it be characterized under CERCLA. Redesigned the configuration of a portion of the landfill for positive drainage and to eliminate excessive settling of the existing cap, provided construction stakeout, and prepared as-built drawings. Assisted in groundwater sampling and editing project reports.

1997–1998: LMES-HAZWRAP–Environmental Remediation, Fort Campbell, KY. As Project Engineer for remedial activities at Fort Campbell:

- Redesigned the final cover configuration, drainage system, and access roads for a non-permitted landfill site (Landfill No. 9), which was constructed prior to current regulatory requirements. Prepared the initial construction layout and as-built drawings.
- For Landfill 7, redesigned the cap, surrounding channels, and final topography. Supervised construction of the channels, placement of riprap, and construction stakeout of the final cover. Duties included site characterization and design, removal of landfill debris, collection of quality assurance (QA)/QC samples to determine if all the debris was removed and whether any contaminants had leached into the soil beneath the landfill, and supervised disposal of the excavated debris at Landfill 7. This project resulted in considerable savings to the client partially because the channels were designed to use existing drainages.

The client and USACE were very pleased with the success of this project and, therefore, increased the scope of work to include the construction of an additional 500 feet of channels.

- Designed investigation-derived waste (IDW) site. Prepared the site grading/drainage plan and road design and sited a pre-fabricated metal building and a truck/drill rig washing facility. This site was designed to facilitate decontamination onsite for regulatory driven investigations, resulting in more rapid decontamination of equipment and shorter field investigations.
- Conducted preconstruction site preparation for the new troop medical and dental facility, which was to be built on an old landfill. Duties included site characterization and removal of landfill debris, QA/QC sampling to determine if all the debris was removed and whether any contaminants had leached into the soil beneath the landfill, and supervised the disposal of excavated debris. The project was completed in a brief amount of time to enable construction of the $7.2 million clinic to proceed on schedule.

1995-1997: Site Assessment, U.S. Bronze Powders; Maryville, TN. Project Engineer for the site investigation, regulatory negotiations, remedial design, and remedial actions of an uncontrolled industrial disposal area containing buried drums, fugitive metallic waste, and concrete debris. This project was one of the initial voluntary cleanup actions in the state and was based on our recommendation to the client to proceed before the regulators required it.

1994–1996: Construction and Demolition Landfill Services, Inc.; Poplar View Landfill, Knoxville, TN. Project Engineer for the planning, investigation, design, and permitting of a 26-acre Class IV RCRA Subtitle D construction/demolition landfill in Knox County. Responsible for the design, construction, construction monitoring/oversight, and certification documents for the Poplar View Landfill. Conducted a hydrogeologic investigation, computer modeling, and completed the construction of a geologic buffer required to satisfy siting requirements.

1994: LMES–K-25 Powerhouse Demolition Project, Oak Ridge, TN. Project Engineer responsible for surveying sampling locations to support decontamination and decommissioning activities. Materials characterized included all insulation, building components and surfaces, wire, roofing material, floor mastic, oils, grease, paint, lead-based materials, and mercury switches. Materials were analyzed for the presence of radiological emissions, PCBs, lead, chromium, cadmium, mercury, and asbestos. The surface area of the buildings that required characterization exceeded one million square feet.

1994: LMES–Landfill Design, Oak Ridge, TN. Project Engineer for conducting three conceptual designs for Class IV RCRA Subtitle D landfills within the K-25 site. This included addressing site access, placement of wastes, and operational and cover requirements for a substantial quantity of demolition debris. Responsible for producing conceptual designs for landfills at the K-25 site, which will be used for disposal of wastes generated from decommissioning and demolition activities.

1994: IMCO Recycling, Inc., Landfill Design, Rockwood, TN. Project Engineer for the planning, site investigation, design, and permitting of a 150-acre Subtitle D, Class II industrial landfill in Roane County. Responsibilities included the conceptual design, hydrogeological investigation using computer modeling, and the design to contain and dispose of special industrial waste that produces heat and ammonia when exposed to water. The design included ponds, roads, and disposal cells using the EPA's Hydrologic Evaluation of Landfill Performance (HELP) computer model.

1994–2000: Jacobs Engineering Group, Jacobs Environmental Management Team, Oak Ridge, TN. Civil Engineer providing support to the Jacobs Environmental Management Team. Determined capping requirements and storm water impacts for the feasibility study for the Bear Creek Valley Project at Y-12. This site included numerous waste disposal areas, and analyses indicated that contaminants were migrating off site.

This project was the pilot study for the watershed approach to investigation and remediation and resulted in substantial savings to the client.

1993–1996: TVA, Landfill Closure Plans, New Johnsonville, TN. Project Engineer for the design and preparation of closure plans for TVA landfills in Tennessee and Kentucky. Responsible for site investigations, RCRA corrective action plans, cap design and construction, construction QA/QC during remedial actions, and closure certification for a 2-acre Class IV demolition landfill contaminated with TCE. Work included site characterization and engineering design to minimize/prevent migration of TCE to groundwater beneath the site.

1993–1996: Construction and Demolition Landfill Services, Inc., Ridgeview Landfill, Knoxville, TN. Project Engineer for the planning, investigation, design, and permitting of a 18-acre Class IV RCRA Subtitle D construction/demolition landfill in Knox County. Responsible for the design, construction, construction monitoring/oversight, and certification documents for Ridgeview Landfill. Project activities included a hydrogeologic investigation, associated computer modeling, and addressing zoning issues. Designed and supervised the construction of a storm water impoundment as well as a leachate control system. Also responsible for design of the cap and the daily operation plan. The project included the treatment and disposal of approximately 50,000 gallons of contaminated water.

Metal Resources, Inc., Loudon, TN. Design Engineer for redesigning a landfill in Loudon County for disposal of heat and ammonia producing industrial waste. The landfill was redesigned according to RCRA Subtitle C requirements to improve the efficiency and maintenance requirements of the initial design and to reduce construction costs. The design included a double liner system, leachate collection and leak detection systems, ponds and impoundments for surface runoff, access roads, disposal cells, grading to promote positive drainage, control of gas migration, and a vegetative cover to minimize erosion.

IMCO Recycling, Inc., Roane County, TN. Design Engineer for the design of a RCRA Subtitle C landfill near Midtown in Roane County. The first phase of the project was a preliminary investigation of the soils and a stream as well as conceptual design plans. The second phase consisted of conducting the hydrogeological investigation for the Part II permit application required by the Tennessee Division of Solid Waste Management. This investigation included 84 soil borings and associated testing/evaluation of the samples, which were used to describe the subsurface conditions. Based on this information, the next phase entailed producing the engineering designs for a monolithic landfill. Although the regulations do not require such stringent designs for Class II industrial solid waste disposal facilities, this landfill was designed to meet the requirements of RCRA Subtitle C for hazardous wastes. The landfill was designed using two geomembrane liners in addition to the geologic buffer. Specific design elements included establishing the perimeter of the landfill and final contours, balancing cut and fill, developing the phasing and sequencing plan, preparing the basin/ditch layout and hydrologic investigation, designing collection and diversion ditches, designing sediment impoundments and the leachate collection system, conducting a threatened and endangered species survey, and conducting a Phase I archaeological survey. A second conceptual design was prepared that specified having all waste disposal activities conducted under a moving shelter system on rails to keep the wastes dry. This design was proposed because the waste produced ammonia gas when contacted by water. The site closure plan included provisions for management of the landfill gases, erosion control, and grading for proper drainage.

Roane County–Roane County, TN. Project Engineer for the redesign, regulatory negotiation, leachate control, remediation, construction, and construction management of a 30-acre Class I solid waste landfill. Prevented discharge of leachate mixed with surface water into Watts Bar Lake for three months. Designed and constructed a ten million gallon holding pond. This project allowed the client to successfully comply with regulations by redesigning the operations and closure plan for the landfill. The closure plan included regrading the site to promote positive drainage, a cover of vegetation in order to minimize erosion damage, and gas migration controls.

TVA–Gallatin, TN. Project Engineer responsible for construction QC during remedial actions and closure certification for a seven acre demolition Class II landfill containing asbestos.

Previous Experience

Core Group, Inc., 1989–1992
Vice President/Owner

Responsible for permitting, design, and environmental compliance for coal mines and landfills.

Kenwill, Inc., 1981–1989
Maryville, Tennessee
Vice President/Natural Resources

Served in progressive roles from engineering technician to vice president of the Natural Resources Division. Responsible for the permitting, design, and environmental compliance of coal mines and landfills.

G&B Nolan, Inc., 1979–1981
Lake City, Tennessee
Mining Consultant

Responsible for coal mine design, preparing mining permits, and environmental compliance with regulatory guidelines.

Dixie Pine Coal, 1978–1979
Lafollette, Tennessee
Engineering Technician

Assisted with coal mining permits and design.

Professional Memberships/Affiliations

- Sustaining Member of Society of American Military Engineers (SAME)
- Member American Society of Civil Engineers (ASCE)

Honors/Awards

- In August 2000, Mr. Williams received the “Award for Individual Excellence” presented by the Fort Campbell Environmental Restoration staff.

Jenny Vance, Project Chemist/Data Manager

Years with SES Group
<1 Year

Total Years of Experience
25 Years

Employee Title
Project Chemist/Data Manager

Office
Oak Ridge, Tennessee

Academic Background
- B.A., Biology, Maryville College, 1981

Professional Training
- 12-module Supervisor/Manager Training Program
- Environmental Laws and Regulations

Ms. Vance has more than 25 years of experience supporting environmental projects including environmental monitoring, site characterization, soil remediation, and waste characterization. Her work experience includes serving as a benchtop chemist analyzing environmental and mixed waste media, coordinating analytical projects, and managing and evaluating chemical and radiological data. Ms. Vance is proficient in Structured Query Language (SQL) and relational databases.

Ms. Vance is currently the Project Chemist and Data Manager for three projects at multiple sites across the U.S. involving investigations of various matrices for polyfluorinated compounds. Responsibilities include coordination with the analytical laboratory, review of analytical data, database administration, and ERPIMS (Environmental Resources Program Information Management Systems) submittals.

Experience Highlights

2015–Present: Site Investigation of Perfluorinated Compound (PFC) Release Areas at Multiple BRAC Installations. Project Chemist and Data Manager for a $19M task order with the Air Force Civil Engineer Center (AFCEC) to investigate potential PFC releases at 17 installations. Responsible for coordination with the analytical laboratory, review of analytical data, database administration, and ERPIMS submittals.

2015–Present: Site Investigations of Fire Fighting Foam Usage at Various Air Force Bases in the Eastern United States. Chemist and Data Manager for an almost $7M investigation, contracted through the USACE Savannah District, at 20 military installations that were identified during preliminary assessments to determine if there is a confirmed release of poly-fluorinated alkyl substances (PFAS) have occurred in groundwater, soil, surface water and sediment. Responsible for coordination with the analytical laboratory, review of analytical data, database administration, and ERPIMS submittals.

2015–Present: Site Inspection of Aqueous Film Forming Foam Areas Multiple Air Force Installations. Chemist and Data Manager on a $7.5M contract through the USACE, Omaha District, for site inspections of aqueous film forming foam (AFFF) release areas at multiple United States Air Force (USAF) installations to determine if a release of perfluorinated compounds (PFCs) may have occurred in groundwater, soil (surface and subsurface), surface water and sediment. Responsible for coordination with the analytical laboratory, review of analytical data, database administration, and ERPIMS submittals.

Previous Experience

Leidos (*formerly SAIC*), 2001–2015
Oak Ridge, Tennessee
Project Chemist/Data Manager

Responsible for managing analytical and data requirements for various environmental and waste characterization projects.

- Analytical project management activities including analytical laboratory interface, field mobilization support, data validation, quality assurance/quality control (QA/QC), and data evaluation and reporting.
- Contributed to, and reviewed, project QA plans, sampling plans, and final reports.
- Data interpretation and manipulation using Microsoft Access, Excel and SQL Server.
- Assignments included support for Department of Defense (DoE) Department of Energy (DOE), and commercial clients including Tinker Air Force Base, Ravenna Army Ammunition Plant, Holston Army

Ammunition Plant, Y-12 Groundwater Protection Program, and Air National Guard installations in multiple states.

- Supported Multi-Agency Radiation Surveys and Site Investigation Manual (MARSSIM) investigations at DOE's Melton Valley Verification project at Oak Ridge National Laboratory (ORNL) and for the Carolinas-Virginia Nuclear Power Association (CVNPA) Parr Site.

Fluor Fernald, 1994-2001
Cincinnati, Ohio
Environmental Scientist/Analytical Project Manager

As Environmental Scientist was responsible for coordinating soil characterization activities for defined areas of the Fernald site.

- Interaction with DOE and U.S. Environmental Protection Agency (EPA) regulators regarding project goals and strategies, status of remediation activities, and document comment resolution.
- Responsible for development of sampling strategies based on research of previous land use and historical analytical data.
- Development and implementation of project specific sampling plans used to define contamination boundaries, to monitor excavation activities, and to certify locations for final land use.
- Coordination of fieldwork including real-time radiological scanning, excavation, sampling, and surveying activities.
- Responsible for generating certification reports to meet regulatory milestones.

As Analytical Project Manager was responsible for managing the analytical portion of Fernald Environmental Management Project (FEMP) projects including the Air Monitoring Program, Site Waste Characterization, and the Operable Unit 3 Remedial Investigation/Feasibility Study (RI/FS).

- Managed contracts with off-site laboratories for industrial hygiene and asbestos analyses.
- Served as liaison between analytical customer, sample shipping, on- and off-site laboratories, contract management, field verification, and data validation groups for projects requiring analysis of air, soil, water, and waste samples.
- Provided guidance regarding analytical methodology and data interpretation, reviewing project plans and data quality objectives, and ensuring analytical schedules are met.
- Assisted in the preparation, review, and placement of off-site analytical task order contracts.

International Technology Analytical Services, 1988-1993
Oak Ridge, Tennessee
Analytical Project Manager/Chemist

Was primary point of contact for client base ranging from small commercial contracts to major DOE clients.

- Evaluated lab's capabilities to meet client's demands for methodology, capacity, and QC requirements for various projects.
- Managed all phases of laboratory activities for specific projects from sample receipt through reporting of analytical results.
- Reviewed and approved Certificate of Analysis prior to submittal to client.
- Assisted client in cost estimations and approved client billing.
- Prioritized lab resources to meet client's requests.
- Assisted client field crew with information regarding laboratory sampling requirements including minimum volumes, preservation techniques, and proper container types.

As Chemist, was responsible for scheduling and analysis of pesticide/PCBs and herbicides using EPA protocols:

- Operated and maintained gas chromatograph.
- Compiled and reviewed data packages and synopses of analytical compliance to method criteria.
- Assisted in training new personnel.

A. E. Staley Manufacturing Company, 1982-988
Loudon, Tennessee
Quality Control Chemist

Monitored and ensured compliance of in-process streams and final product to standard specifications.

- Operation and maintenance of High Performance Liquid Chromatograph, Gas Chromatograph (including Head Space), Atomic Absorption Spectroscopy, Scanning U.V. Spectroscopy, Near Infrared Spectroscopy.
- Performed wet chemistry methods and microbiological procedures.
- Interpersonal and self-management/leadership responsibilities involved in the team-based participative management system.
- Member of Plant Emergency Response Team.

Knox County Public Health Department, 1976-1980
Knoxville, Tennessee
Clerk

Worked closely with the public, maintained records, and performed clerical duties.

Rich Rathnow, Health and Safety Manager

Years with Current Firm
6 Years

Total Years of Experience
31 Years

Employee Title
Corporate Health and Safety Manager

Office
Oak Ridge, TN

Academic Background
- MS, Safety Management, University of Tennessee, 1994
- BS, Occupational Safety/Health & Industrial Technology, Illinois State University, 1983

Registrations/Certifications
- Certified Industrial Hygienist (CIH) #6813, 1995
- Certified Safety Professional (CSP) #9829, 1990

Professional Training
- OSHA 500 Construction Outreach Trainer
- OSHA 40-Hour HAZWOPER and 8-Hour Refreshers
- USACE Construction Quality Management for Contractors
- 30-Hour Construction Safety
- Confined Space Entry Supervisor
- Hazard Communications
- Hearing Conservation
- Respirator Protection
- First Aid/CPR/AED
- Bloodborne Pathogens

Mr. Rathnow has more than 31 years of professional health and safety program management experience including management of successful, large-scale health and safety programs for both commercial and government clients including the U.S. Army Corps of Engineers (USACE), U.S. Navy, Environmental Protection Agency (EPA), Air Force Civil Engineer Center (AFCEC), Department of Energy (DOE), Dow Chemical, Kinder Morgan and Lyondell Chemical. This experience has involved assuring Health and Safety Program (HASP) compliance with the USACE EM 385-1-1, Safety and Health Requirements Manual, as well as 29 Code of Federal Regulations (CFR) 1926, 29 CFR 1910, and other referenced standards.

Highlights of Mr. Rathnow's career include:

- Safety Manager for $329 million in task orders contracted through USACE since 2009 to deliver sustainment, restoration and modernization (SRM) projects at U.S. Air Force Bases throughout the U.S. and overseas: in over six years these have been completed without a single lost-time accident;
- Achieved more than half a million hours for SES companies without a lost-time injury;
- ASL achieved over 1 million work hours without a Days Away/Restricted Time (DART) case;
- Experience Modification Rate (EMR) reduced from 0.92 to 0.74 progressively over five years.
- Contributed significantly as a site safety engineer to the achievement of more than one million safe work hours without a lost time injury at the DOE's Waste Isolation Pilot Plant;
- Achieved more than one million safe work hours as the program health and safety engineer/coordinator without a lost time injury at the Battelle Columbus Laboratories Decommissioning Project.

Experience Highlights

Mr. Rathnow is responsible for the development and implementation of a safety management system using the American National Standards Institute (ANSI)–Z10, Occupational Health and Safety Management System approach with a risk reduction continual improvement emphasis along with a *zero incidents* culture philosophy. He has been responsible for the development and implementation of the behavior/people-based loss prevention program, and he has developed an accident prevention approach to address the incident frequency element of accident prevention as well as focusing on risk reduction for prevention of serious consequence events.

Mr. Rathnow has established a subcontractor health and safety qualification system and enhanced safety language for contract documents; he has revised the corporate health and safety program manual; he has helped ensure project specific implementation and compliance with the USACE EM 385-1-1, Safety and Health Requirements Manual, as well as with 29 CFR 1926, 29 CFR 1910, and other referenced standards; he is responsible for the review, revision, and approval of project accident prevention plans and activity hazard analyses; he has mentored subcontractors on health and safety program development and implementation; and he develops and implements safety training program for all facets of construction health and safety.

Previous Experience

CH2M HILL, Environmental Services Business Group, 1997–2009
Knoxville, Tennessee
Regional Health and Safety Manager, Southeast Region, 2008–2009

Verified that construction and remediation programs/projects were conducted in compliance with federal and state occupational health and safety regulations, often exceeding minimum health and safety regulatory requirements. Identified program and project Health, Safety, Security and Environment (HSSE) requirements during the project scoping phase, including training, medical monitoring, and written program requirements. Played a key role in the determination of bid/no-bid decisions based on health and safety risks, reviewed subcontract language, subcontractor health and safety qualifications and submittals for acceptability and HSSE quality. Managed professional health and safety personnel for program and project support as well as field/project health and safety coordinators to ensure appropriate project HSSE implementation. Managed Southeast Region's Environmental Services 2009 HSSE budget of more than $700,000.

Southeast Region Environmental Safety and Health Operations Manager, 2001–2008

Navy Remedial Action Contract (RAC) U.S. Navy, Southeastern United States. Implemented and directed the company's RAC HSSE program, resulting in over 1,000,000 man-hours with a 1.1 OSHA-recordable incident rate and a 0.3 OSHA Lost Workday Case Rate. Implemented and managed an innovative and highly effective Behavior-Based Loss-Prevention System, conducted regular HSSE audits, and was accountable to achieving corporate zero-incident goals. Developed and implemented the HSSE Program Plans and performed program health and safety training for multiple programs. Served as the health and safety program auditor for the Dow contract HSSE program. Managed other large-scale health and safety programs including AFCEE's Worldwide Environmental Restoration and Construction program, EPA Region 6, Dow Chemical Construction and Kinder Morgan projects. Project work included: clean construction; large-scale environmental investigation and remediation; demolition; asbestos removal; lead-based paint removal; chlor-alkalai plant dismantling with mercury exposure; and dredging.

Health and Safety Manager, 2005–2006

Hurricane Ivan Response, Multiple Award Construction Contract, U.S. Navy Southern Division, Naval Air Station (NAS) Pensacola, FL. Provided HSSE program development and implementation for response to Hurricane Ivan at NAS Pensacola. Work involved repairing and refurbishing military base roofs that were damaged by the hurricane. Responsible for the remediation of asbestos that had been dispersed widely over several areas near the future demolition site of a boiler/powerhouse building. Performed an HSSE audit and provided project support.

Certified Industrial Hygienist (CIH)/Health and Safety Auditor, 2001

Air National Guard (ANG) Environmental Health and Safety Camp Contract. Performed industrial safety and occupational health audits at ANG base facilities including industrial safety aspects (lockout tagout, confined space entry, machine guarding, material handling, etc.) and industrial hygiene aspects (respiratory protection, hazard communication, hearing conservation, medical surveillance, etc.). Assessed conditions and prepared formal reports.

CIH/Site Environmental HSSE Representative, 2001

Environmental Management Waste Management Facility Project, Duratek, Oak Ridge, TN. Implemented HSSE program for relocating aboveground storage facilities for radioactive wastes resulting from cleanup. Managed safety concerns for subcontractor construction personnel. Performed air monitoring for exposure to concrete sealing solvents and nuisance dust exposures.

CIH/Site HSSE Officer, 1999–2000

GCL Tie and Treating Superfund Site, USACE, Sidney, NY. Coordinated HSSE program for soil remediation project. Developed HSSE plan and exposure monitoring strategy for USACE managed site. Performed personal air sampling and site perimeter monitoring for air contaminant concerns including naphthalene, coal tar pitch volatiles, benzene, silica, and nuisance dust. Managed HSSE concerns related to onsite thermal treatment of contaminated soil. Achieved 750,000 work hours without an OSHA recordable injury, for which CH2M HILL was awarded the USACE New York District's 2001 *Safety Contractor of the Year* award.

Northeast/Great Lakes Region HSSE Manager, 1997–1999

Developed site HSSE programs/plans for hazardous waste investigation, remediation, and construction projects, including those performed under the EPA Alternative Remedial Contracting Strategy (ARCS) and RAC programs. Ensured that projects were conducted in compliance with federal and state OSHA regulations and in a safe, healthy manner and performed HSSE audits. Provided specific larger scale project support for:

- **Chevron Refinery**, Chevron, Port Arthur, TX—As CIH, Developed air monitoring strategy, performed personal/area air sampling, and interpreted results for worker exposure to benzene, toluene, ethyl benzene, xylene, and Portland cement contaminants during waste stabilization activities.
- **Reichhold Chemicals**, Ferndale, MI—As CIH/Site Safety Coordinator, managed HSSE efforts (including excavation safety and air sampling for worker exposure) for soil remediation and installation of groundwater collection system at former chemical processing plant. Directed safe and successful use of Level B personal protective equipment (PPE) where vinyl chloride levels in soil exceeded exposure limits.
- **Lockheed Martin**, Paducah, KY—As CIH/HSSE Manager, coordinated HSSE program elements for large-scale environmental investigation and remediation involving trichloroethylene contamination. Evaluated hazards and identified PPE and other hazard control measures and requirements, which included organic solvents, radiological concerns, physical and biological hazards. Developed air monitoring/sampling plan and coordinated monitoring and interpretation of results. Performed HSSE audits.

Battelle Memorial Institute, 1993–1997
Oak Ridge, Tennessee and Columbus, Ohio
Senior Health and Safety Engineer

- Coordinated industrial hygiene and safety support services for decontamination and decommissioning (D & D) projects on the Battelle Columbus Laboratories Decommissioning Project. Performed exposure monitoring for lead, mercury, beryllium, polychlorinated biphenyls (PCBs), organic vapors, heat stress, and noise for employees performing D & D activities. Work involved removal of radiological contamination and associated health physics concerns during D & D of laboratories, research, and support facilities. Assisted in performing gap analysis for health and safety program for Chemical Manufacturer Association’s Responsible Care Program.
- Managed environmental, safety, and health support services contract to Waste Management and Remedial Action Division. Environmental impact statements, safety, and health qualitative risk assessment for hazardous waste treatment, storage, and disposal facility. Risk assessment and safety analysis. Team Leader in enriched uranium operations training department.
- Conducted a chemical hazard analysis and an industrial ventilation needs assessment for hazardous waste sampling activities at the DOE's Pantex Plant. Developed contractor hazardous and mixed waste management standards.
- Performed an environmental, safety, and health qualitative risk assessment for an environmental impact statement developed for a hazardous waste treatment, storage, and disposal facility.
- Performed probabilistic risk assessment and safety analysis work for the Safety Analysis Report Program at the Y-12 Plant. The work included scenario and basic event development, assigning of frequency and probability values, equation derivation, fault-tree development and quantification. Served as team leader in Enriched Uranium Operations training department at the Y-12 Plant to coordinate training

development. Work emphasized nuclear criticality safety concerns for resumption of operations in receipt shipping and storage operations and in rolling and machining operations.

- Contributed significantly to the development of a RCRA Part B Permit Application for hazardous waste treatment units at the Pacific Northwest Laboratories.

M.K. Ferguson, 1990–1993
Oak Ridge, Tennessee
Environmental, Health and Safety Manager/Construction Safety and Fire Protection Manager

Coordinated environmental health and safety administrative activities for the company and directed a staff of eight. Work included accident investigations, trend analysis for injuries and illnesses and safety and industrial hygiene inspection findings, procedure developing, training, worker's compensation, records and statistical analysis, occurrence reporting, root-cause analysis, lessons learned, emergency preparedness, and safety incentives.

As Construction Safety and Fire Protection Manager, managed a staff of 12**.** Responsible for construction safety, fire protection, emergency preparedness, and occupational health programs. Developed and implemented more than 40 safety, industrial hygiene, fire protection, and emergency preparedness procedures and programs. Directed the preparation for the DOE's Tiger Team visits at two facilities, resulting in minimal findings. Helped ensure that project achieved nearly one million employee hours without a lost-time injury. Construction and remediation work was frequently conducted in radiological contaminated manufacturing facilities.

Chemical Waste Management, 1989–1990
Chicago, Illinois
Health and Safety Manager

Managed industrial hygiene and safety programs at a hazardous waste incinerator. Evaluated hazardous waste streams to determine health and safety control requirements. Performed exposure monitoring for PCBs, volatile organic compounds, noise and heat stress for employees handling and processing hazardous waste streams. Implemented industrial hygiene and safety programs, including chemical hazard evaluations, air sampling programs, a hearing conservation program, medical evaluation and surveillance programs, contamination control, machine guarding, fire protection, and contractor safety. Improved the facility's safety audit rating from *"needs significant improvement"* to *"excellent"* within one year.

Westinghouse Electric Corporation, 1987–1989
Carlsbad, New Mexico
Senior Safety Engineer

Developed and implemented health and safety programs and procedures at a DOE defense-generated nuclear waste repository. Coordinated industrial and construction health and safety oversight efforts for support of all surface and underground operations to ensure that all safety programs, procedures, policies, regulations, and codes were enforced. Performed industrial health and safety inspections, construction health and safety inspections, accident investigations, and air sampling for contaminants. Reviewed procedures, design and specifications, and engineering work packages for technical health and safety concerns.

Georgia Pacific Corporation, 1984–1987
Taylorville, Illinois
Safety Supervisor

Developed and implemented manufacturing safety and industrial hygiene programs for a paper mill. Performed detailed accident trend analysis and prepared job hazard analysis for high hazard/frequency tasks. Performed industrial hygiene field surveys, including air monitoring and noise assessments. Managed asbestos abatement engineering project. Established many OSHA-required safety training programs, including hazard communication program, industrial forklift safety training, and hearing conservation training. Processed worker's compensation claims and assumed all accident-reporting responsibilities. Responsible for contractor safety and plant security, and plant emergency organization operations.

Professional Memberships/Affiliations

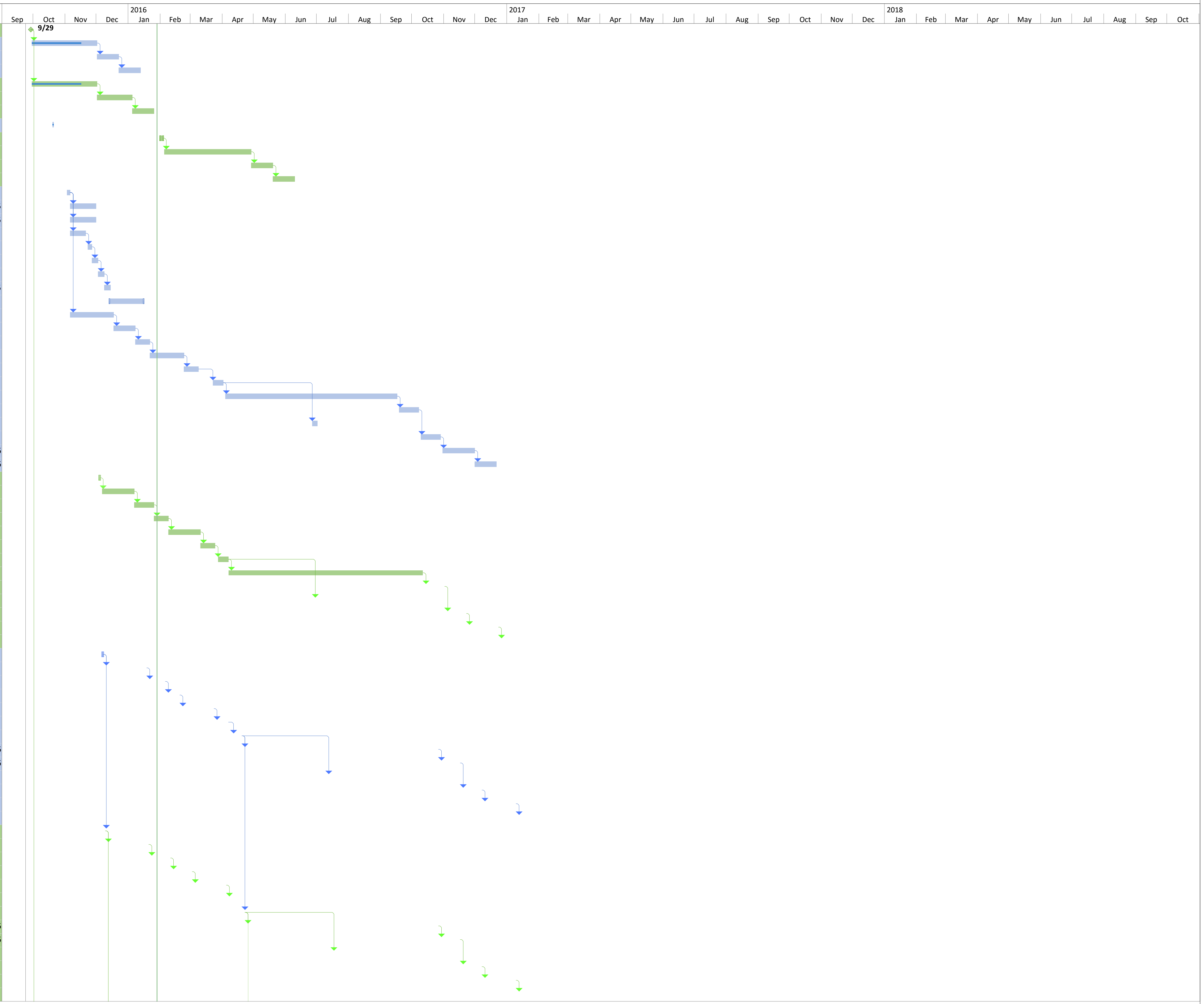
- American Society of Safety Engineers
- American Industrial Hygiene Association
- Board of Certified Safety Professionals
- American Board of Industrial Hygiene

Appendix B

Project Schedule

Site Investigations of Fire Fighting Foam Usage at Various Air Force Bases in the Eastern United States

ID	ℹ	Task Mode	Task Name	Duration	Start	Finish
1	✓	📌	Project Award	0 days	Tue 9/29/15	Tue 9/29/15
2	📅	➜	Prepare Draft Program QAPP	45 days	Wed 9/30/15	Tue 12/1/15
3		➜	Draft Program QAPP Review	15 days	Wed 12/2/15	Tue 12/22/15
4		➜	Prepare Final Program QAPP	15 days	Wed 12/23/15	Tue 1/12/16
5		➜	Prepare Draft APP	45 days	Wed 9/30/15	Tue 12/1/15
6	📅	➜	Draft APP Review	24 days	Wed 12/2/15	Mon 1/4/16
7	📅	➜	Prepare Final APP	15 days	Tue 1/5/16	Mon 1/25/16
8	✓	➜	Kickoff Meeting	1 day	Tue 10/20/15	Tue 10/20/15
9		📌	Niagara ARS PA Site Visit	3 days	Mon 2/1/16	Wed 2/3/16
10		➜	Prepare Draft Niagara ARS PA Report	60 days	Fri 2/5/16	Thu 4/28/16
11		➜	Draft Niagara ARS PA Report Review	15 days	Fri 4/29/16	Thu 5/19/16
12		➜	Prepare Final Niagara ARS PA Report	15 days	Fri 5/20/16	Thu 6/9/16
13	📅	➜	Dover AFB SI Site Visit	3 days	Tue 11/3/15	Thu 11/5/15
14		➜	Update Existing APP for Dover AFB C-5 Crash Site	17 days	Fri 11/6/15	Mon 11/30/15
15		➜	Update Existing SSHP for Dover AFB C-5 Crash Site	17 days	Fri 11/6/15	Mon 11/30/15
16		➜	Prepare Draft Work Plan for Dover AFB C-5 Crash Site	11 days	Fri 11/6/15	Fri 11/20/15
17		➜	Draft Dover AFB C-5 Crash Site Work Plan Review	4 days	Mon 11/23/15	Thu 11/26/15
18		➜	Prepare Draft-Final Dover AFB C-5 Crash Site Work Plan	4 days	Fri 11/27/15	Wed 12/2/15
19		➜	Draft-Final Dover AFB C-5 Crash Site Work Plan Review	4 days	Thu 12/3/15	Tue 12/8/15
20		➜	Prepare Final Dover AFB C-5 Crash Site Work Plan	4 days	Wed 12/9/15	Mon 12/14/15
21		📌	Dover AFB C-5 Crash Site Field Work	25 days	Mon 12/14/15	Fri 1/15/16
22		➜	Prepare Draft Dover AFB Installation Specific QAPP Addendum/SSHP	30 days	Fri 11/6/15	Thu 12/17/15
23		➜	Draft Dover AFB Installation Specific QAPP Addendum/SSHP Review	15 days	Fri 12/18/15	Thu 1/7/16
24		➜	Prepare Draft-Final Dover AFB Installation Specific QAPP Addendum	10 days	Fri 1/8/16	Thu 1/21/16
25		➜	Draft-Final Dover AFB Installation Specific QAPP Addendum Review	23 days	Fri 1/22/16	Tue 2/23/16
26		➜	Prepare Final Dover AFB Installation Specific QAPP Addendum/SSHP	10 days	Wed 2/24/16	Tue 3/8/16
27		➜	Dover AFB Field Work	8 days	Wed 3/23/16	Fri 4/1/16
28		➜	Prepare Draft Dover AFB SI Report	120 days	Mon 4/4/16	Fri 9/16/16
29		➜	Draft Dover AFB SI Report Review	15 days	Mon 9/19/16	Fri 10/7/16
30		➜	Dover AFB ERPIMS Submittal	5 days	Mon 6/27/16	Fri 7/1/16
31		➜	Prepare Draft-Final Dover AFB SI Report	15 days	Mon 10/10/16	Fri 10/28/16
32		➜	Draft-Final Dover AFB SI Report Review	23 days	Mon 10/31/16	Wed 11/30/16
33		➜	Prepare Final Dover AFB SI Report	15 days	Thu 12/1/16	Wed 12/21/16
34		📌	Moody AFB SI Site Visit	1 day	Fri 12/4/15	Fri 12/4/15
35		➜	Prepare Draft Moody AFB Installation Specific QAPP Addendum/SSHP	23 days	Mon 12/7/15	Wed 1/6/16
36		➜	Draft Moody AFB Installation Specific QAPP Addendum/SSHP Review	13 days	Thu 1/7/16	Mon 1/25/16
37		➜	Prepare Draft-Final Moody AFB Installation Specific QAPP Addendum	10 days	Tue 1/26/16	Mon 2/8/16
38		➜	Draft-Final Moody AFB Installation Specific QAPP Addendum/SSHP Review	23 days	Tue 2/9/16	Thu 3/10/16
39		➜	Prepare Final Moody AFB Installation Specific QAPP Addendum/SSHP	10 days	Fri 3/11/16	Thu 3/24/16
40		➜	Moody AFB Field Work	8 days	Mon 3/28/16	Wed 4/6/16
41		➜	Prepare Draft Moody AFB SI Report	134 days	Thu 4/7/16	Tue 10/11/16
42		➜	Draft Moody AFB SI Report Review	15 days	Wed 10/12/16	Tue 11/1/16
43		➜	Moody AFB ERPIMS Submittal	5 days	Thu 6/30/16	Wed 7/6/16
44		➜	Prepare Draft-Final Moody AFB SI Report	15 days	Wed 11/2/16	Tue 11/22/16
45		➜	Draft-Final Moody AFB SI Report Review	23 days	Wed 11/23/16	Fri 12/23/16
46		➜	Prepare Final Moody AFB SI Report	15 days	Mon 12/26/16	Fri 1/13/17
47		📌	Joint Base Langley Eustis - Langley SI Site Visit	1 day	Mon 12/7/15	Mon 12/7/15
48		➜	Prepare Draft Joint Base Langley Eustis - Langley Installation Specific QAPP Addendum/SSHP	30 days	Tue 12/8/15	Mon 1/18/16
49		➜	Draft Joint Base Langley Eustis - Langley Installation Specific QAPP Addendum/SSHP Review	14 days	Tue 1/19/16	Fri 2/5/16
50		➜	Prepare Draft-Final Joint Base Langley Eustis - Langley Installation Specific QAPP Addendum	10 days	Mon 2/8/16	Fri 2/19/16
51		➜	Draft-Final Joint Base Langley Eustis - Langley Installation Specific QAPP Addendum Review	23 days	Mon 2/22/16	Wed 3/23/16
52		➜	Prepare Final Joint Base Langley Eustis - Langley Installation Specific QAPP Addendum/SSHP	10 days	Thu 3/24/16	Wed 4/6/16
53		➜	Joint Base Langley Eustis - Langley Field Work	6 days	Tue 4/12/16	Tue 4/19/16
54		➜	Prepare Draft Joint Base Langley Eustis - Langley SI Report	136 days	Wed 4/20/16	Wed 10/26/16
55		➜	Draft Joint Base Langley Eustis - Langley SI Report Review	15 days	Thu 10/27/16	Wed 11/16/16
56		➜	Joint Base Langley Eustis - Langley ERPIMS Submittal	5 days	Wed 7/13/16	Tue 7/19/16
57		➜	Prepare Draft-Final Joint Base Langley Eustis - Langley SI Report	15 days	Thu 11/17/16	Wed 12/7/16
58		➜	Draft-Final Joint Base Langley Eustis - Langley SI Report Review	23 days	Thu 12/8/16	Mon 1/9/17
59		➜	Prepare Final Joint Base Langley Eustis - Langley SI Report	15 days	Tue 1/10/17	Mon 1/30/17
60		➜	Joint Base Langley Eustis - Eustis SI Site Visit	2 days	Tue 12/8/15	Wed 12/9/15
61		➜	Prepare Draft Joint Base Langley Eustis - Eustis Installation Specific QAPP Addendum/SSHP	30 days	Thu 12/10/15	Wed 1/20/16
62		➜	Draft Joint Base Langley Eustis - Eustis Installation Specific QAPP Addendum/SSHP Review	15 days	Thu 1/21/16	Wed 2/10/16
63		➜	Prepare Draft-Final Joint Base Langley Eustis - Eustis Installation Specific QAPP Addendum	15 days	Thu 2/11/16	Wed 3/2/16
64		➜	Draft-Final Joint Base Langley Eustis - Eustis Installation Specific QAPP Addendum Review	23 days	Thu 3/3/16	Mon 4/4/16
65		➜	Prepare Final Joint Base Langley Eustis - Eustis Installation Specific QAPP Addendum/SSHP	15 days	Tue 4/5/16	Mon 4/25/16
66		➜	Joint Base Langley Eustis - Eustis Field Work	3 days	Wed 4/20/16	Fri 4/22/16
67		➜	Prepare Draft Joint Base Langley Eustis - Eustis SI Report	133 days	Mon 4/25/16	Wed 10/26/16
68		➜	Draft Joint Base Langley Eustis - Eustis SI Report Review	15 days	Thu 10/27/16	Wed 11/16/16
69		➜	Joint Base Langley Eustis - Eustis ERPIMS Submittal	5 days	Mon 7/18/16	Fri 7/22/16
70		➜	Prepare Draft-Final Joint Base Langley Eustis - Eustis SI Report	15 days	Thu 11/17/16	Wed 12/7/16
71		➜	Draft-Final Joint Base Langley Eustis - Eustis SI Report Review	23 days	Thu 12/8/16	Mon 1/9/17
72		➜	Prepare Final Joint Base Langley Eustis - Eustis SI Report	15 days	Tue 1/10/17	Mon 1/30/17

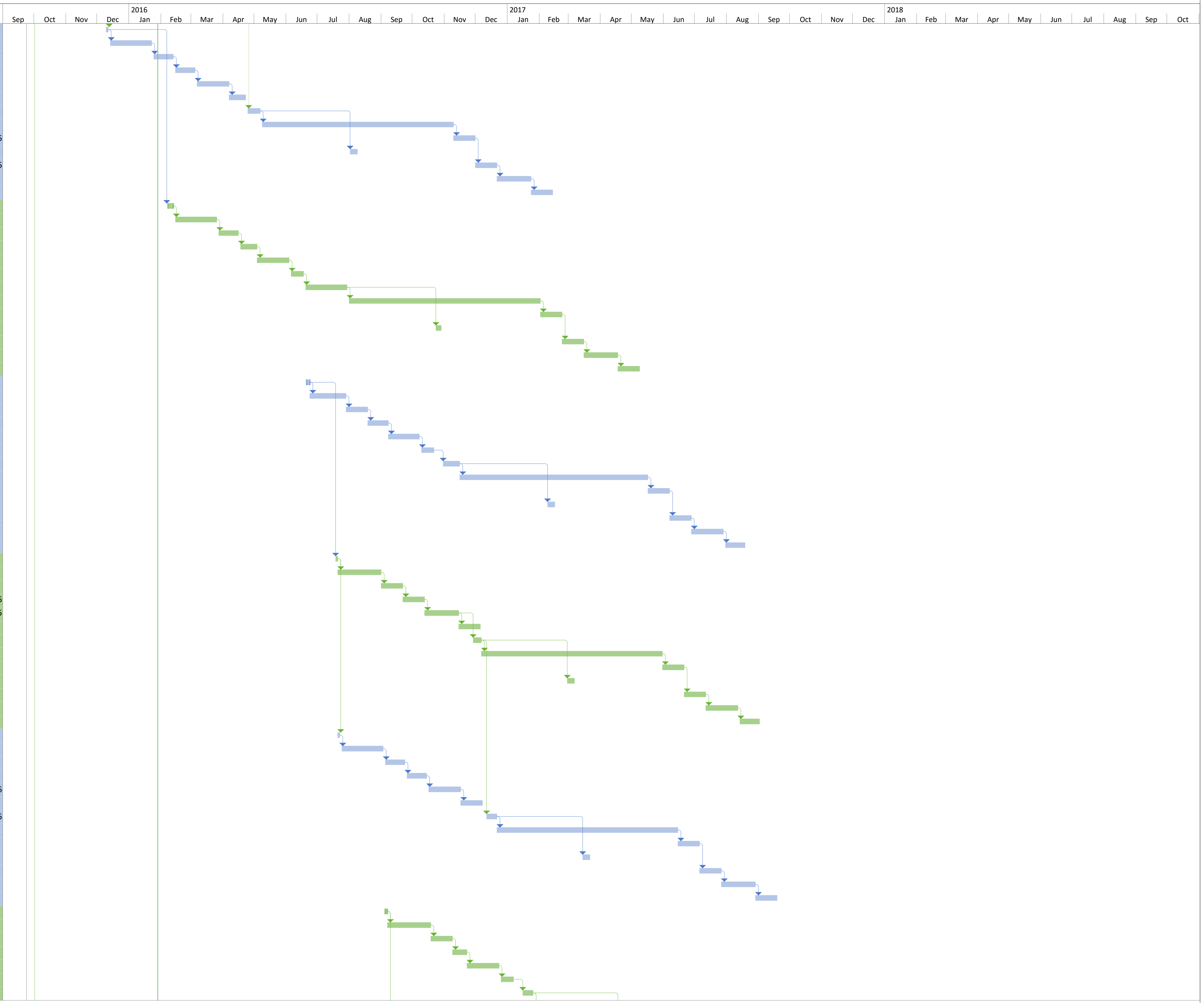


Project: Savannah AFFF Investigations Project Schedule 11 January 2016
Date: Fri 1/29/16

Task
Split
Milestone ◆
Summary
Project Summary
External Tasks
External Milestone ◆
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
Manual Progress

Site Investigations of Fire Fighting Foam Usage at Various Air Force Bases in the Eastern United States

ID	ℹ	Task Mode	Task Name	Duration	Start	Finish
73		➔	Joint Base Andrews SI Site Visit	2 days	Thu 12/10/15	Fri 12/11/15
74		➔	Prepare Draft Joint Base Andrews Installation Specific QAPP Addendum/SSHP	30 days	Mon 12/14/15	Fri 1/22/16
75		➔	Draft Joint Base Andrews Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 1/25/16	Fri 2/12/16
76		➔	Prepare Draft-Final Joint Base Andrews Installation Specific QAPP Addendum	15 days	Mon 2/15/16	Fri 3/4/16
77		➔	Draft-Final Joint Base Andrews Installation Specific QAPP Addendum Review	23 days	Mon 3/7/16	Wed 4/6/16
78		➔	Prepare Final Joint Base Andrews Installation Specific QAPP Addendum/SSHP	12 days	Thu 4/7/16	Fri 4/22/16
79		➔	Joint Base Andrews Field Work	10 days	Mon 4/25/16	Fri 5/6/16
80		➔	Prepare Draft Joint Base Andrews SI Report	133 days	Mon 5/9/16	Wed 11/9/16
81		➔	Draft Joint Base Andrews SI Report Review	15 days	Thu 11/10/16	Wed 11/30/16
82		➔	Joint Base Andrews ERPIMS Submittal	5 days	Tue 8/2/16	Mon 8/8/16
83		➔	Prepare Draft-Final Joint Base Andrews SI Report	15 days	Thu 12/1/16	Wed 12/21/16
84		➔	Draft-Final Joint Base Andrews SI Report Review	23 days	Thu 12/22/16	Mon 1/23/17
85		➔	Prepare Final Joint Base Andrews SI Report	15 days	Tue 1/24/17	Mon 2/13/17
86		📌	Joint Base McGuire-Dix-Lakehurst SI Site Visit	5 days	Mon 2/8/16	Fri 2/12/16
87		➔	Prepare Draft Joint Base McGuire-Dix-Lakehurst Installation Specific QAPP Addendum/SSHP	30 days	Mon 2/15/16	Fri 3/25/16
88		➔	Draft Joint Base McGuire-Dix-Lakehurst Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 3/28/16	Fri 4/15/16
89		➔	Prepare Draft-Final Joint Base McGuire-Dix-Lakehurst Installation Specific QAPP Addendum	12 days	Mon 4/18/16	Tue 5/3/16
90		➔	Draft-Final Joint Base McGuire-Dix-Lakehurst Installation Specific QAPP Addendum Review	23 days	Wed 5/4/16	Fri 6/3/16
91		➔	Prepare Final Joint Base McGuire-Dix-Lakehurst Installation Specific QAPP Addendum/SSHP	10 days	Mon 6/6/16	Fri 6/17/16
92		➔	Joint Base McGuire-Dix-Lakehurst Field Work	30 days	Mon 6/20/16	Fri 7/29/16
93		➔	Prepare Draft Joint Base McGuire-Dix-Lakehurst SI Report	133 days	Mon 8/1/16	Wed 2/1/17
94		➔	Draft Joint Base McGuire-Dix-Lakehurst SI Report Review	15 days	Thu 2/2/17	Wed 2/22/17
95		➔	Joint Base McGuire-Dix-Lakehurst ERPIMS Submittal	5 days	Mon 10/24/16	Fri 10/28/16
96		➔	Prepare Draft-Final Joint Base McGuire-Dix-Lakehurst SI Report	15 days	Thu 2/23/17	Wed 3/15/17
97		➔	Draft-Final Joint Base McGuire-Dix-Lakehurst SI Report Review	23 days	Thu 3/16/17	Mon 4/17/17
98		➔	Prepare Final Joint Base McGuire-Dix-Lakehurst SI Report	15 days	Tue 4/18/17	Mon 5/8/17
99		📌	Joint Base Charleston SI Site Visit	3 days	Tue 6/21/16	Thu 6/23/16
100		➔	Prepare Draft Joint Base Charleston Installation Specific QAPP Addendum/SSHP	25 days	Fri 6/24/16	Thu 7/28/16
101		➔	Draft Joint Base Charleston Installation Specific QAPP Addendum/SSHP Review	15 days	Fri 7/29/16	Thu 8/18/16
102		➔	Prepare Draft-Final Joint Base Charleston Installation Specific QAPP Addendum	14 days	Fri 8/19/16	Wed 9/7/16
103		➔	Draft-Final Joint Base Charleston Installation Specific QAPP Addendum Review	22 days	Thu 9/8/16	Fri 10/7/16
104		➔	Prepare Final Joint Base Charleston Installation Specific QAPP Addendum/SSHP	10 days	Mon 10/10/16	Fri 10/21/16
105		➔	Joint Base Charleston Field Work	12 days	Mon 10/31/16	Tue 11/15/16
106		➔	Prepare Draft Joint Base Charleston SI Report	130 days	Wed 11/16/16	Tue 5/16/17
107		➔	Draft Joint Base Charleston SI Report Review	15 days	Wed 5/17/17	Tue 6/6/17
108		➔	Joint Base Charleston ERPIMS Submittal	5 days	Thu 2/9/17	Wed 2/15/17
109		➔	Prepare Draft-Final Joint Base Charleston SI Report	15 days	Wed 6/7/17	Tue 6/27/17
110		➔	Draft-Final Joint Base Charleston SI Report Review	23 days	Wed 6/28/17	Fri 7/28/17
111		➔	Prepare Final Joint Base Charleston SI Report	15 days	Mon 7/31/17	Fri 8/18/17
112	▦	➔	Seymour Johnson AFB SI Site Visit	2 days	Tue 7/19/16	Wed 7/20/16
113		➔	Prepare Draft Seymour Johnson AFB Installation Specific QAPP Addendum/SSHP	30 days	Thu 7/21/16	Wed 8/31/16
114		➔	Draft Seymour Johnson AFB Installation Specific QAPP Addendum/SSHP Review	15 days	Thu 9/1/16	Wed 9/21/16
115		➔	Prepare Draft-Final Seymour Johnson AFB Installation Specific QAPP Addendum	15 days	Thu 9/22/16	Wed 10/12/16
116		➔	Draft-Final Seymour Johnson AFB Installation Specific QAPP Addendum Review	23 days	Thu 10/13/16	Mon 11/14/16
117		➔	Prepare Final Seymour Johnson AFB Installation Specific QAPP Addendum/SSHP	15 days	Tue 11/15/16	Mon 12/5/16
118		➔	Seymour Johnson AFB Field Work	6 days	Tue 11/29/16	Tue 12/6/16
119		➔	Prepare Draft Seymour Johnson AFB SI Report	125 days	Wed 12/7/16	Tue 5/30/17
120		➔	Draft Seymour Johnson AFB SI Report Review	15 days	Wed 5/31/17	Tue 6/20/17
121		➔	Seymour Johnson AFB ERPIMS Submittal	5 days	Tue 2/28/17	Mon 3/6/17
122		➔	Prepare Draft-Final Seymour Johnson AFB SI Report	15 days	Wed 6/21/17	Tue 7/11/17
123		➔	Draft-Final Seymour Johnson AFB SI Report Review	23 days	Wed 7/12/17	Fri 8/11/17
124		➔	Prepare Final Seymour Johnson AFB SI Report	15 days	Mon 8/14/17	Fri 9/1/17
125	▦	➔	Shaw AFB SI Site Visit	2 days	Thu 7/21/16	Fri 7/22/16
126		➔	Prepare Draft Shaw AFB Installation Specific QAPP Addendum/SSHP	30 days	Mon 7/25/16	Fri 9/2/16
127		➔	Draft Shaw AFB Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 9/5/16	Fri 9/23/16
128		➔	Prepare Draft-Final Shaw AFB Installation Specific QAPP Addendum	15 days	Mon 9/26/16	Fri 10/14/16
129		➔	Draft-Final Shaw AFB Installation Specific QAPP Addendum Review	23 days	Mon 10/17/16	Wed 11/16/16
130		➔	Prepare Final Shaw AFB Installation Specific QAPP Addendum/SSHP	15 days	Thu 11/17/16	Wed 12/7/16
131		➔	Shaw AFB Field Work	8 days	Mon 12/12/16	Wed 12/21/16
132		➔	Prepare Draft Shaw AFB SI Report	125 days	Thu 12/22/16	Wed 6/14/17
133		➔	Draft Shaw AFB SI Report Review	15 days	Thu 6/15/17	Wed 7/5/17
134		➔	Shaw AFB ERPIMS Submittal	5 days	Wed 3/15/17	Tue 3/21/17
135		➔	Prepare Draft-Final Shaw AFB SI Report	15 days	Thu 7/6/17	Wed 7/26/17
136		➔	Draft-Final Shaw AFB SI Report Review	23 days	Thu 7/27/17	Mon 8/28/17
137		➔	Prepare Final Shaw AFB SI Report	15 days	Tue 8/29/17	Mon 9/18/17
138		📌	Avon Park AFR SI Site Visit	2 days	Mon 9/5/16	Tue 9/6/16
139		➔	Prepare Draft Avon Park AFR Installation Specific QAPP Addendum/SSHP	30 days	Wed 9/7/16	Tue 10/18/16
140		➔	Draft Avon Park AFR Installation Specific QAPP Addendum/SSHP Review	15 days	Wed 10/19/16	Tue 11/8/16
141		➔	Prepare Draft-Final Avon Park AFR Installation Specific QAPP Addendum	10 days	Wed 11/9/16	Tue 11/22/16
142		➔	Draft-Final Avon Park AFR Installation Specific QAPP Addendum Review	23 days	Wed 11/23/16	Fri 12/23/16
143		➔	Prepare Final Avon Park AFR Installation Specific QAPP Addendum/SSHP	10 days	Mon 12/26/16	Fri 1/6/17
144		➔	Avon Park AFR Field Work	8 days	Mon 1/16/17	Wed 1/25/17



Project: Savannah AFFF Investigations Project Schedule 11 January 2016
Date: Fri 1/29/16

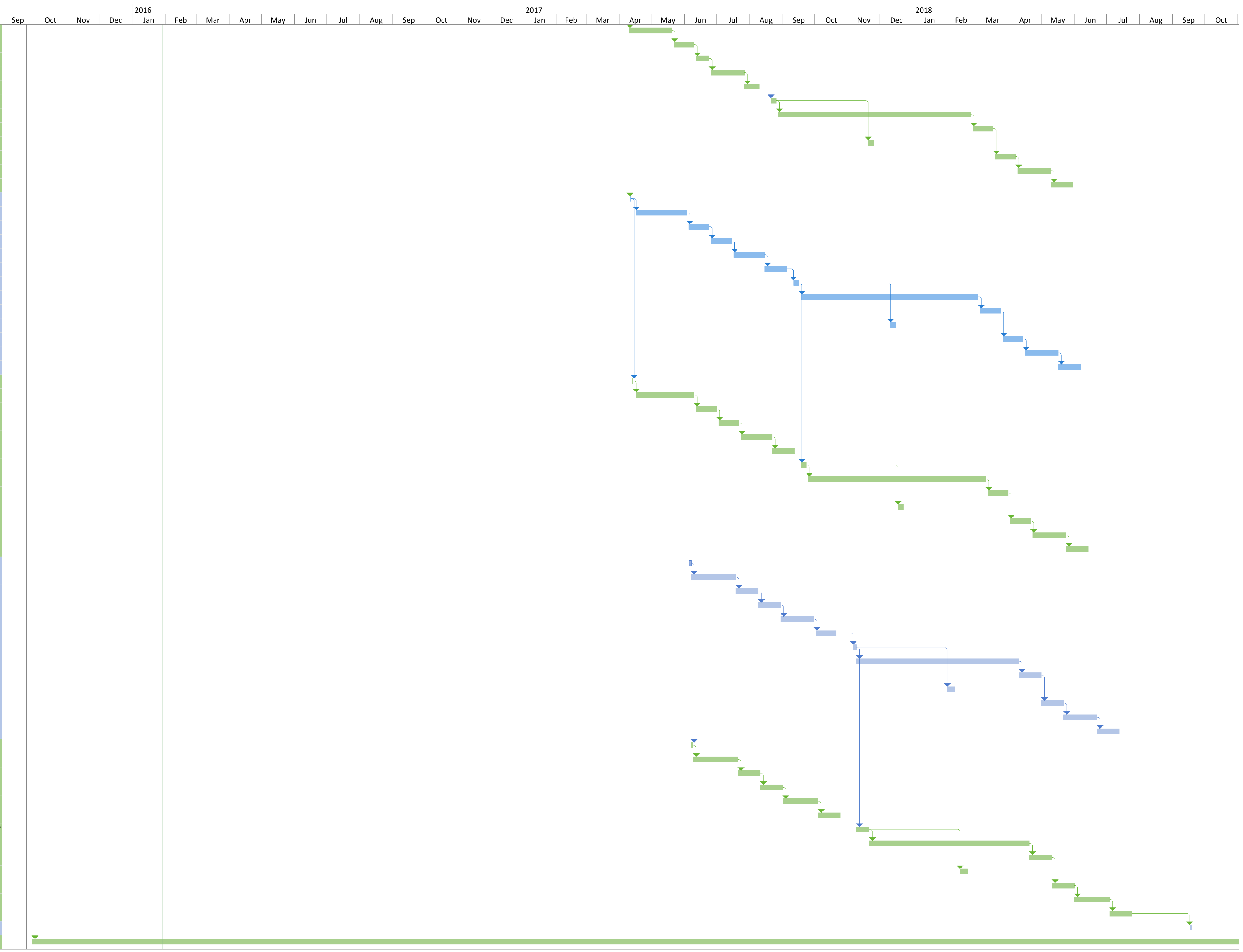
Task	▬	Summary	┏━┓	External Milestone	◆	Inactive Summary	┏━┓	Manual Summary Rollup	▬	Finish-only	]
Split	┅	Project Summary	┏━┓	Inactive Task	▭	Manual Task	▬	Manual Summary	┏━┓	Deadline	⬇
Milestone	◆	External Tasks	▬	Inactive Milestone	◇	Duration-only	▬	Start-only	[	Progress	─
										Manual Progress	─

ID	ⓘ	Task Mode	Task Name	Duration	Start	Finish
145			Prepare Draft Avon Park AFR SI Report	124 days	Thu 1/26/17	Tue 7/18/17
146			Draft Avon Park AFR SI Report Review	15 days	Wed 7/19/17	Tue 8/8/17
147			Avon Park AFR ERPIMS Submittal	5 days	Tue 4/18/17	Mon 4/24/17
148			Prepare Draft-Final Avon Park AFR SI Report	15 days	Wed 8/9/17	Tue 8/29/17
149			Draft-Final Avon Park AFR SI Report Review	24 days	Wed 8/30/17	Mon 10/2/17
150			Prepare Final Avon Park AFR SI Report	15 days	Tue 10/3/17	Mon 10/23/17
151	▦		Homestead ARB SI Site Visit	2 days	Wed 9/7/16	Thu 9/8/16
152			Prepare Draft Homestead ARB Installation Specific QAPP Addendum/SSHP	30 days	Fri 9/9/16	Thu 10/20/16
153			Draft Homestead ARB Installation Specific QAPP Addendum/SSHP Review	15 days	Fri 10/21/16	Thu 11/10/16
154			Prepare Draft-Final Homestead ARB Installation Specific QAPP Addendum	15 days	Fri 11/11/16	Thu 12/1/16
155			Draft-Final Homestead ARB Installation Specific QAPP Addendum Review	23 days	Fri 12/2/16	Tue 1/3/17
156			Prepare Final Homestead ARB Installation Specific QAPP Addendum/SSHP	15 days	Wed 1/4/17	Tue 1/24/17
157			Homestead ARB Field Work	6 days	Thu 1/26/17	Thu 2/2/17
158			Prepare Draft Homestead ARB SI Report	124 days	Fri 2/3/17	Wed 7/26/17
159			Draft Homestead ARB SI Report Review	15 days	Thu 7/27/17	Wed 8/16/17
160			Homestead ARB ERPIMS Submittal	5 days	Wed 4/26/17	Tue 5/2/17
161			Prepare Draft-Final Homestead ARB SI Report	15 days	Thu 8/17/17	Wed 9/6/17
162			Draft-Final Homestead ARB SI Report Review	24 days	Thu 9/7/17	Tue 10/10/17
163			Prepare Final Homestead ARB SI Report	15 days	Wed 10/11/17	Tue 10/31/17
164		📌	Tyndall AFB SI Site Visit	3 days	Tue 9/27/16	Thu 9/29/16
165			Prepare Draft Tyndall AFB Installation Specific QAPP Addendum/SSHP	30 days	Fri 9/30/16	Thu 11/10/16
166			Draft Tyndall AFB Installation Specific QAPP Addendum/SSHP Review	14 days	Fri 11/11/16	Wed 11/30/16
167			Prepare Draft-Final Tyndall AFB Installation Specific QAPP Addendum	10 days	Thu 12/1/16	Wed 12/14/16
168			Draft-Final Tyndall AFB Installation Specific QAPP Addendum Review	23 days	Thu 12/15/16	Mon 1/16/17
169			Prepare Final Tyndall AFB Installation Specific QAPP Addendum/SSHP	10 days	Tue 1/17/17	Mon 1/30/17
170			Tyndall AFB Field Work	10 days	Tue 2/7/17	Mon 2/20/17
171			Prepare Draft Tyndall AFB SI Report	134 days	Tue 2/21/17	Fri 8/25/17
172			Draft Tyndall AFB SI Report Review	15 days	Mon 8/28/17	Fri 9/15/17
173			Tyndall AFB ERPIMS Submittal	5 days	Mon 5/15/17	Fri 5/19/17
174			Prepare Draft-Final Tyndall AFB SI Report	15 days	Mon 9/18/17	Fri 10/6/17
175			Draft-Final Tyndall AFB SI Report Review	23 days	Mon 10/9/17	Wed 11/8/17
176			Prepare Final Tyndall AFB SI Report	15 days	Thu 11/9/17	Wed 11/29/17
177		📌	Robins AFB SI Site Visit	5 days	Mon 10/24/16	Fri 10/28/16
178			Prepare Draft Robins AFB Installation Specific QAPP Addendum/SSHP	30 days	Mon 10/31/16	Fri 12/9/16
179			Draft Robins AFB Installation Specific QAPP Addendum/SSHP Review	14 days	Mon 12/12/16	Thu 12/29/16
180			Prepare Draft-Final Robins AFB Installation Specific QAPP Addendum	10 days	Fri 12/30/16	Thu 1/12/17
181			Draft-Final Robins AFB Installation Specific QAPP Addendum Review	23 days	Fri 1/13/17	Tue 2/14/17
182			Prepare Final Robins AFB Installation Specific QAPP Addendum/SSHP	10 days	Wed 2/15/17	Tue 2/28/17
183			Robins AFB Field Work	27 days	Wed 2/22/17	Thu 3/30/17
184			Prepare Draft Robins AFB SI Report	128 days	Fri 3/31/17	Tue 9/26/17
185			Draft Robins AFB SI Report Review	15 days	Wed 9/27/17	Tue 10/17/17
186			Robins AFB ERPIMS Submittal	5 days	Mon 6/26/17	Fri 6/30/17
187			Prepare Draft-Final Robins AFB SI Report	15 days	Wed 10/18/17	Tue 11/7/17
188			Draft-Final Robins AFB SI Report Review	23 days	Wed 11/8/17	Fri 12/8/17
189			Prepare Final Robins AFB SI Report	15 days	Mon 12/11/17	Fri 12/29/17
190		📌	ANG Burlington SI Site Visit	2 days	Mon 4/3/17	Tue 4/4/17
191			Prepare Draft ANG Burlington Installation Specific QAPP Addendum/SSHP	30 days	Wed 4/5/17	Tue 5/16/17
192			Draft ANG Burlington Installation Specific QAPP Addendum/SSHP Review	15 days	Wed 5/17/17	Tue 6/6/17
193			Prepare Draft-Final ANG Burlington Installation Specific QAPP Addendum	10 days	Wed 6/7/17	Tue 6/20/17
194			Draft-Final ANG Burlington Installation Specific QAPP Addendum Review	23 days	Wed 6/21/17	Fri 7/21/17
195			Prepare Final ANG Burlington Installation Specific QAPP Addendum/SSHP	10 days	Mon 7/24/17	Fri 8/4/17
196			ANG Burlington Field Work	4 days	Mon 8/7/17	Thu 8/10/17
197			Prepare Draft ANG Burlington SI Report	130 days	Fri 8/11/17	Thu 2/8/18
198			Draft ANG Burlington SI Report Review	15 days	Fri 2/9/18	Thu 3/1/18
199			ANG Burlington ERPIMS Submittal	5 days	Mon 11/6/17	Fri 11/10/17
200			Prepare Draft-Final ANG Burlington SI Report	15 days	Fri 3/2/18	Thu 3/22/18
201			Draft-Final ANG Burlington SI Report Review	23 days	Fri 3/23/18	Tue 4/24/18
202			Prepare Final ANG Burlington SI Report	15 days	Wed 4/25/18	Tue 5/15/18
203	▦		AFRL-Rome SI Site Visit	2 days	Wed 4/5/17	Thu 4/6/17
204			Prepare Draft AFRL-Rome Installation Specific QAPP Addendum/SSHP	30 days	Fri 4/7/17	Thu 5/18/17
205			Draft AFRL-Rome Installation Specific QAPP Addendum/SSHP Review	15 days	Fri 5/19/17	Thu 6/8/17
206			Prepare Draft-Final AFRL-Rome Installation Specific QAPP Addendum	15 days	Fri 6/9/17	Thu 6/29/17
207			Draft-Final AFRL-Rome Installation Specific QAPP Addendum Review	23 days	Fri 6/30/17	Tue 8/1/17
208			Prepare Final AFRL-Rome Installation Specific QAPP Addendum/SSHP	15 days	Wed 8/2/17	Tue 8/22/17
209			AFRL-Rome Field Work	4 days	Mon 8/14/17	Thu 8/17/17
210			Prepare Draft AFRL-Rome SI Report	130 days	Fri 8/18/17	Thu 2/15/18
211			Draft AFRL-Rome SI Report Review	15 days	Fri 2/16/18	Thu 3/8/18
212			AFRL-Rome ERPIMS Submittal	5 days	Mon 11/13/17	Fri 11/17/17
213			Prepare Draft-Final AFRL-Rome SI Report	15 days	Fri 3/9/18	Thu 3/29/18
214			Draft-Final AFRL-Rome SI Report Review	23 days	Fri 3/30/18	Tue 5/1/18
215			Prepare Final AFRL-Rome SI Report	15 days	Wed 5/2/18	Tue 5/22/18
216	▦		Niagara Falls ARS SI Site Visit	1 day	Fri 4/7/17	Fri 4/7/17

Project: Savannah AFFF Investigations Project Schedule 11 January 2016
Date: Fri 1/29/16

Task	▬	Summary	┌─┐	External Milestone	◆	Inactive Summary	┌─┐	Manual Summary Rollup	▬	Manual Progress	─
Split	┄┄┄	Project Summary	┌─┐	Inactive Task	▭	Manual Task	▬	Finish-only	]		
Milestone	◆	External Tasks	▬	Inactive Milestone	◇	Duration-only	▬	Start-only	[	Deadline	⇩
								Manual Summary	┌─┐	Progress	─

ID	ℹ	Task Mode	Task Name	Duration	Start	Finish
217		➔	Prepare Draft Niagara Falls ARS Installation Specific QAPP Addendum/SSHP	30 days	Mon 4/10/17	Fri 5/19/17
218		➔	Draft Niagara Falls ARS Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 5/22/17	Fri 6/9/17
219		➔	Prepare Draft-Final Niagara Falls ARS Installation Specific QAPP Addendum	10 days	Mon 6/12/17	Fri 6/23/17
220		➔	Draft-Final Niagara Falls ARS Installation Specific QAPP Addendum Review	23 days	Mon 6/26/17	Wed 7/26/17
221		➔	Prepare Final Niagara Falls ARS Installation Specific QAPP Addendum/SSHP	10 days	Thu 7/27/17	Wed 8/9/17
222		➔	Niagara Falls ARS Field Work	5 days	Mon 8/21/17	Fri 8/25/17
223		➔	Prepare Draft Niagara Falls ARS SI Report	130 days	Mon 8/28/17	Fri 2/23/18
224		➔	Draft Niagara Falls ARS SI Report Review	15 days	Mon 2/26/18	Fri 3/16/18
225		➔	Niagara Falls ARS ERPIMS Submittal	5 days	Mon 11/20/17	Fri 11/24/17
226		➔	Prepare Draft-Final Niagara Falls ARS SI Report	15 days	Mon 3/19/18	Fri 4/6/18
227		➔	Draft-Final Niagara Falls ARS SI Report Review	23 days	Mon 4/9/18	Wed 5/9/18
228		➔	Prepare Final Niagara Falls ARS SI Report	15 days	Thu 5/10/18	Wed 5/30/18
229	▦	➔	Hanscom AFB SI Site Visit	1 day	Tue 4/11/17	Tue 4/11/17
230	▦	➔	Prepare Draft Hanscom AFB Installation Specific QAPP Addendum/SSHP	35 days	Mon 4/17/17	Fri 6/2/17
231	▦	➔	Draft Hanscom AFB Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 6/5/17	Fri 6/23/17
232	▦	➔	Prepare Draft-Final Hanscom AFB Installation Specific QAPP Addendum	15 days	Mon 6/26/17	Fri 7/14/17
233	▦	➔	Draft-Final Hanscom AFB Installation Specific QAPP Addendum Review	21 days	Mon 7/17/17	Mon 8/14/17
234	▦	➔	Prepare Final Hanscom AFB Installation Specific QAPP Addendum/SSHP	15 days	Tue 8/15/17	Mon 9/4/17
235	▦	➔	Hanscom AFB Field Work	5 days	Mon 9/11/17	Fri 9/15/17
236	▦	➔	Prepare Draft Hanscom AFB SI Report	120 days	Mon 9/18/17	Fri 3/2/18
237	▦	➔	Draft Hanscom AFB SI Report Review	15 days	Mon 3/5/18	Fri 3/23/18
238	▦	➔	Hanscom AFB ERPIMS Submittal	5 days	Mon 12/11/17	Fri 12/15/17
239	▦	➔	Prepare Draft-Final Hanscom AFB SI Report	15 days	Mon 3/26/18	Fri 4/13/18
240	▦	➔	Draft-Final Hanscom AFB SI Report Review	23 days	Mon 4/16/18	Wed 5/16/18
241	▦	➔	Prepare Final Hanscom AFB SI Report	15 days	Thu 5/17/18	Wed 6/6/18
242	▦	➔	Westover ARB SI Site Visit	1 day	Thu 4/13/17	Thu 4/13/17
243	▦	➔	Prepare Draft Westover ARB Installation Specific QAPP Addendum/SSHP	40 days	Mon 4/17/17	Fri 6/9/17
244	▦	➔	Draft Westover ARB Installation Specific QAPP Addendum/SSHP Review	15 days	Mon 6/12/17	Fri 6/30/17
245	▦	➔	Prepare Draft-Final Westover ARB Installation Specific QAPP Addendum	15 days	Mon 7/3/17	Fri 7/21/17
246	▦	➔	Draft-Final Westover ARB Installation Specific QAPP Addendum Review	21 days	Mon 7/24/17	Mon 8/21/17
247	▦	➔	Prepare Final Westover ARB Installation Specific QAPP Addendum/SSHP	15 days	Tue 8/22/17	Mon 9/11/17
248	▦	➔	Westover ARB Field Work	5 days	Mon 9/18/17	Fri 9/22/17
249	▦	➔	Prepare Draft Westover ARB SI Report	120 days	Mon 9/25/17	Fri 3/9/18
250	▦	➔	Draft Westover ARB SI Report Review	15 days	Mon 3/12/18	Fri 3/30/18
251	▦	➔	Westover ARB ERPIMS Submittal	5 days	Mon 12/18/17	Fri 12/22/17
252	▦	➔	Prepare Draft-Final Westover ARB SI Report	15 days	Mon 4/2/18	Fri 4/20/18
253	▦	➔	Draft-Final Westover ARB SI Report Review	23 days	Mon 4/23/18	Wed 5/23/18
254	▦	➔	Prepare Final Westover ARB SI Report	15 days	Thu 5/24/18	Wed 6/13/18
255		📌	Air Force Plant 6 SI Site Visit	1 day	Tue 6/6/17	Tue 6/6/17
256		➔	Prepare Draft Air Force Plant 6 Installation Specific QAPP Addendum/SSHP	30 days	Wed 6/7/17	Tue 7/18/17
257		➔	Draft Air Force Plant 6 Installation Specific QAPP Addendum/SSHP Review	15 days	Wed 7/19/17	Tue 8/8/17
258		➔	Prepare Draft-Final Air Force Plant 6 Installation Specific QAPP Addendum	15 days	Wed 8/9/17	Tue 8/29/17
259		➔	Draft-Final Air Force Plant 6 Installation Specific QAPP Addendum Review	23 days	Wed 8/30/17	Fri 9/29/17
260		➔	Prepare Final Air Force Plant 6 Installation Specific QAPP Addendum/SSHP	15 days	Mon 10/2/17	Fri 10/20/17
261		➔	Air Force Plant 6 Field Work	3 days	Mon 11/6/17	Wed 11/8/17
262		➔	Prepare Draft Air Force Plant 6 SI Report	108 days	Thu 11/9/17	Mon 4/9/18
263		➔	Draft Air Force Plant 6 SI Report Review	15 days	Tue 4/10/18	Mon 4/30/18
264		➔	Air Force Plant 6 ERPIMS Submittal	5 days	Fri 2/2/18	Thu 2/8/18
265		➔	Prepare Draft-Final Air Force Plant 6 SI Report	15 days	Tue 5/1/18	Mon 5/21/18
266		➔	Draft-Final Air Force Plant 6 SI Report Review	23 days	Tue 5/22/18	Thu 6/21/18
267		➔	Prepare Final Air Force Plant 6 SI Report	15 days	Fri 6/22/18	Thu 7/12/18
268	▦	➔	Dobbins ARB SI Site Visit	2 days	Wed 6/7/17	Thu 6/8/17
269		➔	Prepare Draft Dobbins ARB Installation Specific QAPP Addendum/SSHP	30 days	Fri 6/9/17	Thu 7/20/17
270		➔	Draft Dobbins ARB Installation Specific QAPP Addendum/SSHP Review	15 days	Fri 7/21/17	Thu 8/10/17
271		➔	Prepare Draft-Final Dobbins ARB Installation Specific QAPP Addendum	15 days	Fri 8/11/17	Thu 8/31/17
272		➔	Draft-Final Dobbins ARB Installation Specific QAPP Addendum Review	23 days	Fri 9/1/17	Tue 10/3/17
273		➔	Prepare Final Dobbins ARB Installation Specific QAPP Addendum/SSHP	15 days	Wed 10/4/17	Tue 10/24/17
274		➔	Dobbins ARB Field Work	8 days	Thu 11/9/17	Mon 11/20/17
275		➔	Prepare Draft Dobbins ARB SI Report	108 days	Tue 11/21/17	Thu 4/19/18
276		➔	Draft Dobbins ARB SI Report Review	15 days	Fri 4/20/18	Thu 5/10/18
277		➔	Dobbins ARB ERPIMS Submittal	5 days	Wed 2/14/18	Tue 2/20/18
278		➔	Prepare Draft-Final Dobbins ARB SI Report	15 days	Fri 5/11/18	Thu 5/31/18
279		➔	Draft-Final Dobbins ARB SI Report Review	23 days	Fri 6/1/18	Tue 7/3/18
280		➔	Prepare Final Dobbins ARB SI Report	15 days	Wed 7/4/18	Tue 7/24/18
281		➔	Presentation of Findings	2 days	Mon 9/17/18	Tue 9/18/18
282		➔	Period of Performance	1305 days	Tue 9/29/15	Mon 9/28/20



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Date: Fri 1/29/16

Task	▬	Summary	⎴	External Milestone	◆	Inactive Summary	⎴	Manual Summary Rollup	▬	Finish-only	]	Manual Progress	―
Split	⋯	Project Summary	⎴	Inactive Task	▭	Manual Task	▬	Manual Summary	⎴	Deadline	⇩		
Milestone	◆	External Tasks	▬	Inactive Milestone	◇	Duration-only	▬	Start-only	[	Progress	―		

Appendix C

Aerostar SES LLC

Standard Operating Procedures

Aerostar SES LLC
Standard Operating Procedure 001
Logbooks

August 2013
(Revision 0)

Prepared by: Name: Greg Carlson

Signature: Greg Carlson

Title: Geologist

Date: 8/7/13

Approved by: Name: Paula Bond, PG

Signature: Paula Bond

Title Technical Manager

Date: 8/7/13

Approved by: Name: Roy Hoekstra, PE

Signature:

Title Quality Assurance Manager

Date: 8/7/13

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES LLC (ASL) field personnel for the purposes of documenting factual information in logbooks related to field investigations and activities. Information to be documented can include but it not limited to: Sampling, field measurements, instrument calibration, daily activities, and the activities of subcontractors on site.

1.2 SCOPE AND APPLICATION

This document describes the various types of information that should be included in field logbooks used to document field activities conducted by ASL field personnel. Information included in field logbooks will likely later be included in final reports for a site, making accurate recording of information in field logbooks critical. This procedure is applicable to all ASL field sampling projects unless otherwise noted or other site-specific project procedures are required to meet project data quality objectives.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-010-R5, Logbooks. This document is designed to be utilized as a general guideline and illustrate the minimal guidelines for field documentation, however, field personnel must always keep in mind that different projects, and different states, may have more stringent requirements with regards to record keeping. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

2. FIELD RECORDS AND DOCUMENTATION PROCEDURES

2.1 GENERAL

Dedicated bound logbooks will be used for field data collection including but not limited to: Sampling, field measurements, instrument calibration, daily activities, and the activities of subcontractors on site. Logbook entries should be objective, factual, clear and concise. All pertinent information will be recorded at the time of the event or measurement to avoid a loss of data or a collection of inaccurate information.

To help facilitate complete and accurate documentation of field sampling and measurement activities, ASL forms should be used in the absence of Federal or State requirements. These forms may be electronic or handwritten and must be filled out at the time of the event. In the case of electronic forms, daily forms should be uploaded to the central file system or saved to a mobile storage devise at the end of each day. Utilization of forms separate from the bound logbook must be approved by the Project Manager.

Any deviations from the approved Work Plan that occur while in the field will be noted in the logbook(s). Logbook entries that may be considered privileged or confidential information will be handled following ASL policies concerning client confidentiality. At the end of a field event all logbook entries should be copied or scanned and stored in the project file.

At a minimum, daily logs should include:

1. Date and time of arrival on site
2. Weather on site
3. Personnel and Subcontractors on site
4. Activities accomplished throughout the day

5. Visitors on site (If applicable)
6. Important telephone calls or conversations
7. Changes to project plans or designs
8. Signature page for data entry personnel and quality control verification

2.2 FIELD DATA INTEGRITY AND ACCOUNTABILITY

The following requirements apply to ALL LOGBOOKS:

1. The ASL project number and project name should be clearly printed on the cover of the bound logbook, as well as on each logbook page.
2. Each page will be consecutively numbered, dated, and signed.
3. Observations, data collected, calculations and similar information will be recorded at the time they are made.
4. All entries into the field logbook will be made using permanent ink. All entries should be legible, and contain accurate and fully inclusive information of project activities.
5. Upon completion of a field event a clear entry indicating this such as “End of shift” should be made. Any blank space left on the final page should be rendered invalid with a diagonal line, and the line should be initialed, dated, and noted with a comment such as “No Further Entries” or “End of Shift”.
6. In order to demonstrate continuity of the project and prevent questioning of the data collection process, pages shall not be removed from the bound logbook under any circumstance.
7. Data or other information that has been entered incorrectly will be corrected by drawing a line through the incorrect entry, initialing and dating the correction, and then properly entering the correct information next to the original entry. Under no circumstance will the incorrect entry be rendered unreadable or erased.
8. If preprinted labels are placed into the logbook to enhance the accuracy of the information recorded the field investigator who has placed the label in the logbook will sign the book so that the signature falls on both the bound page and the label, ensuring that the label cannot be removed without detection.

2.3 LOGBOOK ENTRY INFORMATION

2.3.1 General Information Required in All Logbooks

The following information will be included on the front cover of all logbooks:

1. Project Name
2. Project Location
3. ASL Project ID number
4. Field Investigators Name
5. Company name and address
6. Contact phone number

2.3.2 Information required for Sample Collection

1. Date and time of collection
2. Sample identification number
3. Method of collection
4. Number and types of containers
5. Sample collection equipment
6. Sample collection equipment serial numbers (if applicable)

7. Sample equipment calibration information (if applicable)
8. Method of collection
9. Matrix sampled and additional observations if warranted
10. Sample Preservation
11. Conditions that may adversely affect the sample quality such as wind, rain, smoke etc.
12. GPS Coordinates of the sample (if applicable)
13. Location of electronic records and backup locations (if applicable)
14. Other pertinent information

2.3.3 Information Required for Field Measurements

In addition to the information listed in section 2.3.1 the following information will be included in all logbooks in which measurements are conducted.

1. Date and time of measurement
2. Sample or location ID
3. Sample measurement equipment
4. Serial number of measurement equipment (if applicable)
5. Manufacturers name, lot number and expiration date of all buffers and standards
6. Calibration information, including before and after readings
7. Measurement values for non logging equipment
8. GPS Coordinates (if Applicable)
9. Conditions that may adversely impact the instruments readings such as temperature extremes
10. Any maintenance that was performed such has the replacement of a sensor
11. Any meter malfunctions that may occur
12. Ambient temperature
13. Location of electronic records and backup locations (if applicable)
14. Other pertinent information

2.3.4 Additional Information for Inclusion

The following information should be included as appropriate:

1. Maps and sketches
2. Photographic logs
3. Documentation of events on site or around the site that may affect the project
4. Health and safety concerns

3. DATA VERIFICATION

Each logbook will contain a signature page for those field persons filling out the logbook each day. In addition, a signature block will be included to document that the logbook has been reviewed for completeness and accuracy. At the end of each field task, field logbooks will be reviewed and entries verified. Logbook data verification will be conducted by the Project Manager or his/her designee.

4. REFERENCES

EPA Region 4, 2013. Operating Procedure SESDPROC-010-R5, Logbooks

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

Aerostar SES LLC
Standard Operating Procedure 002
Groundwater Sampling

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures with regards to groundwater sampling. Methods and considerations described in this document are intended as a guideline for ASL personnel when conducting groundwater sampling events for screening or laboratory analysis purposes.

1.2 SCOPE AND APPLICATION

The procedures contained within this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion where ASL field personnel determine that the procedures described are either inappropriate or impractical to implement, another procedure may be used only with approval from the Project Manager and must be documented in the field logbook (ASL-001) along with the rationale for the use of an alternate procedure.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Science and Ecosystem Support Division (SESD) Operating Procedure SESDPROC-301-R3, Groundwater Sampling (2013). This document is designed to be utilized as a general guideline and illustrate the minimal guidelines for groundwater sampling, however, field personnel must always keep in mind that different projects, and different states, may have more stringent requirements with regards to groundwater sampling. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples:

1. Special care should be taken not to cross contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long term storage or shipment.
2. Always sample from the location anticipated to be the cleanest, i.e. least contaminated to the most contaminated location. This will minimize the opportunity for cross contamination to occur.
3. Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party. If samples are transported by the sampler, they will remain under his or her custody or be stored in a secure location until they are relinquished.
4. Shipped samples shall conform to all U.S. Department of Transportation rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR Parts 171-179), and or International Air

Transportation (IATA) hazardous shipping materials requirements found in the current edition of IATA's Dangerous Goods Regulations.

5. Field sampling will be documented a bound field logbook (ASL SOP-001).
6. Chain of custody documents shall be filled out and remain with the samples until custody is relinquished. All shipping documents, such as air bills, bills of lading etc. shall be retained by the site or project manager and placed in the project files.

2. SPECIAL SAMPLING CONSIDERATIONS

2.1 SAMPLE HANDLING AND PRESERVATION REQUIREMENTS

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.
2. During sample collection make sure that the pump discharge line or bailer does not contact the sample container.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC, acidity and alkalinity must not have any headspace. All other sample containers must be filled with an allowance for expansion.
4. All samples requiring preservation must be pre-preserved from the analytical laboratory if possible. If not, samples should be preserved as soon as practically possible, ideally, immediately at the time of sample collection.

2.2 RECORDS

Information generated or obtained by ASL personnel will be organized and accounted for in accordance with project plans. Field notes, recorded in a bound logbook will be generated, as well as chain of custody documentation in accordance with ASL-001, Logbooks and ASL-017, Sample and Evidence Management.

3. GROUNDWATER SAMPLING METHODS-PURGING

3.1 GENERAL

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance, turbidity, and dissolved oxygen of the water being removed. Additionally, the water level should be monitored and a flow rate and cumulative and total volumes of water being removed should be recorded.

There are several strategies that may be used, depending on specific conditions encountered for given well sampling situations. When the traditional multiple volume purge method is considered and it is determined that excessive quantities of investigation-derived wastes (IDW) would be generated using this method, it may be appropriate to use an alternate method that reduces the time and amount of purge water to be removed prior to sampling the well. The project manager will select the alternate method only after careful consideration of the conditions presented by the well and the impact these conditions have on all aspects of the sampling event.

3.2 PURGING METHODS AND STRATEGIES

3.2.1 Traditional Volume Purge

3.2.1.1 Purge volume determination

Prior to initiating the purge, the amount of water standing in the water column should be determined. To do this, the diameter of the well should be determined along with the water level and total depth of the well. Specific procedures for conducting these measurements can be found in ASL SOP 005, Field Measurement of Groundwater Levels and Well Depth Measurement. Once this information is obtained, the volume of water to be purged can be determined using one of several methods.

V=0.041 d2h
Where: h = depth of water in feet
d = diameter of well in inches
V = Volume of water in gallons

Alternatively, the volume of standing water in the well may be determined using known values from the table below:

Table 3-1 Summary of Casing Water Volumes

Casing Diameter (inches)	Gallons/ft., One Water Column	Gallons/ft., Three Water Columns
1	0.04	0.12
2	0.16	0.48
3	0.37	1.11
4	0.65	1.98
5	1.02	3.06
6	1.47	4.41
7	1.99	5.97
8	2.61	7.83
9	3.30	9.90
10	4.08	12.24
11	4.93	14.79
12	5.87	17.61

3.2.1.2 Chemical parameter stabilization criteria

With respect to ground water chemistry, an adequate purge is achieved when the pH and specific conductance of ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). (Note: Because groundwater temperature is subject to rapid changes when collected for parameter measurement, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from the list of parameters used for stability determination. Even though temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters during well purging, as it may be needed to interpret other chemical parameter results in some situations.)

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than approximately 10 percent. Other parameters, such as dissolved oxygen (DO), may also be used as a purge adequacy parameter. Normal goals for DO are 0.2 mg/L or 10% saturation, whichever is greater. DO measurements must be conducted using either a flow-through cell or an over-topping cell to minimize or reduce any oxygenation of the sample during measurement. Oxidation-Reduction Potential (ORP) should not be used as a purge stabilization parameter but may be measured during purging to obtain the measurement of record for ORP for the sampling event.

There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes, for example, may be sufficient. At a minimum, at least six time intervals of stabilization parameters should be recorded in addition to an initial recording immediately after purging begins. If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to five well volumes), should be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project manager whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible, with respect to turbidity. The conditions of sampling should be noted in the field log.

3.2.1.3 Purge adequacy considerations

In some situations, even with slow purge rates, a well may be pumped dry or evacuated. In these situations, this generally constitutes an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample containers). It is not necessary that the well be evacuated three times before it is sampled. The pH, specific conductance, temperature, and turbidity should be measured and recorded, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

For wells with slow recovery, attempts should be made to avoid purging to dryness. This can be accomplished, for example, by slowing the purge rate. As water enters a well that has been purged to dryness, it may cascade down the sand pack and/or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

If adequate volume is available immediately upon completion of purging, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

3.2.2 “Tubing In Screened Interval” Method

The "Tubing-in-Screen" method, sometimes referred to as the "Low Flow" method, is used primarily when calculated purge volumes for the traditional purging method are excessive and present issues related to timely completion of the project and/or management of investigation derived waste. It should be noted that many states now recognize “Low Flow” purging as a standard practice.

3.2.2.1 Placement of pump tubing or intake

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. By definition, this method cannot be applied for purging with a bailer.

3.2.2.2 Conditions of pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well being sampled to monitor the static water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. If this condition cannot be met, then one of the other methods should be employed.

3.2.2.3 Stability of chemical parameters

As with the traditional purging method described in Section 3.2.1, chemical parameters should be stable as defined in Section 3.2.1.1 prior to sampling.

3.3 EQUIPMENT CONSIDERATIONS FOR PURGING

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The equipment utilized will usually consist of peristaltic pumps and variable speed electric submersible pumps, but may also include bladder pumps or inertial pumps. The pump of choice is usually a function of the well diameter, the depth to water, the depth of the well and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. For wells where the water level is below the limit of suction (approximately 25' to 30', and/or where there is a large volume of water to be purged), the variable speed electric submersible pump would be the pump of choice. ASL SOP 003 Pump Operation contains the use and operating instructions for all pumps commonly used during ASL ground water investigations.

Bailers may also be used for purging in appropriate situations; however, their use is discouraged. Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled. If a bailer is used, it should be a closed-top Teflon® bailer.

3.3.1 Wells without plumbing or In Place Pumps

For permanent monitoring wells, the depth to water (water level) and depth of the well (total depth) should be determined before purging. Caution should be exercised during this procedure to prevent cross-contamination between wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected for cleaning procedures for well sounders (see ASL SOP 015 Field Equipment Cleaning and Decontamination). After cleaning, the well sounding device should be protected to keep it clean until its next use.

3.3.1.1 Peristaltic pumps

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard new tubing, equal to the well depth plus an additional five to ten feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.
2. Place one end of the tubing into the vacuum side of the peristaltic pump head silicon tubing. Proper sizing of the Teflon and silicon tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.
3. Run a short section of tubing (does not have to be Teflon) from the discharge side of the pump head to a graduated bucket.
4. Place the free end of the tubing into the well until the end of the tubing is located just below the top of the water table.
5. Secure the tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.
6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.
7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.
8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging. Standard field measurements should frequently be taken during this process to verify adequacy of the purge and readiness for sampling, as described in Section 3.

3.3.1.2 Submersible pumps

When a submersible pump is used for well purging, the pump itself is lowered into the water column. Ensure that the pump has been properly decontaminated prior to use. The pump/hose assembly used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. It is recommended that the pump not be lowered more than three to five feet into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown. After the pump is removed from the well, the pump should be cleaned and decontaminated.

3.3.1.3 Purging with bailers

A closed top bailer with new nylon rope is lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

3.3.2 Temporary Monitoring Wells

3.3.2.1 General considerations

Procedures used to purge temporary ground water monitoring wells differ from permanent wells because temporary wells are installed for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler or a Hydropunch® sampler. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply because stagnant water is not present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well purging criteria to it to re-achieve aquifer conditions.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low stress purging techniques using variable speed peristaltic pumps.

3.3.2.2 Purging when water level is within head constraints

In situations where the elevation of the top of the water column is within the required head constraints (no greater than about 25 feet head difference between the pump and the water level), a variable speed peristaltic pump may be used to purge temporary wells. Enough tubing is deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing is slowly lowered to the bottom of the screen and is used to remove any formation material which may have entered the well screen during installation. This is critical to ensuring rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing is slowly raised through the water column to near the top of the column. The tubing can be held at this level to determine if the pump rate is drawing down the water level in the well. If the water level remains the same, secure the tubing at the surface to maintain this pumping level.

If drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the drawdown stabilizes, maintain that level, however, if it continues to lower, "chase" the water column until the well is evacuated. In this case, the recovered water column may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide enough volume for a complete sample.

3.3.2.3 Purging when water level is greater than the head constraints

In situations where the elevation of the water table is greater than the limit of suction, peristaltic pumps cannot be used to purge temporary wells. If the temporary well is a ScreenPoint15® sampler with small diameter probe rod riser, the only practical choices for water removal are a small diameter bailer, a small diameter bladder pump or an inertial pump. If the well is to be used strictly for VOC screening, it may be acceptable to use the bailer to bail as much sediment from the well as possible prior to sampling. If metals are the analytes of concern, the bladder pump is the best choice for lowering the turbidity of the water column prior to sampling, followed next by the inertial pump. For larger diameter temporary wells, two-inch diameter or greater, bailers and the Grundfos® RediFlo2 may be used although excessive silt or other "fines" may present problems with the operation of the pump.

3.3.2.4 Considerations for direct push groundwater sampling

With many of the direct push sampling techniques, purging is either not practical or possible; therefore, no purging is conducted. The sampling device is simply pushed or driven to the desired depth and opened and the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the subject procedure may yield a turbid sample that is not appropriate for metals analyses.

3.4 FIELD CARE OF PURGING EQUIPMENT

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative purging methods, such as bailers, should be considered.

3.5 INVESTIGATION DERIVED WASTE

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. See ASL SOP 021 Management of Investigation Derived Waste for guidance on management and disposal of this waste.

4. GROUNDWATER SAMPLING METHODS-SAMPLING

4.1 GENERAL

Sampling is the process of obtaining, containerizing, and preserving (if required) a ground water sample after the purging process is complete. Non-dedicated pumps for sample collection generally should not be used. Many pumps are made of materials such as brass, plastic, rubber, or other elastomeric products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

4.1.1 Equipment Available

The pump of choice for sampling ground water is the variable-speed peristaltic pump where possible (<25 ft head difference). Its use is described in the following sections. Other acceptable alternatives that may be used under these conditions are the RediFlo2® electric submersible pump, Proactive Monsoon electric submersible pump and bailers.

4.1.1.1 Peristaltic pump, direct from pump head tubing

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the pump head tubing. This method is acceptable under the following conditions:

1. The pump head tubing must be changed between sampling locations
2. An equipment rinsate blank is collected by pumping de-ionized water through a piece of the tubing.

4.1.1.2 Peristaltic pump, vacuum jug

It is not acceptable to collect samples for organic compound analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.
2. Insert the tubing into one of the ferrule nut fittings of a Teflon or poly vacuum container transfer cap assembly.
3. Place a suitable length of Teflon, Teflon lined, or poly tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.
4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table.
5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers.
6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable.
7. When sampling is completed, all tubing should be discarded.
8. NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with tubing or bailer or by other approved methods, such as the "soda straw" method. The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying

the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

4.1.1.3 RediFlo 2 electronic submersible pump

After purging has been accomplished with RediFlo2® electric submersible pump, the sample may be obtained directly from the pump discharge. The discharge rate of the pump should be reduced during volatile organic compound sample collection to minimize sample disturbance. Note, if the RediFlo2® electric submersible pump is used for sampling, the pump must undergo a full external and internal cleaning. In addition, pump rinsate blanks must be collected, at the appropriate frequency, to demonstrate that the pump has been adequately cleaned between wells.

4.1.1.4 Bailers

New bailer rope should be attached to the bailer. If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling. The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be slowly removed and the contents emptied into the appropriate sample containers.

4.2 MICRO PURGE OR NO PURGE SAMPLING PROCEDURES

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Low flow sampling procedures are the same as above with the exception that purge rate are less than 0.5 liters per minute. The purge rate should equal the groundwater flow rate so as to not draw down the monitoring well.

4.3 SPECIAL SAMPLE COLLECTION PROCEDURES

4.3.1 Volatile Organic Compound (VOC) Analysis

Groundwater samples for VOC analysis are collected in 40 mL vials with Teflon septa. The vial may be either preserved with concentrated hydrochloric acid (HCL) or they may be unpreserved. Preserved samples have a 14 day holding time whereas unpreserved samples have a seven day holding time. Typically, preserved bottles are used to take advantage of the greater holding time. In some situations however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high, calcium carbonate content, an effervescent reaction with the HCl preservative may produce multiple air bubbles, rendering the sample unacceptable. In this case, unpreserved vials should be used and arrangements made with the laboratory to ensure that they can accept the unpreserved vials and meet the shortened holding time.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present a new vial should be obtained and the sample recollected.

Samples for VOC analysis must be collected using either stainless steel, Teflon, Teflon lined, or polypropylene (poly) tubing and equipment. The selection of sampling equipment and materials should be based on project DQOs but may include:

1. Stainless Steel, Teflon, or poly bailers
2. Rediflo2 or Stainless Steel Monsoon submersible pumps should be equipped with Teflon, Teflon Lined, or poly sample delivery tubing based on project DQOs.
3. Peristaltic pump/vacuum jug assemblies should be outfitted with Teflon, Teflon lined, or poly tubing from the water column to the transfer cap which should also be constructed of Teflon.

4.3.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, an adequate purge, with respect to turbidity, is often difficult to achieve. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to collect the aliquot for metals first. Therefore, the preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds and volatile organic compounds.

4.3.3 Filtering

As a standard practice, ground water samples will not be filtered for routine analysis. When filtered samples are collected based on project DQO's, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered.

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.
2. Use a 45 um pore-size filter for the purpose of determining the colloidal constituent concentrations. A 0.1 um pore-size filter should be used to remove most non-dissolved particles.
3. Rinse the cartridge or barrel-type filter with 500 milliliters of the solute (groundwater to be sampled) prior to collection of sample. If a membrane filter is used, rinse with 100 milliliters of solute prior to sample collection.

5. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 003 Pump Operation

ASL 2013. Standard Operating Procedures 005 Field Measurement of Groundwater Levels and Well Depth Measurement.

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

ASL 2013. Standard Operating Procedure 021, Management of Investigation Derived Waste.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-301-R3, Groundwater Sampling.

AerostarSES LLC

Aerostar SES LLC
Standard Operating Procedure 003
Pump Operation

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures, methods and considerations to be used and observed when operating a variety of pumps that may be used for purging monitoring wells and for collecting samples of aqueous phase environmental media, including groundwater, surface water and certain wastewaters, for field screening or laboratory analysis.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when using pumps during the process of collecting samples of aqueous phase environmental media in the field. On the occasion that ASL field personnel determine that any of the procedures described in this section cannot be used to obtain samples of the particular media of interest, and that another method or pump must be used to obtain said sample, use of the variant pump and/or procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-203-R2, Pump Operation (2013). This document is designed to be utilized as a general guideline for basic pump operation for use by ASL field personnel, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding pumps to be used for a specific analyte or sampling procedure. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when using electrical pumps. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

The following precautions should be considered when operating pumps used for collecting samples of aqueous environmental media:

1. When using pumps for collection of environmental samples, always work from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
2. Observe limitations of certain pumps for collection of certain analyte groups (ASL-002 SOP for Groundwater Sampling).
3. Documentation of field sampling should be completed in a bound logbook.
4. Observe appropriate safety and cross-contamination precautions when operating pumps powered by gasoline powered generators

2. PERISTALTIC PUMP

2.1 GENERAL

Groundwater sampling procedures are detailed in the ASL-SOP-002 Groundwater Sampling. When relatively small volumes of water are required for purging and sampling, and the water level is within the limit of suction, peristaltic pumps can be used. These pumps are generally small, light-weight, portable, and are powered by 12-volt batteries. The limit of suction is approximately 25 - 27 feet of vertical separation between the pump and water surface.

The application of these pumps differs with respect to purging and sampling. The following sections detail the use of peristaltic pumps for both purposes.

2.2 PURGING WITH A PERISTALTIC PUMP

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of new Teflon®, Teflon® lined or poly tubing (depending on site specific requirements), equal to the well depth plus an additional five to ten feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.
2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the down hole tubing should allow for a snug fit of the tubing inside the flexible tubing mounted in the pump head.
3. Run a short section of tubing from the discharge side of the pump head to a graduated bucket.
4. Place the free end of the tubing into the well until the end of the tubing is just below the surface of the water column,
5. Secure the tubing to the well casing or other secure object using a zip tie or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.
6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.

If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.

2.3 SAMPLING WITH A PERISTALTIC PUMP

It is not acceptable to collect samples for organic compounds analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. Samples of some inorganic constituents (i.e., metals and cyanide) may be collected directly through the tubing if a rinse blank of the tubing is collected. The vacuum container method is detailed in the following steps.

The following step-by-step procedures describe the process of sampling with a peristaltic pump (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.
2. Insert the tubing into one of the ferrule nut fittings of a vacuum container transfer cap assembly.
3. Place a suitable length of tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.
4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).
5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers.
6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon® valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned.
7. When sampling is completed, all tubing should be discarded.

NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a bailer or by other approved methods, such as the "soda straw" method. The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

3. SMALL DIAMETER ELECTRIC SUBMERSIBLE PUMPS

3.1 GENERAL

Included within this category are the Grundfos® Redi-Flo2 and Proactive Stainless Steel Monsoon small diameter electric submersible pumps. With diameters of approximately 1.75 inches, they are designed to be used in 2-inch diameter and larger wells. These pumps are variable speed pumps capable of providing pump rates from less than 100 ml/minute to in excess of 8 gallons per minute. The pumping rate is largely dependent on the diameter of tubing being utilized.

The Grundfos® Redi-Flo2, depending on the controller being used, operates with either 115v or 220v power. The pump rate is controlled by adjusting the frequency of the current going to the pump motor. It is a light-weight pump and can be easily handled by one person when lowering, but two people are generally needed when removing the pump, one to pull and another to reel in the hose and power lead.

The Proactive Stainless Steel Monsoon operates off the power provided by a 12V battery, and comes with a control box. The rheostat on the control boxes are notoriously imprecise, and require monitoring to provide a steady flow rate. The rate is controlled by adjusting the voltage that the control box is transferring to the pump itself. It is a light-weight pump and can be easily handled by one person when lowering, but two people are generally needed when removing the pump, one to pull and another to reel in the hose and power lead.

3.2 SAFETY

Safety concerns for the Grundfos® Redi-Flo2 are far more involved than those for the Proactive Stainless Steel Pump. The following is a list concerning the Grundfos® Redi-Flo2:

1. Place the generator on dry ground or plastic sheeting as far as practical from the well, in the down-wind direction.
2. Inspect the electrical extension cord, as well as the lead to the pump, for frays, breaks, exposed wiring, etc.
3. Check the head space of the well for the presence of an explosive atmosphere with a combustible gas meter.
4. If purge water is not collected, direct the discharge away from the well and generator, preferably down gradient of the area.
5. Make sure that the generator is set to the proper voltage.
6. Do not add gasoline or oil to the generator while it is running.
7. Store the generator, gasoline, and oil in a trailer dedicated to this type of equipment. Do not haul this equipment in the back of any passenger vehicle or with any sampling equipment or containers.

The Proactive Stainless Steel Monsoon Pump is generally connected directly to the battery of a vehicle instead of utilizing a generator.

3.2.1 Grundfos® Redi-Flo2

1. Check the oil and gasoline in the generator, making sure that there is enough gasoline to test the generator prior to loading onto the trailer. Take the generator outside and start. Place a load on the generator, if possible.
2. Inspect the pump and all hoses, rope, and electrical cord and connections. In particular, open the water reservoir on the bottom of the pump and check to make sure that it is full of water. If not, using the syringe in the controller case, top the reservoir off with organic-free water. Return the pump to its operating vertical position and shake. Re-open the reservoir and add additional water, if needed, to top it off a second time.

3.2.2 Proactive Stainless Steel Monsoon Pump

1. Inspect the pump and all hoses, rope, and electrical cord and connections.
2. Inspect the fuse on the control box, and ensure that you have spares. Additionally ensure that the control knob hasn’t come loose over time.

3.3 OPERATION

With the exception of the generator, operation of these two pumps is similar. The following is a list a basic step for the operation of submersible pumps:

1. Place the pump, the controller, and enough hose for the measured well depth on plastic sheeting next to the well. Set the generator in a dry, safe location downwind of the well, but do not plug the cord from the controller into the generator.
2. Lower the pump, power lead, and hose into the well, placing the pump approximately five feet into the water column.
3. Start the generator, then connect the power cord from the pump. Make sure the proper voltage has been selected.
4. After starting the pump, closely observe operation to determine if drawdown is occurring in the well. If the water level is not pulled down, raise the pump in the water column one to two feet from the top of the water column and continue to purge. If the water level drops, however, lower the pump to keep up with the drawdown. Do not allow the pump to run dry. This condition will create a thermal overload and shut the pump down. While this may not necessarily damage the pump, it will create delays in sampling.

3.4 MAINTENANCE AND PRECAUTIONS

1. Empty the hose of contaminated water before leaving the sampling location.
2. Field clean the pump prior to using at the next sampling location in accordance with the ASL-SOP-015 for Field Equipment Cleaning and Decontamination.
3. Do not run the generator without first checking the oil.
4. Do not put the pump in the trailer with the generator.
5. If the pump is equipped with a check valve or back flow preventer, periodically check this device to make sure that it is operating. This is a common place for debris or other material to accumulate and interfere with the proper operation of the device.
6. If you are using the Monsoon, periodically check to ensure that the control box is not over heating
7. If the monsoon stops running, and the LCD voltage readout is blank, check the fuse, this is a likely source of malfunction.

4. BLADDER PUMP

The bladder pump consists of a stainless steel housing that encloses a flexible membrane or bladder made of Teflon®. A screen is attached below the bladder to filter any material that may clog the bladder check valves. The pump may be operated by using an air compressor, compressed air, or compressed nitrogen. Advantages of bladder pumps include ease of operation, ability to pump larger volumes of water, and all analytical suites can be samples directly through the discharge tubing.

4.1 OPERATION

There are several bladder pump types on the market and the operation should be in accordance with the manufactures recommendations. However, generally, the pump and attached groundwater discharge tubing and air tubing is lowered into the well to the desired depth. The air supply line is attached to the controller and the discharge line is placed into a suitable receptacle. The controller apparatus can be manipulated to determine groundwater pumping rates in accordance with project specific data quality objectives. Do not allow the sampling flow rate to exceed the flow rate used while purging.

The bladder pump should be decontaminated prior to use in each well by disassembling the pump and cleaning the bladder, check valves, and outer stainless steel casing.

5. REFERENCES

ASL 2013. Standard Operating Procedure 002 Groundwater Sampling

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-203-R2, Pump Operation.

Aerostar SES LLC
Standard Operating Procedure 004
Surface Water Sampling

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES, LLC (ASL) field personnel for the purposes of surface water sampling. This document describes procedures, methods and considerations to be used and observed when conducting surface water sampling for field screening or laboratory analysis.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when conducting surface water sampling in the field. On the occasion that ASL field personnel determine that any of the procedures described in this section cannot be used to obtain samples of the particular media of interest, and that another method must be used, variant procedures will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-201-R3, Surface Water Sampling (2013). This document is designed to be utilized as a general guideline for surface water sampling, however, field personnel must always keep in mind that different projects and different states, may have specific regulations regarding surface water sampling. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting surface water sampling. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

The following precautions should be considered when collecting surface water samples:

1. In flowing water, downstream surface water samples will be collected prior to upstream samples to prevent sediment disturbed by surface water collection from impacting samples.
2. Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
3. Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
4. If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
5. Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or

International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

6. Documentation of field sampling is done in a bound logbook.
7. Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
8. All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project manager and stored in a secure place.

2. SPECIAL SAMPLING CONSIDERATIONS

2.1 VOLATILE ORGANIC COMPOUND (VOC) ANALYSIS

Surface water samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid (HCL) or they may be unpreserved. Preserved samples have 14 day holding time, whereas, unpreserved samples have only a seven day holding time. Typically, the pre-preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the surface water sample contains a high concentration of dissolved calcium carbonate, there may be an effervescent reaction between the HCL and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a reverse or convex meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis can be collected using either stainless steel, Teflon®, or polypropylene sampling equipment. Determination of sampling equipment should be based project-specific data quality objectives.

2.1.1 Special Precautions for Surface Water Sampling

1. A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
2. Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.
3. All background or control samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed from downstream locations to upstream locations. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.

4. Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to procedures contained in ASL SOP 015 Field Equipment Cleaning and Decontamination.

2.2 EQUIPMENT SELECTION CONSIDERATIONS

The physical location of the investigator when collecting a sample may dictate the equipment to be used. If surface water samples are required, direct dipping of the sample container into the stream is desirable. Collecting samples in this manner is possible when sampling from accessible locations such as stream banks or by wading or from low platforms, such as small boats or piers. Wading or streamside sampling from banks, however, may cause the re-suspension of bottom deposits and bias the sample. Wading is acceptable if the stream has a noticeable current (is not impounded), and the samples are collected while facing upstream. If the stream is too deep to wade, or if the sample must be collected from more than one water depth, or if the sample must be collected from an elevated platform (bridge, pier, etc.), supplemental sampling equipment must be used.

To collect a surface water sample from a water body or other surface water conveyance, a variety of methods can be used:

1. Dipping Using Sample Container
2. Scoops
3. Peristaltic Pumps
4. Discrete Depth Samplers
5. Bailers
6. Buckets
7. Submersible Pumps
8. Automatic Samplers

Regardless of the method used, precautions should be taken to ensure that the sample collected is representative of the water body or conveyance. These methods are discussed in the following sections.

2.2.1 Dipping Using Sample Container

When the surface water source is accessible by wading or other means, a sample may be collected directly into the sample container or into another device to transfer water to the sample container. The sample transfer device may be disposable or constructed of a clean nonreactive material, such as glass, stainless steel or Teflon®. The sampler should face upstream if there is a current and collect the sample without disturbing the bottom sediment. The surface water sample should always be collected prior to the collection of a sediment sample at the same location. The sampler should be careful not to displace the preservative from a pre-preserved sample container, such as the 40-ml VOC vial.

2.2.2 Scoops

Stainless steel scoops provide a means of collecting surface water samples from surface water bodies that are too deep to access by wading. They have a limited reach of about eight feet and, if samples from distances too far to access using this method are needed, a mobile platform, such as a boat, may be required.

Stainless steel scoops are useful for reaching out into a body of water to collect a surface water sample. The scoop may be used directly to collect and transfer a surface water sample to the sample container, or it may be attached to an extension in order to access the selected sampling location.

2.2.3 Peristaltic Pumps

The peristaltic pump can be used to collect a water sample from any depth if the pump is located at or near the surface water elevation. There is no suction limit for these applications. The use of a metal conduit to which the tubing is attached, allows for the collection of a vertical sample which is representative of the water column. The tubing intake is positioned in the water column at the desired depth by means of the conduit. Using this method, discrete samples may be collected by positioning the tubing intake at one depth or a vertical composite may be collected by moving the tubing intake at a constant rate vertically up and down the water column over the interval to be composited.

Samples for VOC analysis cannot be collected directly from the peristaltic pump discharge or from the vacuum jug. If a peristaltic pump is used for sample collection and VOC analysis is required, the VOC sample must be collected using one of the "soda straw" variations. Ideally, the tubing intake will be placed at the depth from which the sample is to be collected and the pump will be run for several minutes to fill the tubing with water representative of that interval. After several minutes, the pump is turned off and the tubing string is retrieved. The pump speed is then reduced to a slow pumping rate and the pump direction is reversed. After turning the pump back on, the sample stream is collected into the VOC vials as it is pushed from the tubing by the pump. Care must be taken to prevent any water that was in contact with the pump head tubing from being incorporated into the sample.

2.2.4 Discrete Depth Samplers

When discrete samples are desired from a specific depth, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position, thus allowing free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample containers. With a rubber tube attached to the valve, dissolved oxygen sample bottles can be properly filled by allowing an overflow of the water being collected. With multiple depth samples, care should be taken not to disturb the bottom sediment, thus biasing the sample.

When metals and organic compounds parameters are of concern, then a double-check valve, stainless steel bailer or Kemmerer sampler should be used to collect the sample.

2.2.5 Bailers

Bailers may also be used for surface water sampling if the study objectives do not necessitate a sample from a discrete interval in the water column. A closed-top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found.

2.2.6 Buckets

A plastic bucket can be used to collect samples for measurement of water quality parameters such as pH, temperature, and conductivity. Samples collected for analysis of classical water quality parameters including but not limited to ammonia, nitrate-nitrite, phosphorus, and total organic carbon may also be collected with a bucket. Typically, a bucket is used to collect a sample when the water depth is too great for wading, it is not possible to deploy a boat, or access is not possible (excessive vegetation or steep embankments) and the water column is well mixed. The water body is usually accessed from a bridge. The bucket is normally lowered by rope over the side of the bridge. Upon retrieval, the water is poured into the appropriate sample containers

Caution should be exercised whenever working from a bridge. Appropriate measures should be taken to insure the safety of sampling personnel from traffic hazards.

2.2.7 Submersible Pumps

Submersible pumps can be used to collect surface water samples directly into a sample container. The constituents of interest should be taken into consideration when choosing the type of submersible pump and tubing to be used. If trace contaminant sampling of extractable organic compounds and/or inorganic analytes will be conducted, the submersible pump and all of its components should be constructed of inert materials such as stainless steel and/or Teflon®. If reusing the same pump between sample locations, the pump should be decontaminated using ASL SOP 015 Field Equipment Cleaning and Decontamination. New tubing should be used at each sample location.

If the samples will be analyzed for parameters such as ammonia, nitrate-nitrite, phosphorus, or total organic carbon, the pump and tubing may be constructed of components other than stainless steel and Teflon®. The same pump and tubing may be re-used at each sampling station after rinsing with deionized water and then purging several volumes of sample water through the pump and tubing prior to filling the sample containers.

Either a grab or composite sample can be collected using a submersible pump. A composite sample can be collected by raising and lowering the pump throughout the water column. If a composite sample is collected, it may be necessary to pump the sample into a compositing vessel for mixing prior to dispensing into the sample containers. If a compositing vessel is required, it should be constructed of materials compatible with the constituents of concern and decontaminated between sample stations according to appropriate procedures, again depending on the constituents of concern.

2.2.8 Automatic Samplers

Where unattended sampling is required (e.g., storm-event sampling, time-of-travel studies) an automatic sampler may be used. The automatic sampling device may be used to collect grab samples based on time, in-stream flow or water level or used to collect composite samples as dictated by the study data needs. The automatic sampling device should be calibrated prior to deployment to insure the proper volume is collected. The manufacturer's instruction manual should be consulted for automatic sampler operation.

3. SAMPLE HANDLING AND PRESERVATION REQUIREMENTS

1. Surface water samples will typically be collected either by directly filling the container from the surface water body being sampled or by decanting the water from a collection device such as a stainless steel scoop or other device.

2. During sample collection, if transferring the sample from a collection device, make sure that the device does not come in contact with the sample.
3. Place the sample into appropriate, labeled containers. Samples collected for VOC analysis must not have any headspace. All other sample containers must be filled with an allowance for expansion.
4. All samples requiring preservation must be preserved as soon as practically possible, ideally laboratory supplied pre-preserved sample containers will be used.
5. Samples requiring reduced temperature storage should be placed on ice immediately.
6. If using the dipping method by submerging the sample container, it is helpful to complete the label, affix the label to the sample container and cover the label with a clear waterproof sealing tape before immersion.

4. RECORDS

Information generated or obtained by ASL personnel will be organized and accounted for in accordance with project plans. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with ASL SOP 001 Logbooks, ASL SOP 017 Sample and Evidence Management.

5. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

ASL 2013. Standard Operating Procedure 017, Sample and Evidence Management.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-201-R3, Surface Water Sampling.

Aerostar SES LLC
Standard Operating Procedure 005
Groundwater Level and Well Depth Measurements

August 2013
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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures, methods and considerations to be used and observed when conducting groundwater level and well depth measurements.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when well depth and groundwater level measurements. On the occasion that ASL field personnel determine that any of the procedures described in this section cannot be used to obtain accurate measurements, the use of a variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-105-R2, Groundwater Level and Well Depth Measurement (2013). This document is designed to be utilized as a general guideline for water level and well depth measurements, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding groundwater level and well depth measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting groundwater and well depth measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

1. Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by decontaminating the sounders or other measuring devices between wells, according to ASL SOP 015 Field Equipment Cleaning and Decontamination, and maintaining the sounders in clean environment while in transit between wells.
2. Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project as per ASL SOP 001, Logbooks. Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

2. QUALITY CONTROL ISSUES

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

1. Devices used to measure groundwater levels will be periodically verified for accuracy. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. All verification and maintenance data should be documented electronically or recorded in a logbook maintained on site for the project.
2. These devices should be decontaminated according to the procedures specified in the ASL SOP 015 Field Equipment Cleaning and Decontamination prior to use at the next well.

3. WATER LEVEL AND DEPTH MEASUREMENT PROCEDURES

3.1 GENERAL

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging.

All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field logbook.

To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group, if necessary.

Water levels should be allowed to equilibrate prior to measurement after removing well caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

3.2 SPECIFIC GROUNDWATER LEVEL MEASUREMENT TECHNIQUES

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

1. Electronic Water Level Indicators - These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.
2. Other Methods - There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, air line pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells.

3. Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

3.3 TOTAL WELL DEPTH MEASUREMENT TECHNIQUES

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements.

The operator may find it easier to allow the weight to touch bottom and then detect the 'tug' on the tape while lifting the weight off the well bottom. All total depth measurements must be made and recorded to the nearest 0.1 foot. As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe.

4. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-105-R2, Groundwater Level and Well Depth Measurement

Aerostar SES LLC
Standard Operating Procedure 006
Field Measurement of DO

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES LLC (ASL) field personnel when conducting field measurements of dissolved oxygen in groundwater and surface water.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of dissolved oxygen, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-106-R2, Field Measurement of Dissolved Oxygen (2010). This document is designed to be utilized as a general guideline for field measurement procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding dissolved oxygen measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting dissolved oxygen measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

2. QUALITY CONTROL

All dissolved oxygen meters will be maintained and operated in accordance with the manufacturer's instructions and the ASL SOP 027 Equipment Inventory and Management. Before a meter is taken to the field, it will be calibrated and verified to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook. For in-situ measurements, an instrument warm-up period appropriate for that instrument should be provided. Consult manufacturer's documentation for appropriate warm-up time.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperatures, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD MEASUREMENT OF DISSOLVED OXYGEN

3.1 GENERAL

Dissolved oxygen can be defined as the volume of oxygen contained in a volume of water. The solubility of oxygen in water is dependent on the water temperature, salinity, and pressure. As the temperature of the water decreases, the solubility of oxygen increases. As salinity increases, the solubility of oxygen decreases. And finally, as the pressure decreases (altitude increases), the solubility of oxygen decreases.

3.1.1 Clark Cell Probe

Clark cell probes utilize an oxygen permeable membrane that covers an electrolytic cell which consists of a cathode and an anode. The anode acts as a reference electrode. After passing through the permeable membrane, the oxygen is reduced by an applied potential voltage that is referenced to the anode. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid, expressed as %-air saturation. The concentration of oxygen, in mg/1, is calculated based on the %-air saturation reading and the solubility of oxygen in water at the sample temperature.

In general, sample collection using a DO probe requires only lowering the probe into the sample media or connecting the probe to a flow-thru cell and recording or logging the results. The probe should be lowered gently to prevent damage to the membrane and gently turned when initially lowered to remove any attached air bubbles. If the instrument requires the use of a stirrer, the stirrer should be turned on before recording any readings. Prior to use, the instrument should be calibrated and any manufacturer specified warm-up period should be observed.

3.2 CALIBRATION

Many brands of instruments are commercially available for in-situ measurement of dissolved oxygen using Clark cell probes. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use.

Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. In general, calibrations should be conducted at temperatures and pressures as close as possible to those of the sample media for the most accurate measurements, Most dissolved oxygen meters utilize a one-point calibration which is performed using either water saturated air, air-saturated water or the iodometric method. When using the water-saturated air method, the probes should be placed in a 100% relative humidity environment and the temperature and dissolved oxygen readings should be allowed to equilibrate. After equilibration, the meter should be set to read the appropriate dissolved oxygen concentration based on the temperature and barometric pressure,
When using air-saturated water for calibration, an aeration device such as an aquarium pump with a diffusion stone should be placed in a vessel containing tap water. The water in the vessel should be aerated for a minimum of one hour at a constant temperature. Saturation should be verified by placing the dissolved oxygen probe in the vessel and monitoring the temperature and dissolved oxygen readings for stabilization. Avoid placing the probe in the direct stream of air bubbles. Bubbles can accumulate on the probe surface and cause erroneous readings. Once the water is saturated, the temperature of the water and

the barometric pressure can be used to determine the dissolved oxygen value. The meter can then be set to read that value.

3.3 MAINTENANCE

Maintenance procedures vary depending on the technology utilized by each instrument and the manufacturer. The manufacturer's instruction manual should be consulted fore instrument specific procedures. Following are some general guidelines for maintaining dissolved oxygen meters:

1. Inspect probes for damage prior to use.
2. For Clark cell probes, membranes and electrolyte solution should be changed prior to each study, if feasible.
3. Battery voltages should be checked. For meters that will be deployed unattended, new or fully charged batteries should be used for each study.
4. All calibration and maintenance procedures performed should be thoroughly documented.

3.4 CONDUCTING FIELD MEASUREMENT OF DISSOLVED OXYGEN

Following are guidelines for conducting field measurements of dissolved oxygen:

- Except as described in specific operating procedures, dissolved oxygen measurements should if possible be conducted in-situ.
- When measuring DO at distinct points in the water column, the probe should be allowed to equilibrate at each location prior to recording the measurement.
- In water bodies with a great deal of flow, a weight may be attached to the probe guard or support cable to insure the probe is maintained at the proper depth.
- Insure that the measurement location is representative of conditions within the water body or reach. Avoid measurements directly below turbulent sections or still water unless these conditions represent most of the water body or reach.
- If DO measurements are conducted in saline water, the DO meter should either be capable of correcting for salinity or a separate instrument should be used to measure salinity so that the final DO measurements can be corrected.
- When measuring DO through a flow-thru cell, ensure consistent flow through the cell with no water bubbles.

3.5 OPERATIONAL CHECK

It may be appropriate to check the calibration of a DO meter periodically during the course of a day's measurements when conducting individual measurements rather than deploying an instrument. When this is done, it should be noted in the field logbook. The calibration of meters checked throughout the day maybe adjusted if drift is occurring.

4. REFERENCES

ASL 2013. Standard Operating Procedure 027, Equipment Inventory and Management

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-106-R2, Field Measurement of Dissolved Oxygen.

Aerostar SES LLC
Standard Operating Procedure 007
Field Measurement of pH

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used and observed by Aerostar SES LLC (ASL) field personnel when conducting field pH measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of pH, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-100-R3, Field pH Measurement (2013). This document is designed to be utilized as a general guideline for field measurement procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding pH measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting pH measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

All field pH measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the ASL SOP 001 Logbooks and ASL SOP 027 Equipment Inventory and Management.

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to manufacturer’s specifications.

2. QUALITY CONTROL

All pH meters will be maintained and operated in accordance with the manufacturer's instructions and the ASL SOP 027 Equipment Inventory and Management. Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD MEASUREMENT OF PH

3.1 GENERAL

pH is defined as the negative logarithm of the effective hydrogen-ion concentration. For routine work, a pH meter accurate and reproducible to within 0.2 Standard Unit (S.U.) is suitable. Meters should have a range of 0 to 14 S.U. and be equipped with a temperature-compensation adjustment.

3.2 CALIBRATION

Many brands of instruments are commercially available for the measurement of pH incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. At a minimum, a two-point calibration should be conducted to ensure the accuracy of the meter. The following are basic guidelines for calibration/verification:

1. If the pH range of the sample is not known, the pH of the sample to be tested should be estimated either from historical data or by using a four-color pH indicator paper or equivalent. Using this information, calibrate the pH meter with the buffers that bracket the expected pH range. Buffer solutions are commonly pH 4, 7 and 10. It may be possible to configure the pH meter so that it can be standardized with buffers other than those in the default configuration.
2. Immerse the probe in the first buffer solution and calibrate the meter to read the correct pH. After the initial buffer calibration, calibrate the meter using other buffer solutions, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water between the different buffer solutions. Record the buffer values and temperatures used to calibrate the meter.
3. Rinse the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer and read as a sample. If the meter reads within ± 0.2 S.U. of the known value of the buffer, record the value indicated by the meter. If the meter is outside of the acceptable accuracy range, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the electrode and/or meter should be replaced.
4. Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it according to manufacturer's recommendations. Certain instruments may require being left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against a known calibration buffers if used for extended periods (> 4 hrs.).

3.3 CONDUCTING FIELD MEASUREMENT OF PH

These procedures should be followed when conducting field pH measurements of grab samples:

1. Collect a sample. If the meter's thermistor is to be used for the temperature of record for the measurement activity, the temperature should be read as soon as the reading stabilizes and prior to measuring the pH.
2. Immerse the probe in the sample keeping it away from the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.
3. While suspending the probe away from the sides and bottom of the sample container, record the pH.
4. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution until the next sample is ready.

These procedures should be followed when conducting in-situ or flow-through cell field pH measurements:

1. Place the probe into the media to be measured and allow the pH and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.
2. When deploying meters for extended periods of time, insure the measurement location is representative of average media conditions.

4. OPERATIONAL CHECK

Even though it is not necessary to re-calibrate pH meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

1. While in use, periodically check the pH by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer solution. If the measured pH differs by > 0.2 S.U. or 0.1 S.U. (depending on the application) from the buffer solution, the meter must be recalibrated.

5. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 027, Equipment Inventory and Management

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-100-R3, Field pH Measurement.

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Standard Operating Procedure 009
Field Measurement of Specific Conductance

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES LLC (ASL) field personnel when conducting field specific conductance measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of specific conductance, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-101-R5, Field Specific Conductance Measurement. This document is designed to be utilized as a general guideline for field measurement procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding specific conductance measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL CONSIDERATIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting specific conductivity measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

All field specific conductance measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the ASL SOP 001 Logbooks and ASL SOP 027 Equipment Inventory and Management.

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to manufacturer’s specifications.

2. QUALITY CONTROL

All specific conductivity instruments will be maintained and operated in accordance with the manufacturer's instructions and the ASL SOP 027 Equipment Inventory and Management. Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD SPECIFIC CONDUCTANCE MEASUREMENT PROCEDURES

3.1 GENERAL

Specific conductance is a measure of the ability of an aqueous solution to conduct an electric current and is customarily reported in microsiemens per centimeter (µS/cm) or micromhos per centimeter (µmhos/cm) at 25°C.

3.2 INSTRUMENT CALIBRATION AND VERIFICATION

Many brands of instruments are commercially available for the measurement of specific conductance incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

Conductivity is affected by temperature; therefore, for instruments that do not automatically compensate for temperature, the user should document temperature first so that appropriate adjustments can be made in accordance with the manufacturer's instructions and/or method. The following are basic guidelines for calibration/verification and are provided as an example:

1. Rinse the probe with de-ionized water and blot dry before conducting the following calibration and verification checks.
2. Immerse the probe in the standard solution and calibrate or verify the meter against that solution. Fresh standards should be used for each calibration.
   Note: Some instruments require that calibration standards reflect the anticipated specific conductance of the media being measured.
3. Some meters will auto-recognize standards during calibration. For example, the Orion Star Series meter will auto-recognize standards 1413 uS/cm, 100 uS/cm and 12.9 mS/cm. If the meter is calibrated in a manner where it does not auto-recognize the standard, and the meter is not accurate to within ± 10 % of the standard solution(s) known values, the meter or probe should be repaired or replaced. If this condition can be corrected by adjusting the cell constant of the probe, refer to the instruction manual and make the adjustment.
4. After calibration is complete, place the probe back into the calibration standard used and record a post-calibration reading. Record a post calibration reading for each standard used. If the meter is not accurate to within ± 10 % of the standard solution(s) known values, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the probe and/or meter should be replaced.

5. Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution. Certain meters may require that the instrument be left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against the known calibration standards if used for extended periods (> 4 hrs.).

3.3 SAMPLE MEASUREMENT PROCEDURES

The following procedures should be followed when conducting field specific conductance measurements of grab samples:

1. Collect the sample, check and record its temperature.
2. Correct the instrument's temperature adjustment to the temperature of the sample (if required).
3. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the center portion of the probe be wetted by the sample.
4. Allow meter to stabilize. Record the results in a logbook.
5. Rinse probe with de-ionized water.

The following procedures should be followed when conducting in-situ and flow-through cell field specific conductivity measurements:

1. Place the probe into the media to be measured and allow the specific conductivity and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.
2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 OPERATIONAL CHECKS

Even though it is not necessary to re-calibrate conductivity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change, have impacted the meter's performance. If an operational check is warranted, the following procedures should be followed to ensure that the performance of the meter has not changed.

Check the conductivity meter with fresh conductivity standard. Rinse the conductivity probe with deionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate conductivity standard. If the measured conductivity value is not with ± 10% of the standard, the probe should be re-calibrated. If the probe is still not within ± 10% of the standard, the probe should be repaired or replaced. These measurements must be recorded in the field logbook.

REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 027 Equipment Inventory and Management.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-101-R5, Field Specific Conductance Measurement

Aerostar SES LLC
Standard Operating Procedure 010
Field Measurement of Temperature

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES LLC (ASL) field personnel when conducting field temperature measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of temperature, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-102-R3, Field Temperature Measurement. This document is designed to be utilized as a general guideline for field measurement procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding temperature measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting temperature measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

2. QUALITY CONTROL

All thermometers should be maintained and operated in accordance with the manufacturer's instructions and the ASL SOP 027 Equipment Inventory and Management. Temperature measurement devices such as pH, conductivity and dissolved oxygen (DO) meter thermistors will be calibrated at the same time as the parent device.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD TEMPERATURE MEASUREMENT PROCEDURES

3.1 GENERAL

Field temperature measurements may be made with a field thermometer, equipment thermistor, or NIST-traceable thermometer. At a minimum, the temperature measurement device should be capable of measuring in 0.1°C increments.

3.2 INSPECTIONS

All temperature measurement devices should be inspected for leaks, cracks, and/or function prior to each use. It should be noted that temperature probe calibration cannot be performed by ASL field personnel and calibration and maintenance should be conducted by the manufacturer.

3.3 SAMPLE MEASUREMENT PROCEDURES

(Make measurements in-situ when possible)

1. Clean the probe end with de-ionized water and immerse into sample.
2. If not measuring in-situ, swirl the instrument in the sample for mixing and equilibration.
3. Allow the instrument to equilibrate with the sample for at least one minute.
4. Suspend the instrument away from the sides and bottom, if not in-situ, to observe the temperature reading.
5. Record the reading in the log book. For most applications, report temperature readings to the nearest 0.5°C or to the nearest 0.1°C depending on need.

Note: Always clean the thermometer with de-ionized water or a detergent solution, if appropriate, prior to storage and/or use.

3.4 UNITS

Degrees Celsius (°C) or Degrees Fahrenheit (°F)
Conversion Formulas:
°F = (9/5 °C) + 32   or   °C = 5/9 (°F - 32)

4. REFERENCES

ASL SOP 001 Logbooks and ASL SOP 027 Equipment Inventory and Management

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-102-R3, Field Temperature Measurement

Aerostar SES LLC
Standard Operating Procedure 011
Field Measurement of Turbidity

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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES LLC (ASL) field personnel when conducting field turbidity measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of turbidity, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-103-R3, Field Turbidity Measurement. This document is designed to be utilized as a general guideline for field measurement procedures, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding turbidity measurements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting turbidity measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern

1.3.2 Procedural Precautions

All field turbidity measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the ASL SOP 001 Logbooks and ASL SOP 027 Equipment Inventory and Management.

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to manufacturer’s specifications.

2. QUALITY CONTROL

All turbidity meters and probes shall be maintained and operated in accordance with the manufacturer's instructions and the ASL Procedure for Equipment Inventory and Management. Before a meter or probe is taken to the field, it shall be properly calibrated or verified, according to Sections 3.2 and 3.3 of this procedure, to ensure it is operating properly. These calibration and verification checks shall be documented and maintained in a logbook.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD TURBIDITY MEASUREMENT PROCEDURES

3.1 GENERAL

Turbidity is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic organisms. Many methods are available for the measurement of turbidity including turbidimeters and optical probes. Turbidity is measured by determining the amount of scatter when a light is passed through a sample.

3.2 INSTRUMENT CALIBRATION AND VERIFICATION

Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use OR on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within ± 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:

3.2.1 Meter Calibration and Verification

3.2.1.1 HACH 2100Q Turbidimeter:

Portable turbidimeters are calibrated with Formazin Primary Standards. The manufacturer recommends calibration with a primary standard such as StablCal® Stabilized Standards or with formazin standards every three months.

Generally only a calibration verification measurement is required in the field; however, if a calibration is needed, record a post calibration reading for each calibration standard used.

3.2.1.2 Meter verification:

1. Push Verify Cal to enter the Verify menu.
2. Gently invert the liquid standard several times prior to insertion into meter. Insert the 10.0 NTU (or other defined value) Verification Standard and close the Lid.
3. Push Read. The display shows "Stabilizing" and then shows the result and tolerance range.
4. Push done to return to the reading display. Repeat the calibration verification if the verification failed. If a meter is unable to pass verification, then that meter will need to be calibrated.

3.2.1.3 Meter calibration:

1. Push the CALIBRATION key to enter the Calibration mode. Follow the instructions on the display. Note: Gently invert each standard several times before inserting the standard and use a non-abrasive, lint-free paper or cloth to wipe off the standards.
2. Insert the 20 NTU StablCal Standard and close the lid. Push Read. The display shows "Stabilizing" and then shows the result. Record the result.
3. Repeat Step 2 with the 100 NTU and 800 NTU StablCal Standard. Record both results.
4. Push Done to review the calibration details.
5. Push Store to save the results. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

3.2.2 Probe Calibration and Verification

The manufacturer's instruction manual should be consulted for specific procedures regarding probe's calibration, maintenance and use. Their calibration must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. The following are basic guidelines for calibration/verification of probes and are provided as an example:

1. Turn the meter "ON" and allow it to stabilize
2. Immerse the probe in the first standard solution and calibrate the probe against the solution.
3. Rinse the probe with de-ionized water, remove excess rinse water and calibrate the probe using additional standards as appropriate.
4. Record the standard values used to calibrate the meter.

3.3 SAMPLE MEASUREMENT PROCEDURES

3.3.1 Grab Sample Measurement

These procedures should be followed when conducting turbidity measurements of grab samples: Collect a representative sample and pour off enough to fill the cell to the fill line (about 15 mL) and replace the cap on the cell.

1. Wipe off excess water and any streaks with a soft, lint-free cloth (lens paper).
2. Turn instrument on. Place the meter on a flat, sturdy surface. Do not hold the instrument while making measurements.
3. Insert the sample cell in the instrument so the diamond or orientation mark aligns with the raised orientation mark in the front of the cell compartment. Close the lid.
4. If appropriate, select manual or automatic range selection by pressing the range key.
5. If appropriate, select signal averaging mode by pressing the Signal Average key. Use signal average mode if the sample causes a noisy signal (display changes constantly).
6. Press Read. The display will show — NTU. Then the turbidity is displayed in NTU. Record the result after the lamp symbol turns off.
7. Rinse the cell with de-ionized water or rinse out with sample water prior to the next reading.

3.3.2 In-Situ Measurement

These procedures should be followed measurements:

1. When conducting in-situ turbidity measurements or using a flow-through cell, place the probe into the media to be measured and allow the turbidity reading to stabilize. Once the reading has stabilized, record the measurement in the logbook.

2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 OPERATIONAL CHECK

Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by ± 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated.

3.5 UNITS

Turbidity measurements are reported in nephelometric turbidity units (NTUs).

4. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 027 Equipment Inventory and Management

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDPROC-103-R3, Field Turbidity Measurement.

Aerostar SES LLC
Standard Operating Procedure 012
Sediment Sampling

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1. GENERAL INFORMATION

1.1 Purpose

This procedure is to be used by Aerostar SES LLC (ASL) field personnel when collecting sediment samples for field screening or analysis.

1.1 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a sediment sample, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the U.S. Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA, 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-200-R2, Sediment Sampling. This document is designed to be utilized as a general guideline for field sample collection procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding sediment sampling. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.2 GENERAL PRECAUTIONS

1.2.1 Safety

Proper safety precautions must be observed when conducting sediment samples. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.2.2 Procedural Precautions

The following precautions should be considered when collecting sediment samples.

1. Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
2. Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
3. If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
4. Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
5. Documentation of field sampling is done in a bound logbook.
6. Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
7. All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project manager and stored in a secure place.

2. SPECIAL SAMPLING CONSIDERATIONS

2.1 SEDIMENT SAMPLES FOR VOLATILE ORGANIC COMPOUNDS (VOCS)

If samples are to be analyzed for volatile organic compounds (VOCs), they should be collected in a manner that minimizes disturbance of the sample. The sample for VOC analysis should be collected directly from the sample device, if possible, before it is emptied into the homogenization pan. It may not be possible to do this with certain types of sediment sampling equipment. In cases such as these, the VOC aliquots should be collected from the retrieval device immediately after they have been deposited in the pan and prior to any mixing. The sample shall be placed in the appropriate container (En Core® Sampler or other Method 5035 compatible container) with no headspace. Samples for VOC analysis are not homogenized. Preservatives may be required for some samples with certain variations of Method 5035. Consult the method description below in Section 2.2, Sediment Sampling (Method 5035) or the principal analytical chemist to determine if preservatives are necessary.

In some cases, the sediment may be soft and not lend itself to collection by plunging En Core® Samplers or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sample device, i.e., the En Core® Sampler barrel or syringe, prior to sample collection, and to carefully place the sediment in the device, filling it fully with the required volume of sample.

2.2 SEDIMENT SAMPLING (METHOD 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in sediments at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

2.2.1 Equipment

Once the sediment has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. sediment VOC container, or pre-prepared 40 ml vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

2.2.2 Sampling Methodology- Low Concentrations

When the total VOC concentration in the sediment is expected to be less than 200 ug/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 ml pre-prepared vial) immediately to reduce volatilization losses. The 40 ml vials should contain 10 ml of organic-free water for an un-preserved sample or approximately 10 ml of organic-free water and a preservative. It is recommended that the 40 ml vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A sediment sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 ml pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. sediment jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 ml pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Sediment samples may be prepared for shipping and analysis as follows:

1. En Core® Sampler - the sample shall be capped, locked, and secured in a plastic bag.

2. Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-ml pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

3. Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 ml containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

2.2.3 Sampling Methodology- High Concentrations

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Sediments containing high total VOC concentrations may also be collected as described in Section 2.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 ml methanol.

2.2.4 Special Techniques and Considerations for Method 5035

2.2.4.1 Effervescence

If low concentration samples effervesce from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic-free water. An appropriate amount of organic-free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

2.2.4.2 Sample size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

2.2.4.3 Holding times

Sample holding times are specified in project work plans. Field investigators should note that the holding time for an un-preserved VOC sediment sample is 48 hours. Arrangements should be made to ship the sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

2.2.4.4 Percent moisture

Samplers must ensure that the laboratory has sufficient material to determine percent moisture in the VOC sediment sample to correct the analytical results to dry weight. If other analyses requiring percent moisture determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent moisture determination will be required.

2.2.4.5 Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

2.2.4.6 Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities. A summary of the requirements for shipping samples follows. Refer to the code for a complete review of the requirements.

1. The maximum volume of methanol or sodium bisulfate in a sample container is limited to thirty (30) ml.
2. The sample container must not be full of methanol.
3. The sample container must be stored upright and have the lid held securely in place. Note that the mechanism used to hold the cap in place must be able to be completely removed so weight is not added to the sample container, as specified in Method 5035.
4. Sample containers must be packed in an absorbent material capable of absorbing spills from leaks or breakage of the sample containers.
5. The maximum sample shuttle weight must not exceed 64 pounds.
6. The maximum volume of methanol or sodium bisulfate per shipping container is 500 ml.
7. The shipper must mark the sample shuttle in accordance with shipping dangerous goods in acceptable quantities.
8. The package must not be opened or altered until no longer in commerce.

Table 2-1 lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. ASL’s goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

Table 2-1 Compliance Options

Option			Disadvantages
1	Collect 2-40 ml vials with ~5 grams of sample and 1 - 2 oz. glass w/septum lid for screening and % moisture	Screening conducted by lab	Presently a 48 hour holding time for unpreserved samples
2	Collect 3 EnCore® Samplers and 1 - 2oz. glass w/septum lid for screening and % moisture	Lab conducts all preservation/preparation procedures	Presently a 48 hour holding time for preparation of samples
3	Collect 2 - 40 ml vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and 1 - 2 oz. glass w/septum lid for screening and % moisture	High level VOC samples may be composited Longer holding time	Hazardous materials used in field
4	Collect 1 - 2 oz. glass w/septum lid for analysis and % moisture	Lab conducts all preservation/preparation procedures	May have significant VOC loss

2.3 SPECIAL PRECAUTIONS FOR TRACE CONTAMINANT SEDIMENT SAMPLING

1. A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
2. Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately. All background samples shall be collected and placed in separate ice chests or shipping containers. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. In flowing water bodies, samples should be collected from the most downstream, location first working upstream. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
3. If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
4. Samplers must use new, verified and certified-clean disposable or non-disposable equipment cleaned according to procedures contained in ASL SOP 015 Field Equipment Cleaning and Decontamination.

2.4 SAMPLE HOMOGENIZATION

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 5
2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same volume.
3. All sediment samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. Samples for VOC analysis are not homogenized. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

a. The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
b. Two quarters should then be mixed to form halves.
c. The two halves should be mixed to form a homogenous matrix.
d. This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.
e. Place the sample into an appropriate, labeled container(s) using the alternate shoveling method and secure the cap(s) tightly. Threads on the container and lid should be cleaned to ensure a tight seal when closed.
f. Return any unused sample material back to the location from which the sample was collected.

2.5 QUALITY CONTROL

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. The control sample should be collected at an upstream location in the same stream or conveyance from which the primary samples area collected. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools.

2.6 RECORDS

Information generated or obtained by ASL personnel will be organized and accounted for in accordance with project plans. Field notes, recorded in a bound logbook will be generated, as well as chain of custody documentation in accordance with ASL SOP 001, Logbooks and ASL SOP 017, Sample and Evidence Management.

3. GENERAL CONSIDERATIONS

3.1 GENERAL

The sediment sampling techniques and equipment described in the following Section 4 of this procedure document are designed to minimize effects on the chemical and physical integrity of the sample. If the procedures in this section are followed, a representative sample of the sediment should be obtained.

3.2 EQUIPMENT SELECTION CONSIDERATIONS

The physical location of the investigator when collecting a sample may dictate the equipment to be used. Wading is the preferred method for reaching the sampling location, particularly if the stream has a noticeable current (is not impounded). However, wading may disrupt bottom sediments causing biased results; therefore, the samples should be collected facing upstream. If the stream is too deep to wade, the sediment sample may be collected from a platform such as a boat or a bridge.

To collect a sediment sample from a water body or other surface water conveyance, a variety of methods can be used:

- Scoops and spoons
- Dredges (Ponar, Young)

- Coring Devices (tubes, Shelby tubes, Ogeechee Sand Pounders©, and augers)
- Vibracore® (Electronic Vibratory Core Tube Driver)

Regardless of the method used, precautions should be taken to insure that the sample collected is representative of the media. The most common method of collection is discussed in the following paragraphs.

4. STAINLESS STEEL SCOOPS AND SPOONS

4.1 WADING

If the conveyance is dry or is a wadeable surface water body, the easiest way to collect a sediment sample is by using a stainless steel scoop or spoon. If the conveyance is dry, the sediment is accessed directly and is collected using either the stainless steel scoop or spoon. If the conveyance is a wadeable stream or other water body, the method is accomplished by wading into the surface water body and while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed/drained from the scoop or spoon. However, this may result in the loss of some fine-grained particle size material associated with the substrate being sampled. Care should be taken to minimize the loss of this fine-grained material. Aliquots of the sample thus collected are then placed in a glass pan and homogenized according to the quartering method described in Section 2.4.

4.2 BANK/PLATFORM SAMPLING

In surface water bodies that are too deep to wade, but less than eight feet deep, a stainless steel scoop or spoon attached to a piece of conduit can be used either from the banks, if the surface water body is narrow, or from a boat. Again, care should be taken to minimize the loss of the fine particle sizes. The sediment is placed into a glass pan and mixed according to the quartering method described in Section 2.4.

5. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

ASL 2013. Standard Operating Procedure 017, Sample and Evidence Management.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

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Aerostar SES LLC
Standard Operating Procedure 013
Soil Sampling

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures, methods and considerations to be used and observed when collecting soil samples for field screening or analysis.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and do not meet project data quality objectives, alternate sampling methods may be employed. Alternate procedure will be documented in the field log book, along with a description of the circumstances requiring their use. Alternate procedures must be approved by the Project Manager and the Project Quality Assurance Manager.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-300-R2, Soil Sampling (2011). This document is designed to guide field personnel in proper soil collection procedures for typical field projects. However, before beginning any field effort check for local, state, and federal regulations that may supersede the procedures contained herein.

1.3 SAFETY

Proper safety precautions must be observed when conducting soil sampling. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.1 Procedural Precautions

The following precautions should be considered when collecting soil samples.

1. Special care must be taken not to cross contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
2. Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
3. If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
4. Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
5. Documentation of field sampling is done in a bound logbook.
6. Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
7. All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and stored in a secure place.

1.4 SAMPLING CONSIDERATIONS

1. A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
2. Sample containers for samples suspected of containing high concentrations of contaminants shall be collected, handled and stored separately.
3. All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
4. If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
5. Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESG-015 Field Equipment Cleaning and Decontamination, for collection of samples for trace metals or organic compound analyses.

1.5 RECORDS

Information generated or obtained by ASL personnel will be organized and accounted for in accordance with project plans. Field notes, recorded in a bound logbook will be generated, as well as chain of custody documentation in accordance with ASL SOP 001, Logbooks and ASL SOP 017, Sample and Evidence Management.

2. MANUAL SOIL SAMPLING METHODS

2.1 GENERAL

These methods are used primarily to collect surface and shallow subsurface soil samples. If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

2.2 SPOONS

Stainless steel spoons may be used for surface soil sampling where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

2.2.1 Special Considerations when using spoons

When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or Terracore® sampler used to collect the sub-sample for Method 5035 should be collected directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to collecting the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation DQOs.

2.3 HAND AUGERS

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning the sampler using an attached handle with extensions (if needed). The bucket should be advanced to the appropriate depth and the contents transferred to the homogenization container for processing. Observe precautions for volatile organic compound sample collection found in Section 9, Method 5035.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torqueing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

2.3.1 Special Considerations for Soil Sampling with the Hand Auger

1. Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
2. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035. Collect the VOC sample directly from the auger bucket, if possible.
3. Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
4. When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

3. MECHANICAL METHODS

3.1 DIRECT PUSH SOIL SAMPLING METHODS

3.1.1 General

Direct push sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. It should be noted that if gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

3.1.1.1 Special Considerations when using Direct Push Sampling Method

Liner Use and Material Selection - Direct push soil samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terepthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. Typically, the standard polymer liner material for a sampling tool will be acceptable. When project DQO's require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.

1. Sample Orientation - When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the core liner. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Orientation can be indicated by marking on the exterior of the liner with a permanent marker.
2. Core Catchers - Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.
3. Decontamination - The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESG-015.
4. Decommissioning - Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet depth that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface, or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.

4. SPLIT SPOON/DRILL RIG METHODS

4.1 GENERAL

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon, advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

4.2 STANDARD SPLIT SPOON

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

4.3 CONTINUOUS SPLIT SPOON

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

4.4 SPECIAL CONSIDERATIONS WHEN USING SPLIT SPOON METHODS

Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

5. SHELBY TUBE/THIN WALLED SAMPLING METHODS

5.1 GENERAL

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

5.2 SHELBY TUBE SAMPLING METHODS

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

6. BACKHOE SAMPLING METHOD

6.1 GENERAL

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

6.2 SCOOP METHOD

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop. First a scoop with a long handle is lowered into the backhoe pit to scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

6.3 DIRECT FROM BUCKET METHOD

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

6.4 SPECIAL CONSIDERATIONS WHEN SAMPLING WITH A BACKHOE

1. Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.
2. Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.
3. Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
4. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

6.5 SAMPLE HOMOGENIZATION

Samples for VOC analysis should not homogenized. Samples to be collected for other analysis may be homogenized based on site specific data quality objectives.

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.
2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.
3. All soil samples must be thoroughly mixed to ensure that the sample is representative of the sample media. The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows: The material in the sample pan/bowl should be divided into quarters and each quarter should be mixed individually. Two quarters should then be mixed to form halves. The two halves should be mixed to form a homogenous matrix.
4. This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until each container is full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

7. ANALYTICAL CONSIDERATIONS

All soil samples should be labeled in accordance with project requirements and stored on ice immediately after sample collection. Typically soil samples are collected into un-preserved 4 oz glass jars. However, certain analysis may require additional equipment, containers and/or preservatives. Below describes the procedures for collecting samples for VOC analysis.

7.1 METHOD 8260C FOR VOC ANALYSIS

If project DQO's indicate grab soil samples are to be collected for analysis of VOCs via method 8260C, collected soils (using the manual/mechanical methods described above) will be placed into a 4 oz glass jar with a septum lid.

7.2 METHOD 5035 FOR VOC ANALYSIS

The procedures outlined here are summarized from Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035. This method uses a closed-system purge-and-trap process for the analysis of low concentration (0.5-200 µg/kg) volatile organic compounds (VOCs) in solid materials (e.g., soils, sediments, and solid waste). When method 5035 is to be used, the following sampling protocol should be followed.

7.2.1 Equipment

Soil aliquots for VOC analysis may be collected using either the EnCore® Sampler, TerraCore® sampler or other Teflon syringe. Soils are collected by advancing the sampling device into the soil to be analyzed. Soils may be retrieved from the subsurface using the methods described in Sections 4-8 of this procedures. When using the TerraCore®, a typical 5 gram soil sample is ejected into a pre-preserved 40 mL vials. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

7.2.2 Sampling Methodology – Low Concentrations

When the total VOC concentration in the soil is expected to be less than 200 ug/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately 10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape.

Syringe - Add the 5 grams of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

7.2.3 Sampling Methodology – High Concentrations

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils containing high total VOC concentrations may also be collected as described in Section 3.2.2 and preserved using 10 mL methanol.

7.2.4 Special Techniques and Considerations for method 5035

7.2.4.1 Effervescence

If low concentration samples effervesce from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

7.2.4.2 Sample size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

7.2.4.3 Holding times

Sample holding times are specified in the Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil sample at 4ºC is 48 hours. Arrangements should be made to ship the soil VOC samples to the laboratory by overnight delivery the day of collection so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

7.2.4.4 Percent moisture and preservative compatibility (MOICA)

Samplers must ensure that the laboratory has sufficient material to determine percent moisture in the VOC soil sample to correct the analytical results to dry weight. A separate sample (minimum of 2 oz.) for percent moisture determination will be required. The sample collected for percent moisture may also be used by the laboratory to check for preservative compatibility.

7.2.4.5 Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

7.2.4.6 Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

8. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 017 Sample and Evidence Management

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2011. Operating Procedure SESDPROC-300-R2, Soil Sampling

Aerostar SES LLC
Standard Operating Procedure 014
Field Sampling of Total Residual Chlorine

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures, methods and considerations to be used and observed when conducting field screening of total residual chlorine in surface water and wastewater effluent.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement for total residual chlorine, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

1.3 DOCUMENTATION/VERIFICATION

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-112-R3, Field Screening of Total Residual Chlorine. This document is designed to be utilized as a general guideline for field measurement procedures; however, field personnel must always keep in mind that, different projects, and different states, may have specific regulations regarding total residual chlorine measurements. Before beginning any field effort, check for local, state, and federal regulations that may supersede this document.

1.4 SAFETY PRECAUTIONS

Proper safety precautions must be observed when conducting pH measurements. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

2. QUALITY CONTROL

All total residual chlorine meters will be maintained and operated in accordance with the manufacturer's instructions and the ASL SOP 027 Equipment Inventory and Management. Before a meter is taken to the field, it will be verified according to Section 3.2 of this procedure to ensure it is operating properly. Calibration verifications and maintenance procedures will be documented and maintained in a logbook.

The following are general guidelines for maintaining total residual chlorine meters:

1. Each meter should be visually inspected before and after each use.
2. Check the battery strength.
3. Ensure that the reagents are fresh and up to date before field trips.
4. Ensure that gel standards are up to date prior to use.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer's specified range of operating temperatures.

If, at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3. FIELD SCREENING OF TOTAL RESIDUAL CHLORINE

3.1 GENERAL

The chlorination of water supplies and polluted water serves primarily to destroy or deactivate disease-producing microorganisms. Chlorine applied to water in its molecular or hypochlorite form initially undergoes hydrolysis to form free available chlorine. Free available chlorine reacts with ammonia and certain nitrogenous compounds to form combined chlorine.

Chlorination may produce adverse effects. Potentially carcinogenic chloro-organic compounds such as chloroform may be formed. To fulfill the primary purpose of chlorination and to minimize any adverse effects, it is essential that proper testing procedures be used. Several methods for measurement of total residual chlorine are available including iodometric methods, amperometric titration methods, and N,N-diethyl-p-phenylenediamine (DPD) methods. This operating procedure will discuss a DPD Colorimetric Method.

3.2 INITIAL VERIFICATION CHECK

The pocket colorimeter shall be checked with a minimum of three gel standards and a blank. Table 3-1 shows the specific tolerance range for the gel standard used in the verification process.

Table 3-1 Specific Tolerance Range

Calibration Standard (mg/L)	Certificate of Analysis
STD 1	0.23 +/- 0.09
STD 2	0.93 +/- 0.10
STD 3	1.66 +/- 0.014
Blank	0 .00

When checking the instrument verification against the three gel standards, the observed values should be within the applicable tolerance range of the Certificate of Analysis for each gel standard. The tolerance ranges must be verified for each new batch of gel standards against its Certificate of Analysis and documented in a logbook prior to use in field activities.

3.3 FIELD MEASUREMENT PROCEDURES FOR SCREENING PURPOSES

Total or free residual chlorine measurements must be conducted within 15 minutes of sample collection. When using the DPD colorimetric method for total residual chlorine, gel standards will be used for meter verification.

Once the meter has been verified for field screening purposes, the following steps should be followed using a 2.5 cm sample cell for total residual chlorine concentrations ranging from 0 - 1.66 mg/L.

1. Fill a clean sample cell to the 10-mL mark with a sample blank. Cap the sample cell.
2. Press the Power key to turn the meter on.

3. Remove the meter's cover. Wipe off any excess liquid and fingerprints from the sample cell. Place the blank in the cell holder with the diamond mark facing the keypad. Fit the meter cover over the cell compartment to completely cover the cell.
4. Press the ZERO button.   The display will show "   " then go to "0.00".
5. Record the blank's value in the logbook. Remove the blank from the cell h Fill a second 10-mL cell to the 10-mL line with the sample.
6. Open a DPD total chlorine powder packet and add the contents to the sample cell.
7. Replace the cap on the sample cell and swirl or mix for approximately 20 seconds. Note: Wipe off any excess liquid and fingerprints from the sample cell.
8. Wait three to six minutes after adding the DPD.
9. Press READ/ENTER. The instrument will show “---------” followed by the actual results in mg/L chlorine. Record the sample's value in the logbook.

Also for screening purposes, all of the above steps should be followed using a 1.0 cm sample cell for total residual chlorine concentrations above 1.66 mg/L.

3.4 UNITS

Measurements for total residual chlorine are reported in mg/L.

3.5 LIMITATIONS

Do not use with or in the presence of any oxidizing agents including bromine, iodine, permanganate, hydrogen peroxide, and ozone. Sample color and turbidity may also interfere.

Aerostar SES LLC
Standard Operating Procedure 015
Field Equipment Cleaning and Decontamination

August 2013
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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the office. On the occasion that ASL field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-205-R2 Field Equipment Cleaning and Decontamination (EPA 2011). This document is designed to be utilized as a general guideline for field decontamination procedures, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding equipment cleaning and decontamination. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting decontamination procedures. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.
- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.3.2 Procedural Precautions

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

1.4 HANDLING PRACTICES AND CONTAINERS FOR CLEANING SOLUTIONS

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

1.5 SAMPLE COLLECTION EQUIPMENT CONTAMINATED WITH ENVIRONMENTAL MEDIA

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

- Wipe the equipment clean;
- Water-rinse the equipment;
- Wash the equipment in detergent and water followed by a tap water rinse.
- For grossly contaminated equipment, the procedures set forth in Section 2.3 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the office without being field cleaned. If possible, field personnel should be notified that equipment will be returned without being field cleaned. It is the Site Supervisor's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

1.6 HANDING OF DECONTAMINATED EQUIPMENT

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

2. FIELD EQUIPMENT DECONTAMINATION PROCEDURES

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

2.1 SPECIFICATIONS FOR DECONTAMINATION PADS

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.
- The pad should not leak.
- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.
- Water should be removed from the decontamination pad frequently.
- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.
- At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See ASL SOP 021 Management of Investigation Derived Waste for proper handling and disposal of these materials.

2.2 CLASSICAL PARAMETER SAMPLING EQUIPMENT

Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 2.2 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

2.3 SAMPLING EQUIPMENT USED FOR THE COLLECTION OF TRACE ORGANIC AND INORGANIC COMPOUNDS

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

- Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Luminox® detergent and high pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.
- Rinse thoroughly with tap water.
- Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to air-dry.
- All equipment must be wrapped with foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

2.4 WELL SOUNDERS OR TAPES

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

- Wash with detergent and tap water.
- Rinse with tap water.
- Rinse with distilled water.

2.5 SUBMERSIBLE PUMPS

CAUTION - Do not wet the controller. Always disconnect power from the pump when handling the pump body.

Submersible pumps and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

2.5.1 Groundwater Purging and Sampling Pumps

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately. Wash the pump exterior with detergent and water.
2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution.
3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.
4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.
5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.
6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.
7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.
8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.
9. Place the pump and reel in a clean plastic bag.

2.5.2 Pump Check Valves

Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.

- Using a brush, scrub all components with detergent and tap water.
- Rinse with deionized water.

- Replace the ball check valve to the pump head.

2.6 DOWNHOLE DRILLING EQUIPMENT

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 2.2 of this procedure. Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank. A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam (200ºF plus), with a detergent compartment, should be obtained.

2.6.1 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

All downhole augering, drilling, and sampling equipment should be steam cleaned before use. Any portion of the drilling equipment that is over the borehole (Kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.

Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

2.6.2 Drill Rig Field Cleaning Procedures

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, direct push tooling and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 2.4 of this procedure.

- Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.
- Rinse thoroughly with tap water.
- Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3. REFERENCES

ASL 2013. Standard Operating Procedures 021 Management of Investigation Derived Waste

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2011. Operating Procedure SESDPROC-205-R2 Field Equipment Cleaning and Decontamination.

Aerostar SES LLC
Standard Operating Procedure 016
Shipping Environmental and Waste Samples

August 2013
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1. GENERAL INFORMATION

1.1 PURPOSE

This procedure is to be used by Aerostar SES, LLC (ASL) field personnel for the purposes of shipping environmental samples. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by Department of Transportation under 49 CFR, Subchapter C, Hazardous Materials Regulations, and the International Air Transport Authority (IATA). This document describes general and specific procedures, methods and considerations to be used and observed by ASL field investigators when packing, marking, labeling and shipping environmental and waste samples to ensure that all shipments are in compliance with the above regulations and guidance.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when packing, marking, labeling, and shipping environmental samples and dangerous goods. Samples collected during field investigations or in response to a hazardous materials incident must be classified prior to shipment, as either environmental or hazardous materials (dangerous goods) samples.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-209-R2, Packing, Marking, Labeling, and Shipping of Environmental Waste Samples. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when packing, marking, labeling, and shipping environmental or waste samples. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern

2. SHIPMENT OF DANGEROUS GOODS

The Project Manager is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, then that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for that material. If the composition of the collected sample(s) is unknown, and the project manage knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport.

In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Shipment of nitric acid is strictly regulated. Consult the IATA Dangerous Goods Regulations for guidance.

2.1 PACKAGING PROCEDURES

Environmental samples should be packed prior to shipment using the following procedures:

1. Allow sufficient headspace (ullage) in all bottles (except VOA containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).
2. Ensure that the lids on all bottles are tight (will not leak).
3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags.
4. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape inside and outside. Line the cooler with a large heavy duty plastic bag.
5. Place cushioning/absorbent material in the bottom of the cooler and then place the containers in the cooler with sufficient space to allow for the addition of cushioning between the containers.
6. Put "blue ice" (or ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed) on top of and/or between the containers. Fill all remaining space between the containers with absorbent material.
7. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape).
8. Place the Chain-of-Custody Record into a plastic bag, and tape the bag to the inner side of the cooler lid.
9. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

3. SHIPMENT OF ENVIRONMENTAL SAMPLES

Environmental samples are shipped as non-hazardous material unless the samples meet the established DOT criteria for a “hazardous material” or the International Air Transport Association, ICAO Technical Instructions, and IMDG Code definition of “dangerous goods”. When preparing the cooler for shipment, labels from the outside of the container are removed while being careful not to disturb the custody seals. When completing the paperwork for shipment, the standard non-hazardous shipping forms provided by the courier are completed.

Environmental samples shipped as dangerous goods or hazardous material will conform to DOT, IATA, and IMDG regulations governing the shipment of hazardous materials and dangerous goods. These regulations (49 CFR Parts 171 - 180 and the Dangerous Goods Regulations [DGR] for IATA and IMDG) describe proper marking, labeling, placarding, packaging, and shipping of hazardous materials. IATA regulations apply strictly to both domestic and international commercial air transportation. The IMDG regulations apply to the international transport of dangerous goods by waterway. DOT regulations apply to domestic and international shipments originating in or imported to the United States.

Quantities of certain dangerous goods may be transported as “Small Quantity Exception” or “Limited Quantity Exception.” Shippers and transporters of hazardous materials or dangerous goods are required to have specialized training (DGR, 1.5.0.2 and 49 CFR Part 172, Subpart H). Hazardous material or dangerous goods are only shipped by appropriately trained personnel.

4. REFERENCES

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version.

Title 40 Code of Federal Regulations (CFR), Pt. 136.3, Identification of Test Procedures, July 1, 2001. See Table II, Footnote 3.

Title 49 CFR, Pt. 171.1(d)(5), Applicability of Hazardous Materials Regulations (HMR) to Persons and Functions.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4 2011. Operating Procedure SESDPROC-209-R2, Packing, Marking, Labeling, and Shipping of Environmental Waste Samples.

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Sample and Evidence Management

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) general and specific procedures, methods and considerations to be used and observed by ASL field investigators when handling and managing samples and other types of evidence after their collection and during delivery to the laboratory.

1.2 SCOPE AND APPLICATION

On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to manage and track samples or evidence, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-005-R2, Sample and Evidence Management. This document is designed to be utilized as a general guideline for sample and evidence management procedures, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding sample or evidence management. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

2. SAMPLE AND EVIDENCE IDENTIFICATION

2.1 INTRODUCTION

Sample identification, chain-of-custody records, receipt for sample records and other field records will be legibly recorded with waterproof, non-erasable ink, unless otherwise specified. If errors are made in any of these documents, corrections will be made by crossing a single line through the error and entering the correct information. All corrections must be initialed and dated. If possible, all corrections should be made by the individual making the error.

2.2 SAMPLE AND EVIDENCE IDENTIFICATION PROCEDURES

2.2.1 Sample Identification

The method of sample identification used depends on the type of sample collected. Field measurement samples are those collected for specific field analysis or measurement where the data are recorded directly in bound field logbooks or on the Chain-of-Custody Record. Examples of field measurements and analyses include pH, temperature, dissolved oxygen and conductivity. Samples collected for laboratory analysis will be identified by using a stick-on label or a tag which is attached to the sample container. In some cases such as biological samples, the label or tag may have to be affixed to a bag containing the sample. If a sample tag is used, the sample should be placed in a bag, then the sample and the tag will be placed in a second bag.

The following information will be included on the sample label or tag using waterproof, non-erasable ink:

1. Project number;
2. Field identification or sample station number;

3. Date and time of sample collection;
4. Designation of the sample as a grab or composite;
5. Whether the sample is preserved or unpreserved;
6. Samplers initials; and
7. The types of analyses to be performed.

2.2.2 Photograph, Digital Still Image, and Video Identification

When photographs or digital images are taken for purposes of documenting and supporting a field investigation, a record of each exposure or image will be kept in a bound field logbook. The following information will be recorded in the logbook:

1. An accurate description of what the photograph or image shows, including orientation, if appropriate.
2. The date and time that the photograph or image was taken;
3. The name of the individual who took the photograph or digital image.

When digital images are obtained during a field investigation, an electronic copy of the unaltered investigation-related images will be placed in the official files. If deemed necessary due to project requirements, a printed copy of the original photographs may be placed in the official file. For enforcement cases, it is imperative that the individual who took the image be identified in the field logbook in the event their testimony is required.

2.2.2.1 Video

When a video recording is used the following information should be recorded in a bound field logbook:

1. The date and time that the video was recorded;
2. A brief description of the subject of the video;
3. The person recording the video.

An audio record may also be included in the video tape with the above logistical information, as well as a narrated description of the video record.

A label will be placed on the video media with the appropriate identifying information (i.e., project name, project number, date, location etc.). The original, unaltered recording will be placed in the official files.

2.2.3 Identification of Physical Evidence

Physical evidence, other than samples, will be identified, when possible, by recording the necessary information on the evidence. When samples are collected from vessels or containers which can be moved (drums for example), the vessel or container should be marked with the field identification or sample station number for future identification. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking; however, these markings will be recorded in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain copies of recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. A unique identifier will be recorded on the document with that information as well as the following recorded in the logbook:

1. Starting and ending time(s) and date(s) for the chart;
2. An instantaneous measurement of the media being measured by the recorder will be taken and entered at the appropriate location on the chart along with the date and time of the measurement; and
3. A description of the location being monitored and other information required to interpret the data such as type of flow device, chart units, factors, etc.

The field investigator will indicate who the chart (or copy of the chart) was received from and enter the date and time, as well as the field investigator's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field investigator's signature, the date, the number of pages and from whom they were received.

3. CHAIN OF CUSTODY PROCEDURES

3.1 INTRODUCTION

Chain-of-custody procedures are comprised of the following elements: 1) maintaining custody of samples or other evidence, and 2) documentation of the chain-of-custody for evidence. To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample, or other evidence, from the moment of collection to its introduction into evidence.

3.2 SAMPLE CUSTODY

A sample or other physical evidence is in custody if:

1. It is in the actual possession of an investigator;
2. It is in the view of an investigator, after being in their physical possession;
3. It was in the physical possession of an investigator and then they secured it to prevent tampering; and/or
4. It is placed in a designated secure area.

3.3 DOCUMENTATION OF CHAIN OF CUSTODY

The following are used to identify and demonstrate how sample integrity is maintained and custody is ensured.

3.3.1 Sample Identification

A stick-on sample label or a tag should be completed for each sample container using waterproof, non-erasable ink as specified above.

3.3.2 Sample Seals

If appropriate, samples should be sealed as soon as possible following collection using a custody seal with. The sample custodian will write the date and their initials on the seal. The use of custody seals may be waived if field investigators keep the samples in their custody from the time of collection until the samples are delivered to the laboratory analyzing the samples.

3.3.3 Chain-of-Custody Record

The field Chain-Of-Custody record is used to document the custody of all samples or other physical evidence collected and maintained by investigators. All physical evidence or samples will be accompanied by a Chain-Of-Custody Record. This form is usually a pre-printed multi-sheet carbonless form for hand entry of required information. The Chain-Of-Custody Record documents transfer of custody of samples from the sample custodian to another person, to the laboratory or other organizational elements. The Chain-Of-Custody Record also serves as a sample logging mechanism for the laboratory sample custodian. A separate Chain-of-Custody Record should be used for each final destination or laboratory used during the investigation.

All information necessary to fully and completely document the sample collection and required analyses must be recorded in the appropriate spaces to complete the field Chain-Of-Custody Record. The following requirements apply to Chain-Of-Custody records:

1. All sampling team leaders must sign in the designated signature block.
2. One sample should be entered on each line and not be split among multiple lines.
3. If multiple sampling teams are collecting samples, the sampling team leader's name should be clearly indicated for each sample.
4. The total number of sample containers for each sample must be listed in the appropriate column. Required analyses should be entered in the appropriate location on the Chain-of-Custody Record.
5. The field sample custodian, project manager or other designee, and subsequent transferee(s) should document the transfer of the samples listed on the Chain-of-Custody Record. Both the person relinquishing the samples and the person receiving them must sign the form. The date and time that this occurs should be documented in the proper space on the Chain-of-Custody Record. The exception to this requirement would be when packaged samples are shipped with a common carrier. Even though the common carrier accepts the samples for shipment, they do not sign the Chain-of-Custody Record as having received the samples.
6. The last person receiving the samples or evidence will be the laboratory sample custodian or their designee(s).
7. The Chain-of-Custody Record is a uniquely identified document. Once the Record is completed, it becomes an accountable document and must be maintained in the project file. The suitability of any other form for chain-of-custody should be evaluated based upon its inclusion of all of the above information in a legible format.
8. Physical evidence such as video tapes or other small items will be placed in an evidence bag or envelope and a custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record will be maintained for these items. Any time the custody seal is broken, that fact will be noted on the Chain-of-Custody Record and a new seal affixed.
9. Custody seals can be used to maintain custody of other items when necessary by using similar procedures as those previously outlined in this section.
10. Samples should not be accepted from other sources unless the sample collection procedures used are known to be acceptable, can be documented and the sample chain-of-custody can be established. If such samples are accepted, a standard sample label containing all relevant information and the Chain-Of-Custody Record will be completed for each set of samples.

3.4 TRANSFER OF CUSTODY WITH SHIPMENT

Transfer of custody is accomplished by the following:

1. Samples will be properly packaged for shipment in accordance with the procedures outlined in ASL SOP 016 Shipping Environmental and Waste Samples.

2. All samples will be accompanied by the laboratory copy of the Chain-Of-Custody Record. If pre-printed forms are used, the white and pink sheets will be sent. If multiple coolers are needed for shipment to a particular laboratory, the laboratory copy of the Chain-Of-Custody Record for the entire shipment is placed in a sealed plastic bag in one of the coolers. When shipping samples via common carrier, the "Relinquished By" box should be filled in; however, the "Received By" box should be left blank. The laboratory sample custodian is responsible for receiving custody of the samples and will fill in the "Received By" section of the Chain-of-Custody Record. One copy of the Record will be provided to and retained by the project manager. After samples have been received and accepted by the laboratory, a copy of the Chain-of-Custody Record, with sample identification numbers, will be transmitted to the project manager. This copy will become a part of the project file.
3. If sent by mail, the package will be registered with return receipt requested. If sent by common carrier, an Air Bill should be used. The Air Bill number, shipment tracking number or registered mail serial number will be recorded in the remarks section of the Chain of Custody or in the bound field logbook.

4. REFERENCES

ASL 2013. Standard Operating Procedure 016 Shipping Environmental and Waste Samples

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4 2013. Operating Procedure SESDPROC-005-R2, Sample and Evidence Management

Aerostar SES LLC
Standard Operating Procedure 018
Field Sampling Quality Control

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ASL) procedures established to ensure the quality of ASL field sampling activities, including preparation of sampling and support equipment for field operations. Collectively, these procedures ensure that field sampling teams are provided with equipment that is suitable for sampling use, and that field sampling is conducted using proper procedures, resulting in the collection of representative samples. Strict adherence to these procedures forms the basis for an acceptable field sampling quality assurance program.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field investigators when collecting and handling samples in the field and when preparing sampling equipment for ASL field investigations.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-011-R4, Field Sampling Quality Control. This document is designed to be utilized as a general guideline and familiarize the reader with quality control procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding QC requirements. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

2. FIELD SAMPLING QUALITY CONTROL CONSIDERATIONS

This section provides guidelines for establishing quality control procedures for sampling activities. Strict adherence to all of the standard operating procedures outlined in this subsection forms the basis for an acceptable sampling quality assurance program.

2.1 TRACEABILITY REQUIREMENTS

All sample collection and measurement activities will be traceable through field records to the person collecting the sample or making the measurement. All maintenance and calibration records for sampling and measurement equipment (where appropriate) will be kept so that they are similarly traceable.

2.2 CHAIN OF CUSTODY

Specific chain-of-custody procedures are included in ASL SOP 017 Sample and Evidence Management. These procedures will ensure that evidence collected during an investigation will withstand scrutiny during litigation. To assure that procedures are being followed, it is recommended that field investigators or their designees audit chain-of-custody entries, tags or labels, field notes, and any other recorded information for accuracy.

2.3 SAMPLE PRESERVATION

Samples for some analyses must be preserved in order to maintain their integrity. Preservatives required for samples to be collected will be outlined in the project work plan. All samples requiring preservation should be pre-preserved at the analytical laboratory prior to shipment to the site. Records of sample preservation, including ice, will be documented in the field log books.

All samples preserved with chemicals will be clearly identified by indication on the sample tag or label that the sample is preserved. If samples normally requiring preservation were not preserved, field records should clearly specify the reason.

2.4 SAMPLE COLLECTION PRECAUTIONS

In order to prevent cross-contamination during sample collection, the following precautions will be taken:

1. A clean pair of new, non-powdered, disposable latex or nitrile gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come into contact with the media being sampled.
2. Sample containers for source samples or samples suspected of containing high concentrations of contaminants will be placed in separate plastic bags immediately after collecting, tagging, etc.
3. If possible, environmental (low concentration) samples and source or waste samples (high concentration) should be collected by different field teams. If different field teams cannot be used, all environmental samples should be collected first and placed in separate ice chests or shipping containers. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples. Ice chests or shipping containers for source or waste samples or any samples suspected to contain high concentrations of contaminants will be lined with new, clean, plastic bags.
4. If possible, one member of the field sampling team should record all of the field notes; collect GPS data, etc., while the other members collect the samples.
5. When sampling surface water and sediment at the same location, the water sample should always be collected before the sediment sample is collected.
6. Sample collection activities should proceed progressively from the least suspected contaminated area to the most suspected contaminated area.
7. Investigators should use equipment constructed of Teflon®, stainless steel, or glass that is either new or has been properly pre-cleaned according to either the ASL SOP 015 Field Equipment Cleaning and Decontamination for collection of samples for trace metals or organic compounds analyses. Teflon® or glass is preferred for collecting samples where trace metals are of concern. Equipment constructed of plastic or PVC should not be used to collect samples for trace organic compounds analyses.
8. Field investigators should ensure the sample containers they are using have been verified as suitable for the analyses that will be conducted on the samples through the quality control procedures discussed in Section 3 of this procedure.

Upon returning from the field, un-used sample containers will be examined by project leaders to determine whether bottles should be discarded, recycled or re-shelved for use on other projects. Opened boxes of sampling containers that can be re-used, will be segregated from sealed boxes of new containers.

3. QUALITY CONTROL SAMPLES

Quality control samples are collected during field studies for various purposes, among which are to isolate site effects (control samples), to define background conditions (background sample), and to evaluate field/laboratory variability (spikes and blanks, trip blanks, duplicate, split samples, etc.).

3.1 CONTROL SAMPLE

A control sample is typically a discrete grab sample collected to isolate a source of contamination. Isolation of a source could require the collection of both an up gradient sample at a location where the medium being studied is unaffected by the site being studied, as well as a down gradient control which could be affected by contaminants contributed from the site under study.

3.2 BACKGROUND SAMPLES

A background sample (usually a grab sample) is collected from an area, water body or site similar to the one being studied, but located in an area known or thought to be free from pollutants of concern.

3.3 VARIABILITY SAMPLES

Variability may be defined as a variation in concentrations of compounds or analytes across a site or area of investigation or variations, across time, of waste streams or surface water bodies. Variation can also be introduced during sample handling. The following procedures are used to assess and evaluate variability. When appropriate, spatial duplicate grab and/or composite samples should be collected during investigations and studies in accordance to the project DQOs. In general, no more than ten percent of all samples should be collected as spatial duplicates

3.3.1 Spatial Variability Duplicate

The following spatial duplicate sampling procedures should be used during the collection of samples as a measure of variability within the area represented by the sample. These samples should be collected at the same time, using the same procedures, the same type of equipment, and in the same types of containers as the original samples. They should also be preserved in the same manner and submitted for the same analyses as the required samples.

Spatial variability duplicate samples are typically collected during investigations where samples are collected from grids that are positioned at fixed intervals over the study area and a sample collection pattern is established within the grids. Spatial variability duplicate samples are collected using the same compositing pattern as the original sample and are collected within the same general area of representativeness, however the pattern is shifted relative to the original aliquot locations. This amount and direction of shift for the duplicate sample is dependent upon the size of the grid or area being sampled and should be specified in the QAPP for the investigation. Data from spatial duplicates will be examined by the investigation project leader to determine if the observed spatial variability is acceptable, based on the investigation or study objectives.

3.3.2 Temporal Variability Duplicate

When appropriate, temporal variability at a given sampling location will be measured by collecting temporal duplicate samples. These samples will be collected from the same sampling location, using the same techniques and the same type of equipment, but at a time different from the original sample. The time selected for the temporal duplicate sample will be similar to the time or span of time specified for the original sample in the project work plan. Data from temporal duplicates will be examined by the project leader to determine if samples represent the time span intended in the project work plan.

3.3.3 Sample Handling Variability

The effectiveness of sample handling techniques will be measured by collecting split and blank samples.

3.3.3.1 Duplicate samples

Duplicate samples will be collected by initially collecting twice as much volume as is normally collected. The material will be apportioned, after mixing, if appropriate, into two sets of containers. Both sets of containers will be submitted for analyses with one set designated as an "original sample," the other designated as a "Duplicate." Data from the split samples will be examined by the project leader to assess sample handling variability. On large studies (more than 20 samples collected), a minimum of 5 percent, but no more than 10 percent, of all samples will be collected as split samples unless required by site data quality objectives.

3.3.3.2 Blank samples

The following blank samples will be prepared by the laboratory and obtained by the project manager prior to traveling to a sample site.

1. Water Sample VOC Trip Blank - A water sample VOC trip blank is required for every study where water samples are collected for VOC analysis. Sealed preserved (or unpreserved, if unpreserved vials were used during the investigation) 40-ml VOC vials will be transported to the field. Two sealed VOC vials will be submitted per trip blank sample. At least one trip blank sample will be submitted per sample shipment. Trip blanks will be prepared by lab personnel. These trip blanks will be handled and treated in the same manner as the water samples collected for volatile organic compounds analysis on that particular study. These samples will be clearly identified on sample labels and Chain-of-Custody Records as trip blanks.

The following blanks are prepared in the field:

1. Sample Preservative Blanks – ASL will generally use chemical preservatives stored in individual single-use vials. The chemical preservative will be tested prior to use for the appropriate analytes. The use of pre-tested, single-use vials eliminates the need to routinely collect preservative blanks in the field. If the preservatives are stored in containers that will be used to preserve multiple samples, blanks will be collected to evaluate the potential for cross-contamination resulting from the preservation process.
2. Equipment Rinsate Blanks - Equipment rinsate blanks will be collected whenever field decontamination of equipment to be re-used in sampling activities is performed. When field cleaning of equipment is required during a sampling investigation, a piece of the field-cleaned equipment will be selected for collection of a rinse blank. At least one rinse blank will be collected during each week of sampling operations. After the piece of equipment has been field cleaned and prior to its being used for sample operations, it will be rinsed with organic-free water. The rinse water will be collected and submitted for analyses of all constituents for which normal samples collected with that piece of equipment are being analyzed.

3. Organic-Free Water System Blanks - When using a portable organic-free water generating system in the field, a sample of the water generated by the system will be collected at least once during each week of operations. Based on the objectives of the study or investigation, it may be appropriate to collect a sample of the raw source water. The collected water sample will be submitted for analyses of all constituents for which normal samples are being analyzed.
4. Material Blanks - When construction materials are being used on a site in such a way as to have a potential impact on constituent concentrations in the sample, a sample of each material will be submitted for analysis.
5. Field Blank - A field blank is a sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (for example air-borne dust or organic vapors which could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designated locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.
6. Temperature Blank - A temperature blank is a container of water shipped with each cooler of samples requiring preservation by cooling to >4° C (ice). The temperature of the blank is measured at the time of sample receipt by the laboratory. No temperature blank is necessary for waste samples since waste samples do not require ice for preservation.
7. Wipe Sample Blank - A wipe sample blank is a sample of the material and solvent used for collecting wipe samples. The blank is handled, packaged and transported in the same manner as all other wipe samples with the exception that it is not exposed to actual contact with the sample medium.

3.4 SPIKES

Spike samples are used to measure bias due to sample handling or analytical procedures. Spike samples are typically used by ASL to evaluate the performance of contract laboratories.

3.5 MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES FOR WATER AND SOIL SAMPLES FOR ORGANIC COMPOUND ANALYSIS

Matrix spike and matrix spike duplicate (MS/MSD) samples will be submitted to the laboratory for volatile organic compounds, extractable organic compounds, pesticides/PCBs and/or herbicides analyses from at least one sampling location per project and laboratory used. One MS/MSD sample should be collected per 20 samples per media collected.

Additional volume will be required for the soil MS/MSD samples. Semi-volatile organic compounds, pesticides, and PCB analyses of soil/sediment samples require the collection of one additional eight ounce glass jar. For VOC soil/sediment samples, triple volume, i.e., nine En Cores® or nine 40 ml vials with syringe collected sample, is needed for the MS/MSD samples.

Additional volume will be required for the water MS/MSD samples. For routine full scan analysis, i.e., extractable organic compounds, pesticides and PCBs, four one-liter amber containers provide the required sample volume. Eight containers, therefore, should be submitted for the MS/MSD sample. For VOC water samples, a total of six 40-ml vials should be collected.

MS/MSD samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. The duplicate samples should be clearly identified as "Duplicate Sample for Matrix Spike" or "MS/MSD" on the Chain-Of-Custody Record, and in the field logbook. This procedure will be followed for all projects where water samples are collected for the indicated analyses.

3.6 MATRIX SPIKE/MATRIX SPIKE DUPLICATE SAMPLES FOR WATER AND SOIL SAMPLES FOR IN-ORGANIC COMPOUND ANALYSIS

A matrix spike sample and a duplicate sample (MS/MSD) will be submitted to the laboratory for inorganic analyses from at least one sampling location per project and laboratory used. One matrix spike and duplicate sample should be collected per 20 samples per media collected per laboratory.

Soil/sediment and water samples collected for inorganic analyses will normally have sufficient sample volume to perform the matrix spike analyses without requiring the collection of extra sample volume. The relatively uncontaminated conditions, as the matrix spike sample. For water samples, the sample volume collected will normally provide adequate volume for the MS/MSD analyses.

MS/MSD samples should be collected from a location expected to be relatively free from contamination, since the samples will be used for laboratory quality control purposes. MS/MSD samples should be clearly identified as "Duplicate Sample for Matrix Spike" or "MS/MSD" on the Chain-Of-Custody Record, and in the field logbook. This procedure will be followed for all projects where water samples are collected for the indicated analyses.

4. REFERENCES

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination

ASL 2013. Standard Operating Procedure 017 Sample and Evidence Management

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4 2013. Operating Procedure SESDPROC-011-R4, Field Sampling Quality Control

Aerostar SES LLC
Standard Operating Procedure 019
Monitoring Well Installation

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ALS) general and specific procedures, methods and considerations to be used and observed when designing and installing permanent and temporary groundwater monitoring wells to be used for collection of groundwater samples.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when designing, constructing and installing groundwater monitoring wells. On the occasion that ASL field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for any aspect of the design, construction and/or installation of a groundwater monitoring well, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDGUID-101-R1, Design and Installation of Monitoring Wells. This document is designed to be utilized as a general guideline for well installation procedures; however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding temporary and permanent well installation. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern. Section 2.6, Safety Procedures for Drilling Activities, contains detailed and specific safety guidelines that must be followed by Branch personnel when conducting activities related to monitoring well construction and installation.

1.3.2 Procedural Precautions

The following precautions should be considered when constructing and installing groundwater monitoring wells.

1. Special care must be taken to minimize or prevent inadvertent cross-contamination between borehole locations. Equipment, tools and well materials must be cleaned and/or decontaminated according to procedures found in ASL SOP 0 15 Field Equipment Cleaning and Decontamination.
2. All field activities are documented in a bound logbook according to the procedures found in ASL SOP 001 Logbooks.

2. PERMANENT MONITORING WELL DESIGN CONSIDERATIONS

2.1 GENERAL

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

1. Short-and long-term objectives;
2. Purpose of the well(s);
3. Probable duration of the monitoring program;
4. Contaminants likely to be monitored;
5. Surface and subsurface geologic conditions;
6. Properties of the aquifer(s) to be monitored;
7. Well screen placement;
8. General site conditions; and
9. Potential site health and safety hazards.

In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) must be selected. The preferred drilling methods for installing monitoring wells are those that temporarily case the borehole during drilling and the construction of the well, e.g. hollow-stem augers and sonic methods. However, site conditions or project criteria may not allow using these methods. When this occurs, alternate methods should be selected that will achieve the project objectives. The following discussion of methods and procedures for designing and installing monitoring wells will cover the different aspects of selecting materials and methods, drilling boreholes, and installing monitoring devices.

2.2 DRILLING METHODS

The following drilling methods may be used to install environmental monitoring wells or collect samples under various subsurface conditions. In all cases the preferred methods are those that case the hole during drilling, i.e. Hollow Stem Augers (HSA) and sonic methods using an override system. Other methods may be used where specific subsurface or project criteria dictate.

2.2.1 Hollow Stem Auger

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be used at the bottom of the augers to keep out most of the soils and/or water that have a tendency to enter the bottom of the augers during drilling. Potable water (analyzed for contaminants of concern) may be poured into the augers during drilling to equalize pressure so that the inflow of formation materials will be held to a minimum. Water-tight center bits are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by drilling and washing out the plug using a rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. Bottom plugs can be used where no soil sampling is conducted during the drilling process. The bottom plug is wedged into the bottom of the auger bit and is knocked out at depth with drill pipe or the weight of the casing and screen assembly. The plug material should be compatible with the screen and casing materials. The use of wood bottom plugs is not acceptable. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

2.2.2 Solid Stem Auger

This type of auger consists of a sealed hollow or solid stem or shaft with a continuous spiraled steel flight welded on the outside of the stem. An auger bit connected to the bottom disturbs soil material when rotated and the helical flights transport cuttings to the surface. At the desired depth the entire auger string is removed to gain access to the bottom of the borehole. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock. Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. Minimizing the risk of cross contamination is one of the most important factors to consider when selecting the appropriate drilling method(s) for a project

2.2.3 Sonic Methods

These methods generally alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer 'override' string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of the stratigraphy prior to sampling or disposal. Because there are no auger flights to increase the borehole diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. With moderate rotation, smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers should be used in most cases to facilitate centering, particularly in the case of deep wells with PVC casing.

2.2.4 Rotary Methods

These methods consist of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe, (or within a concentric drill stem in reverse rotary). Except in the case of air rotary, the drilling fluid provides a hydrostatic pressure that reduces or prevents borehole collapse. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole.

Due to the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. Unless contaminated formations are cased off, the circulation of drilling fluids presents a danger of cross contamination between formations. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

2.2.4.1 Water rotary

When using water rotary, potable water (that has been analyzed for contaminants of concern) should be used. If potable water (or higher-quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water does not clog the formation materials, but the suspended drilling fines can be carried into the formation, resulting in a very difficult to develop well. This method is most appropriate for setting isolation casing.

2.2.4.2 Air rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. "Down-the-hole" (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, the cuttings exiting the borehole must be controlled. This can be done using the dual-tube reverse circulation method where cuttings are carried to the surface inside dual-wall drill pipe and separated with a cyclone separator. An air diverter with hose or pipe carrying cuttings to a waste container is also an acceptable alternative. Allowing cuttings to blow uncontrolled from the borehole is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with DTH hammers as well as thread lubricants to be used on drill stem should be evaluated for their potential impact on analytical samples.

2.2.4.3 Mud rotary

Mud rotary is an undesirable drilling method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminates from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be sampled at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

2.2.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior geologist before field work is initiated.

2.3 BOREHOLE CONSTRUCTION

2.3.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2" to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2" nominal diameter (nom.) casing would require a 6" inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4" ID should be the minimum size used for placement of 2" nom. casing and 8-1/4" ID for 4" nom. casing. Larger augers should be used where installation difficulties due to geologic conditions or greater depths are anticipated, e.g. larger augers might be required to place a bentonite pellet seal through a long water column.

2.3.2 Over Drilling the Borehole

Sometimes it is necessary to over-drill the borehole in anticipation of material entering the augers during center bit removal or knocking out of the bottom plug. Normally, 3 to 5 feet is sufficient for over-drilling. The borehole can also be over-drilled to allow for an extra space or a "sump" area below the well screen. This "sump" area provides a space to attach a 5 or 10 foot section of well casing to the bottom of the well screen. The extra space or "sump" below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These "sumps" are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the "sump" preventing the well screen from clogging or "silting up". If the borehole is inadvertently drilled deeper than desired, it can be backfilled to the design depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

2.3.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm base. Also, the filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use hollow stem augers and other methods where the borehole is temporarily cased down to the filter pack.

2.3.4 Filter Pack Seal – Bentonite Pellet Seal

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs./ft. and hydrate to a 30% min. solids material. Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Since bentonite pellets begin hydrating rapidly, they can be very difficult to place properly. They are generally placed by pouring slowly into open boreholes, hollow stem augers or sonic drill pipe. In some cases, pellets are placed by tremie pipe and flushed into place with potable water. A tamper can be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used, the pellets should be hydrated for eight hours, or the manufacturer's recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

2.3.5 Grouting the Annular Space

The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout, or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity. Bentonite grouts are preferred unless the application dictates the use of another material.

Bentonite grout shall be a 30% solids pure bentonite grout. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal.

Cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts (cement without additives) should be mixed using 6 gallons of water per 94-lb bag of Type 1 Portland cement to a density of 15lbs/gal. The addition of bentonite (5 to 10 percent) to the cement grout can be used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

2.3.6 Above Ground Riser Pipe and Outer Casing

The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. The outer protective casing should be of steel construction with a hinged, locking cap. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Other types of protective casing including those constructed of pipe are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a weep hole to allow drainage of accumulated rain or spilled purge water. The weep hole should be approximately 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pad to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

Prior to installing the protective casing, the bentonite grout in the borehole annulus is excavated to a depth of approximately two feet. The protective casing is installed by pouring concrete into the borehole on top of the grout. The protective casing is then pushed into the wet concrete and borehole a minimum of 2 feet. Extra concrete may be needed to fill the inside of the protective casing so that the level of the concrete inside of the protective casing is at or above the level of the surface pad. In areas where frost heave of the surface pad is possible, the protective casing should first be pressed into the top surface of the bentonite grout seal and concrete poured around the protective casing. A granular material such as sand or gravel should then be used to fill the space between the riser and protective casing. The use of granular material instead of concrete between the protective casing and riser will also facilitate the future conversion of the well to a flush-mount finish, if required. The protective casing should extend above the ground surface to a height so that the top of the inner well casing is exposed when the protective casing is opened. At each site, all locks on the outer protective casings should be keyed alike.

2.3.7 Concrete Surface Pad

A concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad is dependent on the well casing size and state regulations. The following are the minimum requirements for a surface pad. If the well casing is 2 inches in diameter, the pad should be 2 feet x 2 feet x 4 inches. If the well casing is 4 inches in diameter, the pad should be 3 feet x 3 feet x 6 inches. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

2.3.8 Surface Protection, Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

2.4 CONSTRUCTION TECHNIQUES

2.4.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible. Slanted boreholes are undesirable and should be noted in the boring logs and final construction logs. The depth and volume of the borehole, including the over-drilling if applicable, should have been calculated and the appropriate materials procured prior to drilling activities.

The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole. In the case of deep wells (>100 ft.) centralizers may be needed to ensure that the well remains as vertical as possible. Another method of placing the well screen and casings into the borehole and plumbing them at the same time is to suspend the string of well screen and casings in the borehole by means of a hoist on the drill rig. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed.

No lubricating oils or grease should be used on casing threads. No glue of any type should be used to secure casing joints. Teflon "O" rings can also be used to insure a tight fit and minimize leakage; however, "O" rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses.

Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. The specific placement intervals should be decided based on site conditions.

When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite pellet seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems.

After the string of well screen and casing is plumb, the filter pack material should then be placed around the well screen to the designated depth. With cased drilling methods, the sand should be poured into the casing or augers until the lower portion is filled. The casing or augers are then withdrawn, allowing the sand to flow into the evacuated space. With hollow stem augers, sand should always fill the augers 6-12 inches, maintained by pouring the sand while checking the level with a weighted tag line. The filter pack sand in open boreholes should be installed by tremie methods, using water to wash the sand through the pipe to the point of placement.

After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours.

After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed.

After the surface pad and protective casing are installed, bumper guards should be installed (if needed). The bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. Each piece of steel pipe or approved material should be installed into an 8-to 10-inch diameter hole, to a minimum depth of 2 feet below ground surface, and filled with concrete. As previously stated, the bumper guard should extend above the ground surface a minimum of 3 feet. The total length of each bumper guard should be a minimum of 5 feet.

After the wells have been installed, the outer protective casing should be painted with a highly visible paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed slightly above grade to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs should be used to cap the well riser to prevent infiltration of any water that might enter the flush cover.

2.4.2 Double Cased Wells

Double-cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross-contamination or when flowing sands make it impossible to install a monitoring well using conventional methods. A highly contaminated surface soil zone may also be cased off so that drilling may continue below the casing with reduced danger of cross contamination. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and\or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient inside diameter to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie, displacement, grout shoe, or Halliburton method from the bottom to the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material, and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, or washing out the seal. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing.

2.4.2.1 Bedrock wells

The installation of monitoring wells into bedrock can be accomplished in two ways:

1. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and "down" pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing will be evaluated on its own merits, and will have to be approved by a senior field geologist before and during drilling activities, if applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the contaminants being monitored could be diluted to the extent of being non-detectable. The installation of open bedrock wells is generally not acceptable in the Superfund and RCRA programs, because of the uncontrolled monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

2. The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

2.5 WELL CONSTRUCTION MATERIALS

2.5.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). In this section, the different types of available materials will be discussed.

2.5.2 Well Screen and Casing Materials

When selecting the materials for well construction, the prime concern should be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the ground water. If the monitoring program is designed to analyze for organic compounds, stainless steel materials are the preferred choice. If the monitoring program calls for the analyses of only inorganic compounds or the contaminants or formation are highly corrosive, then rigid PVC materials meeting National Sanitary Foundation (NSF) Standard 14 type WC (Well Casing) are acceptable. PVC materials may be acceptable for monitoring identified organic compounds in a soluble aqueous phase where incompatibilities are known to not exist. Another concern is to select materials that will be rugged enough to endure the entire monitoring period. Site conditions will generally dictate the type of materials that can be used. A preliminary field investigation should be conducted to determine the geologic conditions, so that the most suitable materials can be selected. The best grade or highest quality material for that particular application should be selected. Each manufacturer can supply the qualitative data for each grade of material that is being considered. All materials selected for monitoring well installation should be evaluated and approved by a senior field geologist prior to field activities.

Well screen and casing materials generally used in monitoring well construction on RCRA and Superfund sites are listed in order of preference:

1. Stainless Steel (304 or 316)
2. Rigid PVC meeting NSF Standard 14 (Schedule 40 PVC Pipe)
3. Other (where applicable)

There are other materials used for well screens and casings such as black iron, carbon steel, galvanized steel, and fiberglass, but these materials are not recommended for use in long term monitoring programs at hazardous waste sites, because of their low resistance to chemical attack and potential constituent contribution to the ground water. In cases where a driven casing is used, or a high strength outer casing is needed, carbon steel may be acceptable in non-corrosive aquifers. This outer casing should have threaded connections. Welding casing is not an acceptable practice unless all relevant safety issues have been adequately addressed.

The minimum nominal casing size for most permanent monitoring wells will be 2". Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less than 5 feet long are generally only used in temporary monitoring wells where ground water samples are collected for screening purposes.

2.5.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be accepted unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there is enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored.

2.5.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. These shallow aquifers are not generally characteristic of aquifers used for drinking water. Therefore, modifications to the procedures used for the design of water well filter packs may be required. In cases where insufficient experience exists with local or similar materials, the filter pack and well screen design should be based on the results of a sieve analysis conducted on soil samples collected from the aquifer or the formation(s) that will be monitored.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those cases the selection of 0.010" screen slots with a 20-40 sand filter pack, or 0.005" screen slots with 100 sand filter pack for very fine formations, will be acceptable practice. Table 2-1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, Design and Installation of Ground Water Monitoring Wells in Aquifers, may be consulted for further guidance on specifications for sand appropriate to these applications.

Table 2-1 Sand Pack Specifications

Screen Opening (in.)	Sand Pack	1% Passing Size (d-1)	10% Passing Size (d-10)	30% Passing Size (d-30)	Derived 60% Passing Size	Range for Uniformity

	Mesh Name	(in.)	(in.)	(in.)	(d-60) (in.)	Coefficient
0.005-0.006	100	.0035 - .0047	.0055 - .0067	.0067 - .0083	.0085 - .0134	1.3 - 2.0
0.010"	20-40	.0098 - .0138	.0157 - .0197	.0197 -.0236	.020 - .0315	1.1 - 1.6

2.6 SAFETY PROCEDURES FOR DRILLING ACTIVITIES

A site health and safety plan should be developed and approved by the Project Manager or designee prior to any drilling activities, and should be followed during all drilling activities. The driller or designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity is initiated, utilities should be marked or cleared by the appropriate state or municipal utility protection organization. In developed areas, additional measures should be taken to locate utilities not covered by the utility protection program. Before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. The following safety requirements should be adhered to while performing drilling activities:

1. All drilling personnel should wear safety hats, safety glasses, and steel toed boots. Ear plugs are required and will be provided by the safety officer or driller.
2. Work gloves (cotton, leather, etc.) should be worn when working around or while handling drilling equipment.
3. All personnel directly involved with the drilling rig(s) should know where the kill switch(s) is located in case of emergencies.
4. All personnel should stay clear of the drill rods or augers while in motion, and should not grab or attempt to attach a tool to the drill rods or augers until they have completely stopped rotating. Rod wipers, rather than gloves or bare hands should be used to remove mud, or other material, from drill stem as it is withdrawn from the borehole.
5. Do not hold drill rods or any part of the safety hammer assembly while taking standard penetration tests or while the hammer is being operated.
6. Do not lean against the drill rig or place hands on or near moving parts at the rear of the rig while it is operating.
7. Keep the drilling area clear of any excess debris, tools, or drilling equipment.
8. The driller will direct all drilling activities. No work on the rig or work on the drill site will be conducted outside of the driller's direction. Overall drill site activities will be in consultation with the site geologist or engineer.
9. Each drill rig will have a first-aid kit and a fire extinguisher located on the rig in a location quickly accessible for emergencies. All drilling personnel will be familiarized with their location.
10. Work clothes will be firm fitting, but comfortable and free of straps, loose ends, strings etc., that might catch on some moving part of the drill rig.
11. Rings, watches, or other jewelry will not be worn while working around the drill rig.

The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

2.7 WELL DEVELOPMENT

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils that have not been washed out of the borehole. Excessive or thick drilling mud cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in approximate increasing order of the energy applied to the formation materials, are generally used to develop wells:

1. Bailing
2. Pumping/overpumping
3. Surging
4. Backwashing ("rawhiding")
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These development procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, over-pumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and re-stabilize to pre-well construction conditions. Because of the danger of introducing contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development and should only be used where there is a specific need for the procedure. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

2.8 WELL DECOMMISSIONING (ABANDONMENT)

When a decision is made to decommission (abandon) a monitoring well, the borehole should be sealed in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly decommission a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well decommissioning requirements, the appropriate state agency should be notified (if applicable) of monitoring well decommissioning. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s). Recall that in ALL cases, state requirements supersede this document.

2.8.1 Decommissioning Procedure

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). This abandonment method can be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth pilot bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials.

Where state regulations and conditions permit, it may be permissible to grout the casing in place. This decision should be based on confidence in the original well construction practice, protection of drinking water aquifers, and anticipated future property uses. The pad should be demolished and the area around the casing excavated. The casing should be sawn off at a depth of three feet below ground surface. The screen and riser should be tremie grouted with a 30% solids bentonite grout in the saturated zone. The remaining riser may be grouted with a cement grout for long term resistance to desiccation.

3. TEMPORARY MONITORING WELL INSTALLATION

3.1 INTRODUCTION

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution.

Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Due to the nature of construction, turbidity levels may initially be high. However, these levels may be reduced by low flow purging and sampling techniques.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured, both against tampering and against the fall hazard of the open annulus. If the well is not sampled immediately after construction, the well should be purged prior to sampling as specified in ASL SOP 002 Groundwater Sampling.

3.2 DATA LIMITATION

Temporary wells described in this section are best used for delineation of contaminant plumes at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Temporary wells can be used in conjunction with a mobile laboratory, where quick analytical results can be used to delineate contaminant plumes.

3.3 TEMPORARY WELL MATERIALS

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. The well screen and casing should be stainless steel for ruggedness and suitability for steam cleaning and solvent rinsing. Other materials may be acceptable, on a case by case basis. Some commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are available commercially; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

3.4 TEMPORARY MONITORING WELL BOREHOLE CONSTRUCTION

Borehole construction for temporary wells is as specified in Section 2.3, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling.

3.5 TEMPORARY MONITORING WELL TYPES

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

3.5.1 No Filter Pack

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the least expensive and fastest well to install.

This type of well is extremely sensitive to turbidity fluctuations because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

3.5.2 Inner Filter Pack

This type differs from the "No Filter Pack" well in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be at least 6-12 inches above the filter pack. The screen slots may plug in some clayey environments with this construction method and others that use sand only inside the well screen.

3.5.3 Traditional Filter Pack

For this type of well, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes, due to collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

3.5.4 Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

3.5.5 Well in a Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole.

This system requires twice as much well screen and riser, with attendant increases in assembly and installation time. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. The use of pre-packed well screens in this application will require rinse blanks of each batch of screens. Pre-pack Screen assemblies cannot be decontaminated for reuse.

3.6 DECOMMISSIONING

Temporary well boreholes must be decommissioned after sampling and removal of the screen and riser. Backfilling the holes with cuttings may be acceptable practice for shallow holes in uniform materials with expected low contamination levels. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was breached. Likewise, where the borehole is adjacent to, or downgradient of contaminated areas, the loose backfilled material could create a highly permeable conduit for contaminant migration.

4. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks

ASL 2013. Standard Operating Procedure 002 Groundwater Sampling.

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

EPA Region 4, 2013. Operating Procedure SESDGUID-101-R1, Design and Installation of Monitoring Wells

Aerostar SES LLC
Standard Operating Procedure 020
Management of Investigation and Remediation Derived Waste

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Table 2-1 Summary of IDW/ RDW Disposal and Types 2

1. GENERAL INFORMATION

1.1 PURPOSE

This document describes procedures and considerations Aerostar SES LLC (ASL) field personnel are to use and observe when managing investigation derived waste (IDW) or remediation derived waste (RDW) generated during the course of hazardous waste site investigations.

1.2 SCOPE AND APPLICATION

The procedures and management options for the different categories of IDW/RDW described in this document are to be used by ASL field personnel to manage IDW/RDW generated during site investigations. On the occasion that ASL field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW/RDW generated at a particular site, the variant procedure will be approved by the project manager and quality assurance manager and documented in the field logbook, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from US Environmental Protection Agency (EPA) Region 4 Operating Procedure SESDPROC-202-R2, Management of Investigation Derived Waste. This document is designed to be utilized as a general guideline for basic IDW management procedures; however, field personnel must note that different projects, and different states, may have specific regulations regarding IDW management. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when managing IDW. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

1.3.2 Procedural Precautions

The following precautions should be considered when managing IDW:

1. Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
2. During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

2. TYPES OF INVESTIGATION DERIVED WASTE

Materials which may become IDW include, but are not limited to:

1. Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.
2. Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon© tubing, broken or unused sample containers, sample container boxes, tape, etc.
3. Soil cuttings from drilling or hand augering.
4. Drilling mud or water used for mud or water rotary drilling.
5. Groundwater obtained through well development or well purging.
6. Cleaning fluids such as spent solvents and wash water.
7. Packing and shipping materials.

Table 2-1 lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

Table 2-1 Summary of IDW/ RDW Types and Disposal

Type	Hazardous	Nonhazardous
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site owner/operator.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site owner/operator or arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange for testing and disposal.
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange for testing and disposal.
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site owner/operator for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange with site owner/operator for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site owner/operator, otherwise arrange with site owner/operator for testing and disposal.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site owner/operator.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis.

3. MANAGEMENT OF NON-HAZARDOUS IDW

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved Work Plan. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions and local regulations permit.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected.
- The collection, handling and proposed disposal method must be specified in the approved Work Plan.

4. MANAGEMENT OF HAZARDOUS IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved Work Plan. Hazardous IDW must be disposed as specified in USEPA regulations. If the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve resources. Most environmental investigations will produce purged groundwater, which may or may not be contaminated, but will generally be treated as contaminated. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination. If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.
- Generation of hazardous IDW should be minimized to the extant practical.

5. REFERENCES

US EPA 2010. SESDPROC-202-R2, Management of Investigation Derived Waste.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6. EPA/600/B-07/001.

Aerostar SES LLC
Standard Operating Procedure 021
Solid Waste Sampling

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes Aerostar SES LLC (ALS) general and specific procedures, methods and considerations Aerostar SES LLC field personnel are to use and observe when collecting waste samples for field screening or laboratory analysis.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by field personnel when collecting and handling waste samples in the field. On the occasion that ASL field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a waste sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-302-R2, Waste Sampling. This document is designed to be utilized as a general guideline for solid waste sampling, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations regarding solid waste sampling to be used for a specific analyte or sampling procedure. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 GENERAL PRECAUTIONS

1.3.1 Safety

Proper safety precautions must be observed when conducting solid waste sampling. Always refer to the Site Safety and Health Plan for the most current guidelines on safety precautions. The precautions listed there are intended as an amendment to the judgment of an experienced professional. Ensure that all site personnel are aware of any chemicals or hazards on site that may pose a specific toxicity or safety concern.

When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Specific levels of dress for waste sampling will be described in greater detail later in this operating procedure.

Sampling equipment contaminated during waste sampling investigations should be cleaned in accordance with the ASL SOP 015 Field Equipment Cleaning and Decontamination. Contaminated sampling equipment that is to be discarded must be properly disposed according to the ASL SOP 021 Management of Investigation Derived Waste. These procedures should be specified in the project work plan.

1.3.2 Procedural Precautions

The following precautions should be considered when collecting waste samples.

1. Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample.
2. Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
3. If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
4. Shipped samples will conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
5. Documentation of field sampling is done in a bound logbook.
6. Chain-of-custody documents will be filled out and remain with the samples until custody is relinquished.

1.4 QUALITY CONTROL PROCEDURES

In some instances, special decontamination procedures will be necessary and should be developed on a case-by-case basis according to the specific material encountered. Any cleaning procedures and equipment repairs conducted in the field, which deviate from those specified in the ASL SOP 015 Field Equipment Cleaning and Decontamination or the work plan, will be thoroughly documented in the logbooks. Equipment blanks will be collected in accordance with the ASL SOP 018 Field Sampling Quality Control. All air monitoring and field analytical/screening equipment should be checked and calibrated before use.

1.5 RECORDS

Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with the ASL SOP 001 Logbooks, and the ASL SOP 017 Sample and Evidence Management.

1.6 INVESTIGATION DERIVED WASTE

Sampling and decontamination can generate investigation derived waste (IDW), the disposition of which must be considered. See the ASL SOP 021 Management of Investigation Derived Waste for guidance on management or disposal of this waste.

2. WASTE SAMPLING

Hazardous wastes are regulated by the USEPA under 40 CFR Parts 260-282. As a consequence, many of the methods that are used to manage, store, treat and dispose hazardous wastes and potential hazardous wastes are of concern to both the regulators and the regulated community.

2.1 WASTE UNIT TYPES

Waste management units can be generally categorized into two types: open and closed. In practice, open units are larger than closed units. Open units include waste piles and surface impoundments whereas closed units include containers and tanks as well as ancillary tank equipment. In addition to containers and tanks, sumps may also be considered closed units because they are designed to collect the spillage of liquid wastes and are sometimes configured as a confined space.

Although both may pose hazards, units that are open to the environment are generally less hazardous than closed units. Sampling of closed units is considered a higher hazard risk because of the potential of exposure to toxic gases and flammable/explosive atmospheres. Because closed units prevent the dilution of the wastes by environmental influences, they are more likely to contain materials that have concentrated levels of hazardous constituents. While opening closed units for sampling purposes when the unit's contents are unknown, investigators will use Level B personal protective equipment (PPE) and air monitoring instruments to ensure that the working environment does not contain hazardous levels of flammable/explosive gases or toxic vapors, and follow the appropriate safety requirements stipulated in the site specific safety plan.

Buried waste materials should be located and excavated with extreme caution. Once the buried waste is uncovered, the appropriate safety and sampling procedures utilized will depend on the type of waste unit.

2.1.1 Open Units

While open units may contain many types of wastes and come in a variety of shapes and sizes, they can be generally regarded as either waste piles or surface impoundments. One of the distinguishing features between waste piles and surface impoundments is the state of the waste. Waste piles typically contain solid or non-flowing materials whereas liquid wastes are usually contained in surface impoundments. The nature of the waste will also determine the mode of delivering the waste to the unit. Wastes are commonly pumped or gravity fed into impoundments while heavy equipment or trucks may be used to dump wastes in piles. Once the waste has been placed in an open unit, the state of the waste may be altered by environmental factors (e.g., temperature, precipitation, etc.).

Surface impoundments may contain several phases such as floating solids, liquid phase(s) and sludges. Waste piles are usually restricted to solids and semi-solids. All of the potential phases contained in a waste unit should be considered in developing the sample design to meet the project objective.

2.1.2 Closed Units

There are a variety of designs, shapes, sizes and functions of closed units. In addition to the challenges of the various designs and the safety requirements for sampling them, closed units are difficult to sample because they may contain liquid, solid, semi-solid/sludge or any combination of phases. Based on the design, it may be necessary to obtain a cross-sectional profile of the closed unit in an attempt to characterize the unit. The following are types of closed waste units described in 40 CFR Part 260.10:

1. Containers - drums, overpacks, pails, totes and roll-offs;
2. Tank - portable tanks, tank trucks and tank cars;
3. Ancillary equipment (tank) - any device including, but not limited to, such devices as piping, fittings, flanges, valves and pumps; and
4. Sump - pits or reservoirs.

Although any of the closed units may not be completely sealed and may be partially open to the environment, the unit should be treated as a closed unit for sampling purposes until a true determination can be made. Once a closed unit is opened, a review of the proposed sampling procedures and level of protection can be performed to determine if the personal protective equipment is suitable for the site conditions.

Samples collected from different waste units should not be composited into one sample container without additional analytical and/or field screening data to determine if the materials are compatible and will not cause an inadvertent chemical reaction.

3. WASTE SAMPLING EQUIPMENT

3.1 GENERAL

Selecting appropriate equipment to sample wastes is a challenging task due to the uncertainty of the physical characteristics and nature of the wastes. It may be difficult to separate, homogenize and/or containerize a waste due to its physical characteristics (viscosity, particle size, etc.). In addition, the physical characteristics of a waste may change with temperature, humidity or pressure. Waste streams may vary depending on how and when a waste was generated, how and where it was stored/disposed and the conditions under which it was stored/disposed. Also, the physical location of the wastes or the unit configuration may prevent the use of conventional sampling equipment.

Given the uncertainties that a waste may present, it is desirable to select sampling equipment that will facilitate the collection of samples that will meet the objective, and that will not unintentionally bias the sample by excluding some of the sample population that is under consideration. However, due to the nature of some waste matrices or the physical constraints of some waste units, it may be necessary to collect samples knowing that a portion of the desired population was omitted due to limitations of the equipment. Any deviations from the study plan or difficulties encountered in the field concerning sample collection that may have an effect on the study's objective should be documented in a logbook, reviewed with the analytical data and presented in the report.

3.1.1 Waste Sampling Equipment

Waste sampling equipment should be made of non-reactive materials that will neither add to nor alter the chemical or physical properties of the material that is being sampled. Table 1 lists some conventional equipment for sampling waste units/ phases and some potential limitations of the equipment. Another reference for selecting sampling equipment is the ASTM, Standard Guide for Selection of Sampling Equipment for Wastes and Contaminated Media Data Collection Activities, D 6232, most recent version.

3.1.2 Ancillary Equipment for Waste Sampling

In addition to the equipment listed in Table 1 which provides the primary device used to collect various waste samples, ancillary equipment may be required during the sampling for safety and/or analytical reasons. Some examples of these types of equipment are glass mixing pans, particle size reducers, remote drum opening devices and spark resistant tools. Any influences that these types of ancillary equipment may have on the data should be evaluated and reported as necessary.

4. WASTE SAMPLING PROCEDURES

4.1 WASTE PILES

Waste piles vary in size, shape, composition and compactness, and may vary in distribution of hazardous constituents and characteristics (strata). These variables will affect safety and access considerations. The number of samples, the type of sample(s), the sample location(s) and interval(s) should be based on the work plan objectives. Commonly used equipment to collect samples from waste piles is listed in Table 1.

Specific procedures will vary depending on the equipment and objectives of the investigation. All equipment should be compatible with the waste and should be cleaned to prevent cross contamination of the sample.

Table 4-1 Waste Sampling Equipment

Equipment	Waste Units/Phases	Limitations
Scoop with bracket/conduit	Impoundments, piles, containers, tanks/liquids, solids, sludges	Can be difficult to collect deeper phases in multiphase wastes. Depth constraints.
Spoon	Impoundments, piles, containers/solids, sludges	Similar limitations as the scoop. Generally not effective in sampling liquids.
Push tube	Piles, containers/cohesive solids, sludges	Should not be used to sample solids with dimensions > the diameter of the tube. Depth constraints.
Auger	Impoundments, piles, containers/solids	Can be difficult to use in an impoundment or a container, or for solidified wastes.
Sediment sampler	impoundments, piles/solids, sludges	Should not be used to sample solids with dimensions > the diameter of the tube.
Ponar dredge	Impoundments/solids, sludges	Must have means to position equipment to desired sampling location. Difficult to decon.
COLIWASA or drum thief	Impoundments, containers, tanks/liquids	Not good with viscous wastes. Devices > 7' require 2 samplers to use effectively.
Dipstick™ / Mucksucker™	Impoundments, containers, tanks/liquids, sludges	Not recommended for tanks >11 feet deep. Devices > 7' require 2 samplers to use effectively.
Bacon bomb	Impoundments, tanks/liquids	Not good with viscous wastes.
Bailer	Impoundments, tanks/liquids	Only if waste is homogeneous. Not good with viscous wastes.
Peristaltic pump with vacuum jug assembly	Impoundments, tanks/liquids	Cannot be used in flammable atmospheres. Not good with viscous wastes.
Back-hoe bucket	Piles/solids, sludges	May be difficult to access desired sampling location. Difficult to decon. Can lose volatiles.
Split-spoon	Piles/solids	Requires drill rig or direct push equipment.
Roto-hammer	Piles, containers/solids	Physically breaks up sample. May release volatiles. Not for flammable atmospheres.

4.2 SURFACE IMPOUNDMENTS

Surface impoundments vary in size, shape and waste content, and may vary in distribution of hazardous constituents and characteristics (strata). The number of samples, the type of sample(s) and the sample location(s) and interval(s) should be based on the study's objectives. Commonly used equipment to collect samples from surface impoundments is listed in Table 1. Specific procedures will vary depending on the equipment and objectives of the investigation. All equipment should be compatible with the waste and should be cleaned to prevent cross contamination of the sample.

Because of the potential danger of sampling waste units suspected of containing elevated levels of hazardous constituents, personnel should never attempt to sample surface impoundments used to manage potentially hazardous wastes from a boat. All sampling should be conducted from the banks or piers of surface impoundments. Any exception must be approved by the project manager.

4.3 DRUMS

Drums are the most frequent type of containers sampled by field investigators for chemical analyses and/or physical testing. Caution should be exercised by the field investigators when sampling drums because of the potential presence of explosive/flammable gases and/or toxic vapors. Therefore, the following procedures should be used when collecting samples from drums of unknown material:

1. Visually inspect all drums that are being considered for sampling for the following:
    a. pressurization (bulging/dimples);
    b. crystals formed around the drum opening;
    c. leaks, holes, stains;
    d. labels, markings;
    e. composition and type (steel/poly and open/bung);
    f. condition, age, rust; and sampling accessibility.
2. Drums showing evidence of pressurization and crystals should be furthered assessed to determine if remote drum opening is needed. If drums cannot be accessed for sampling, heavy equipment is usually necessary to stage drums for the sampling activities. Adequate time should be allowed for the drum contents to stabilize after a drum is handled.
3. Touch the drum opening equipment to the bung or lid and allow an electrical conductive path to form. Slowly remove the bung or drum ring and/or lid with spark resistant tools (brass/beryllium).
4. Screen drums for explosive gases and toxic vapor with air monitoring instruments as bung or drum lid is removed. Depending on site conditions, screen for one or more of the following:
    a. radioactivity;
    b. cyanide fumes;
    c. halogen vapors;
    d. pH; and/or
    e. flash point (requires small volume of sample for testing).
5. Note the state, quantity, phases and color of the drum contents. Record all relevant results, observations and information in a logbook.
6. Select the appropriate sampling equipment based on the state of the material and the type of container. Sampling equipment should be made of non-reactive material.

Liquids – COLIWASAs (COmposite LIquid WAste SAmplers), drum thieves, or bailers are used to collect liquid samples from drums. The COLIWASA or drum thief is slowly lowered to the bottom of the container. Close the COLIWASA with the inner rod or create a vacuum with the sampler's gloved thumb on the end of the thief and slowly remove the sampling device from the drum. Release the full contents from the device into one sample container. Repeat the procedure until a sufficient sample volume is obtained. For bailers, a bottom loading bailer should be used and lowered to the bottom of the drum and the contents poured into the sample containers.

Solids/Semi-Solids – Use a push tube, stainless steel spoon, bucket auger or screw auger or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully use a clean stainless steel spoon to place the sample into container(s) for analyses. Close the drums when sampling is complete.

Close the drums when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the drum screening procedure (Step #5). At a minimum, contaminated, non-disposable equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field..

4.4 TANKS

Sampling tanks is considered hazardous due to the potential for them to contain large volumes of hazardous materials and therefore, appropriate safety protocols must be followed. Unlike drums, tanks may be compartmentalized or have complex designs. Preliminary information about the tank's contents and configuration should be reviewed prior to the sampling operation to ensure the safety of sampling personnel and that the project objectives can be achieved.

In addition to having discharge valves near the bottom of tanks and bulk storage units, most tanks have hatches at the top. It is desirable to collect samples from the top hatch because of the potential for the tank's contents to be stratified. Because wastes often stratify due to different densities of phases or settling of solids, it may be important to obtain a vertical cross section of the entire unit, or it may be desirable to collect grab samples from each strata. Additionally, when sampling from the discharge valve, there is a possibility of a stuck or broken valve which could cause an uncontrolled release. Investigators should not utilize valves on tanks or bulk storage devices unless they are operated by the owner or operator of the facility or a containment plan is in place should the valve stick or break. If the investigator must sample from a tank discharge valve, the valving arrangement of the particular tank must be clearly understood to ensure that the compartment(s) of interest is sampled.

Because of the many different types of designs and materials that may be encountered, only general sampling procedures that outline sampling a tank from the top hatch are listed below:

1. All relevant information concerning the tank such as the type of tank, the tank capacity, markings, condition and suspected contents should be documented in a logbook.
2. The samplers should inspect the ladder, stairs and catwalk that will be used to access the top hatch to ensure that they will support the samplers and their equipment.
3. Before opening, ground each metal tank using grounding wires, alligator clips and a grounding rod or metal structure.
4. Any vents or pressure release valves should be slowly opened to allow the unit to vent to atmospheric pressure. Air monitoring for explosive/flammable gases and toxic vapors should be conducted during the venting with the results recorded in a logbook. If dangerous concentrations of gases evolve from the vent or the pressure is too great, leave the area immediately.
5. Touch tank opening equipment to the bolts in the hatch lid and allow electrical conductive path to form. Slowly remove bolts and/or hatch with spark resistant tools (brass/beryllium). If a pressure build up is encountered or detected, cease opening activities and leave the area.
6. Screen tanks for explosive/flammable gases and toxic vapors with air monitoring instruments. Depending on the project objectives and site conditions, conduct characteristic screening (e.g., pH, halogen, etc.) as desired. Collect a small volume of sample for flash point testing, if warranted. Note the state, quantity, number of phases and color of the tank contents. Record all relevant results, observations, and information in a logbook. Compare the screening results with any pre-existing data to determine if the tank should be sampled.
7. Select the appropriate sampling equipment based on the state of the material and the type of tank. Sampling equipment should be constructed of non-reactive materials.

Liquids -- Slowly lower the bailer, bacon bomb, Dipstick™, COLIWASA, or Teflon® tubing to the desired sampling depth. (NOTE: In work areas where explosive/flammable atmospheres could occur, peristaltic pumps powered by 12 V batteries should not be used.) Close the sampling device or create a vacuum and slowly remove the sampling device from the tank. Release the sample from the device into the sample container. Repeat the procedure until a sufficient sample volume is obtained.

Solids/Semi-Solids - Use a push tube, bucket auger, screw auger, Mucksucker™, or if conditions permit a pneumatic hammer/drill to obtain the sample. Carefully extrude the sample from the sampling device or use a clean stainless steel spoon to place the sample into containers for analyses.

Close the tank when sampling is complete. Segregate contaminated sampling equipment and investigative derived wastes (IDW) containing incompatible materials as determined by the screening procedure (Step

#6). At a minimum, contaminated, non-disposable equipment should be cleaned with laboratory detergent and rinsed with tap water prior to returning it from the field.

4.5 MISCELLANEOUS CONTAMINATED MATERIAL

Sampling may be required of materials or equipment (e.g., documents, building materials, equipment, etc.) to determine whether or not various surfaces are contaminated by hazardous constituents, or to evaluate the effectiveness of decontamination procedures.

Wipe or swab samples may be taken on non-absorbent, smooth surfaces such as metal, glass, plastic, etc. All surfaces and areas selected for sampling should be based on the project objectives.

For items with porous surfaces such as, insulation, wood, etc., actual samples of the materials are required. It is therefore important that during the collection and/or analyses of the sample that evidentiary material is not destroyed. Use scissors or other particle reduction devices. Mix in a glass pan as specified in the ASL SOP 013 Soil Sampling.

5. WASTE SAMPLE HANDLING PROCEDURES

5.1 GENERAL

When collecting samples of concentrated wastes for laboratory analyses, field personnel are required to screen the waste materials to ensure safe handling and transportation of the samples. Safety procedures, sampling and screening methods used to collect the samples must comply with those procedures/methods described in this protocol. It should be noted that waste samples should not be preserved because of the potential for an inadvertent chemical reaction with the preservative. Additionally, concentrated waste samples are not required to be cooled to 4°C.

After samples have been collected and containerized, the outside of the sample containers should be cleaned with water, paper towels and/or oil wipes to remove any spilled material from the exterior of the container. It should be noted that each sample container should be properly labeled and placed in a plastic bag. The bag should be securely closed. Samples collected from materials that did not demonstrate any hazardous properties during the screening process nor have strong chemical odors may be placed in coolers and handled as non-hazardous samples in accordance with the ASL SOP 016 Shipping Environmental and Waste Samples.

Field investigators will use knowledge gained of site practices and processes, labels and marking on waste containers, field screening results and personal observations made during their investigation to determine the hazard potential of a sample. Samples considered to be hazardous by the field investigators or detected to have strong chemical odors will be placed in secondary containment for transport to the laboratory. The bagged samples will be placed in a plastic pail and sealed with a tight fitting lid. The project number for the sampling investigation and the specific sample station number will be marked on the secondary container in indelible ink.

6. REFERENCES

ASL 2013. Standard Operating Procedure 001 Logbooks, and the ASL SOP 017 Sample and Evidence Management.

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination. Contaminated

ASL 2013. Standard Operating Procedure 018 Field Sampling Quality Control.

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Aerostar SES LLC
Standard Operating Procedure 024
Field Measurement of Uncertainty

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1. GENERAL INFORMATION

1.1 PURPOSE

The purpose of this procedure is to provide Aerostar SES LLC (ALS) staff direction regarding reporting uncertainty of field measurements.

1.2 SCOPE AND APPLICATION

Environmental field measurements pose unique challenges for estimating measurement uncertainty. This procedure addresses these uncertainty issues related to field measurements and field instrumentation and provides a methodology for estimating uncertainty for environmental measurements conducted in the field by Aerostar SES LLC (ASL) field personnel. Uncertainty statements can only be made for data collected following the initial effective date of this operating procedure.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-014-R1, Field Measurement Uncertainty. This document is designed to be utilized as a general guideline for measurement uncertainty. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 DEFINITIONS

1.3.1 Accuracy of Measurement (Accuracy)

Closeness of the agreement between the result of a measurement and the true value of the analyte being measured; where the true value is often theoretical or unknowable. Accuracy is a function of both precision and bias.

1.3.2 Precision

With respect to a single device, put into operation repeatedly without adjustments, precision is the ability to produce the same value or result, given the same input conditions and operating in the same environment. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

1.3.3 Bias

Consistent deviation of measured values from the true value, caused by a systematic error, or by two or more such errors operating cumulatively

1.3.4 Qualitative Measurement

Detection techniques used to identify the compounds or physical properties associated with the sample.

1.3.5 Quantitative Measurement

Measurement techniques used to determine the amount of each compound or the amount of the physical property associated with the sample.

1.3.6 Detection Limits

The lowest concentration or amount of target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive.

1.3.7 Standard Deviation

A measure of how much the data in a sample population are scattered around its mean value. It is usually denoted with the letter σ (lower case sigma). A standard deviation is defined as the square root of the variance.

1.3.8 Significant

Having an outcome unlikely to be caused by chance, and therefore indicating a systematic relationship, between measurements and conditions.

2. METHODOLOGY

2.1 GENERAL

ISO/IEC 17025:2005 requires reporting of measurement uncertainty for quantitative analytical results under three conditions:

1. when uncertainty is relevant to the validity or application of a measurement method,
2. when a customer's instruction so requires,
3. when the uncertainty affects compliance to a regulatory limit.

Uncertainty statements are typically requested by the customer in the planning phase of a project. If a customer requests an uncertainty statement following completion of the project, ASL management will determine whether it is feasible to report the uncertainty. For field data appearing in reports, uncertainty should be calculated and reported for data that directly affects compliance to a regulatory limit. For data collected as indicator parameters, (e.g. measurements to verify stabilization of a monitoring well or to develop strata for sample collection) uncertainty statements will not be reported unless the customer requests it or project manager deems it necessary.

The overall goal of documenting measurement uncertainty is to provide information that can be used for decision making. To achieve this goal, it is important to know if measurement uncertainty related to detection limits, field analytical bias, lack of precision and susceptibility to interferences is significant.

2.2 UNCERTAINTY CONTRIBUTORS

Both qualitative and quantitative factors contribute to field measurement uncertainty. For field measurements, there are several factors that can affect qualitative and quantitative measurements. Qualitative uncertainty factors include but are not limited to interferences, environmental conditions, sample handling and instrument maintenance and operation. The ASL field staff can reduce the impact of qualitative uncertainty factors through standard operating procedures that address the previously mentioned factors when possible. To date, a uniform approach to estimating the uncertainty associated with qualitative uncertainty contributors has not been developed by the scientific community. Qualitative uncertainty factors that are not addressed through standard operating procedures (e.g., weather extremes and any potential impact they may have had on the data) are discussed in the final report of a project.

The amount of uncertainty contributed by quantitative uncertainty factors can typically be determined. However, it is important to note that qualitative uncertainty factors can also impact quantitative uncertainty factors. Quantitative uncertainty factors include, but are not limited to, calibration, sample matrix, environmental conditions, sample handling and equipment maintenance and operation. Factors that are known to affect quantitative uncertainty are instrument precision and accuracy, and the accuracy of calibration standards. Field investigators should be aware of inherent instrument limitations, such as potential interferences, detection limits, and accuracy, and should ensure that the instrument is capable of collecting data that satisfies the data quality objectives of the study, particularly for studies that involve regulatory limits.

2.3 REPORTING UNCERTAINTY STATEMENTS

Uncertainty statements will be reported in accordance with the guidance presented in the International Organization for Standardization (ISO) Guide to the Expression of Uncertainty in Measurement (GUM) or other adapted references based on the GUM. The National Institute for Standards and Technology (NIST) Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results (NIST Technical Note 1297) is a helpful aid for understanding the GUM.

In addition to the procedures defined here, if an uncertainty statement is reported, ASL investigators will consult the GUM, NIST or other adapted references in order to specifically evaluate how to use quoted uncertainties to derive and report standard uncertainty for a particular field measurement. See Section 2.1 of this procedure for a list of when uncertainty statements are reported.

2.4 ESTIMATING QUANTITATIVE UNCERTAINTY

When estimating field measurement uncertainty, field investigators will attempt to identify all the major uncertainty contributors and make a reasonable estimation. When an uncertainty statement is required, as discussed previously in Section 2.1, the uncertainty statement will be prepared taking into consideration the instrument uncertainty, calibration standard uncertainty, the data quality objectives and any other applicable factors.

The quantitative uncertainty of a field measurement is not synonymous with the procedural control limits of the instrument. The quantitative uncertainty of a measurement should always be less than the control limits of the measurement procedure. Control limits are established to determine if a field instrument needs to be recalibrated or if data is of sufficient quality to be utilized for decision making purposes.

2.5 UNCERTAINTY TYPES

The GUM and NIST documents discuss the evaluation of uncertainty according to a "Type A" or "Type B" method of evaluation. The Type A method evaluates standard uncertainty by the statistical analysis of a series of repeated observations. The Type B method evaluates uncertainty based on scientific judgment using all of the relevant information available, which may include:

- previous measurement data
- experience with or general knowledge of the behavior and properties of relevant materials and instruments
- manufacturer's specifications
- data provided in calibration certificates and other certificates.

Broadly speaking, Type B uncertainty is either obtained from an outside source, or obtained from an assumed distribution based on judgment using all information available.

Aerostar SES LLC
Standard Operating Procedure 025
Corrective Action

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This document defines the procedure to identify, implement and monitor corrective actions within the Aerostar SES LLC (ASL) field activities and technical operations.

1.2 SCOPE AND APPLICATION

This procedure applies to ASL field staff and all those who may be participating in a field effort. This procedure contains direction developed solely to provide internal guidance to ASL employees.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-009-R4, Corrective Action.

1.3 DEFINITIONS

1.3.1 Corrective Action

An action initiated in response to an identified nonconformance, in order to define a problem, attempt to identify the root cause and determine how to prevent the problem from recurring.

1.3.2 Corrective Action Team

A corrective action team is designated by management and the FQM to investigate the root cause of a nonconformance and to propose a solution to the problem. The corrective action team may consist of one or more people and management may be part of the team if appropriate.

1.3.3 Nonconformance

A departure from ASL policies and procedures resulting in conditions adverse to quality.

2. METHODOLOGY

2.1 GENERAL

This procedure discusses how corrective action will be handled to address nonconforming work within ASL.

2.2 CORRECTIVE ACTION INITIATION AND TRACKING

Once the need for a corrective action has been identified, anyone within ASL can initiate a corrective action request through the Quality Assurance Manager (QAM). Corrective actions will be uniquely identified to facilitate tracking. The QAM will be responsible for tracking and documenting corrective actions.

2.3 CORRECTIVE ACTION PROCESS

The following procedure will be followed for addressing corrective actions.

1. Upon identification or notification of the need for a corrective action, the QAM will assign a corrective action identification number and begin documentation of the corrective action.

2. The QAM in consultation with the affected management will designate a Corrective Action Team (CAT) to assess the issues surrounding the problem.

3. The CAT will investigate the issue and determine the root cause of the problem. A summary of the assessment will be documented.

4. Once the root cause of the problem has been identified, the CAT will determine how to correct the problem and prevent it from recurring. A summary of the cause and solution will be included on the corrective action documentation.

5. The CAT will present the proposed solution to the affected management and the QAM for approval.
6. Upon approval of the solution, if any policies or procedures require updates, the QAM will ensure they are conducted.

7. The QAM will notify all affected personnel either verbally or in writing (email or memo) of any changes that result from the corrective action process.

8. Management is responsible for ensuring all affected personnel are implementing any changes. Some ways that management may do this is through direct communication with their staff and reviews of project records.

9. The QAM or their designee will formally monitor the effectiveness of corrective actions by conducting a review of the corrective action. The time frame for reviews will be determined by the QAM and will be based on the magnitude and risk of the problem. Multiple follow-ups may be conducted to ensure the effectiveness of the corrective action.

10. If the QAM determines that the corrective action is not effective, based on the magnitude and risk of the problem, the CAT or management may be tasked with reevaluating the problem and proposing another solution. If so, steps 5-9 above may be repeated. There may be situations where management needs to reassign members of the CAT due to expertise with a specific issue or to bring new perspective to a problem. In those situations, Steps 2-9 may be repeated.

11. Once the problem has been adequately addressed, the QAM will close-out the corrective action Based on identified areas of nonconformance, the QAM will conduct internal audits of appropriate areas of activity, as needed, to ensure compliance with ASL policies and procedures.

3. REFERENCES

US EPA 2010. SESDPROC-009-R4, Corrective Action.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. U.S. EPA. EPAQA/G-6. EPA/600/B-07/001.

AerostarSES LLC

Aerostar SES LLC
Standard Operating Procedure 026
GPS

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes the Aerostar SES LLC (ASL) Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy.

1.2 SCOPE AND APPLICATION

The procedures contained in this document are to be used by ASL field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In ASL investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that ASL field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-110-R3, Global Positioning Equipment.

2. METHODOLOGY

2.1 GENERAL

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General Use receivers), Mapping Grade receivers, and Survey Grade receivers.

Most General Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.

Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then data logging the results with sufficient information to post-correct the positions as described below. The potential accuracy that can be achieved may be better than one meter.

Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not used by ASL in field investigations. If survey grade accuracy is required, such as for newly installed wells, a subcontractor will be hired.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using triangulation of the ranges to calculate a unique position for the receiver.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels (db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as

Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radio beacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers.

Real-time DGPS can also be implemented with the Wide Area Augmentation System (WAAS). The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While beacon-based DGPS passes range corrections to the receivers, WAAS communicates a model for the errors which is capable of providing more accurate corrections. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. All but the least expensive General Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is generally accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period (generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is generally limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 REQUIREMENTS FOR LOCATIONAL INFORMATION

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

1. Providing an unambiguous means to identify facilities or sampling plots.
2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
3. Differentiating watersheds.
4. Providing information to calculate extents and volumes of contamination.
5. Providing a means to relocate the media represented by samples for removal or treatment.
6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	Application
100 m	Open ocean work where sample is presumed to be representative of a large area
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area
10 m	Stream and river work where samples are presumed to be broadly representative of a reach
5-3 m	Stream work where samples are representative of a specific narrowly defined section
10 m	Air Monitoring Stations
10 - 3 m	Microscale air monitoring
3 - 1 m	Permanent monitoring wells
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation
3 m	Locations of Temporary groundwater wells in broad plumes
3 m	Locations of environmental samples with sample spacing >20 m
5 m	Locations of environmental samples with sample spacing >60 m
200 - 20 m	Coordinates describing a facility where mobile waste units are sampled
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	Description
200 - 50 m	Map Derived, coarse work
40 - 20 m	Map Derived, fine work or using GIS with digital imagery
15 m	General Use Grade GPS, w/o WAAS
5 m	General Use Grade GPS, w/ WAAS or beacon corrections
10 m	Mapping Grade GPS, no corrections, averaged readings,
3 m	Mapping Grade GPS w/ differential correction, averaged readings
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings
10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate is based on several standard deviations probability of including the actual point in the measurement. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of ASL GPS work, the nominal accuracy figures derived from manufacturer's literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 Datums and Data Formats

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. Unless there are specific requirements on a project, all ASL work should be conducted using the WGS84 datum. Alternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option.

ASL requires that coordinates for sample locations be entered in the WGS84 datum and dd.dddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no ASL policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.dddddd°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 QUALITY CONTROL PROCEDURES

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most ASL studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 SPECIAL CONSIDERATIONS

The application will dictate the type of receiver used. There are several specific considerations for the use of the various receiver types.

2.4.1 Special Considerations for Use of Trimble Mapping Grade Receivers

The suggested settings for Trimble® receivers are:

1. Position mode: Over determined 3D (or manual 3D if only 4 satellites are visible)
2. Elevation mask: 15 degrees
3. PDOP: 6
4. Signal to noise ratio (SNR) mask: 6

5. Dynamics code: Land
6. Logging interval: 1 second for points, 5 seconds for lines and areas
7. Audible click: Yes
8. Log DOP data: Yes
9. Coordinate System: Geographic Datum WGS84

The logging interval of most Trimble® GPS receivers defaults to a 5 second interval. This may be changed to a 1 second interval to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by averaging positions. After a minimum of 36 positions are logged and the feature is closed, the averaged position can be obtained by selecting the feature on the 'Map' screen. The averaged position should always be the one entered into field notebooks.

2.5 RECORDS

The GPS coordinates and the ASL equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.
2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.
3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

1. Latitude, generally in dd.dddddd format.
2. Longitude, generally in dd.dddddd format.
3. Date of collection.
4. DOP information where it supports the accuracy requirements.
5. Correction status of each point where it supports the accuracy requirements.
6. The datum used for the export.

3. REFERENCES

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6, EPA/600/B-07/001.

EPA Region 4 2011. Operating Procedure SESDPROC-110-R3, Global Positioning Equipment.

Aerostar SES LLC
Standard Operating Procedure 027
Equipment and Inventory Management

August 2013
(Revision 0)

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1. GENERAL INFORMATION

1.1 PURPOSE

This document describes the Aerostar SES LL C (ALS) procedures necessary to demonstrate the operational status and inventory of equipment used for field measurement activities.

1.2 SCOPE AND APPLICATION

This procedure covers the approaches and documentation used for the purchase, maintenance, calibration, verification and inventory of equipment used for direct field measurement activities. This procedure includes the maintenance and use of microscopes, volumetric equipment and equipment that may come into direct contact with the sample media (i.e. submersible pumps) and has the potential to cross contaminate samples between sampling stations. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

This procedure was developed following the US Environmental Protection Agency (EPA) Guidance for Preparing Standard Operating Procedures (EPA 2007) and adapted from EPA Region 4 Operating Procedure SESDPROC-108-R4, Equipment Inventory and Management. This document is designed to be utilized as a general guideline for equipment maintenance and inventory management procedures at ASL, however, field personnel must always keep in mind that different projects, and different states, may have specific regulations equipment calibration and maintenance. Before beginning any field effort check for local, state, and federal regulations that may supersede this document.

1.3 DEFINITIONS

1.3.1 Calibration

The set of operations which establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system and corresponding known values. The results of a calibration permit the estimation of errors associated with the measurement equipment.

1.3.2 Calibration Verification

Provides a means of determining that deviations between measured values and known values are within the limits of error defined during calibration. The results provide an indication that the instrument/system is working properly.

1.3.3 Preventative Maintenance

A program of routine actions such as cleaning, lubrication, adjusting, or testing to keep equipment ready for use. The most important effect of a preventative maintenance program is to ensure measurement system reliability.

1.3.4 Qualified Individual

Individual who has received on the job training and has experience working with specific measurement instruments.

1.3.5 Equipment Log

Notebook, log book or electronic file that contains a copy of the purchase order, if available, as well as, maintenance, calibration, verification records, performance checks. Equipment logs will be established for all equipment used for field measurement activities or equipment that comes into direct contact with the sample media and has the potential to cross contaminate samples between sampling stations. The development of equipment logs is the responsibility of the designated individual at each ASL Office.

1.4 PRECAUTIONS

To ensure the safe and reliable operation of equipment, the manufacturers' directions for transport, cleaning, decontamination, storage, maintenance and operation of equipment will be followed. When possible, a copy of the instruction manual will be provided with sampling equipment to be taken in the field. Handling of contaminated equipment is addressed in ASL SOP 015 Field Equipment Cleaning and Decontamination.

2. METHODOLOGY

2.1 GENERAL

Equipment (hardware and related software) used for field measurement activities and equipment that comes into direct contact with the sample media and has the potential to cross contaminate samples between sampling stations will meet quality requirements identified for each piece of equipment. Important factors in establishing quality requirements include the parameters to be measured and the sensitivity and specificity of the detection system used. Quality requirements must include ensuring that equipment is ready for use. Specifically:

1. ASL will have adequate equipment to conduct measurement activities.
2. Equipment used for field measurement activities will be capable of achieving the accuracy and precision required by the project objectives.
3. When ASL is required to use environmental data collection equipment outside its permanent control (Rental Equipment), it will ensure that all relevant ASL criteria in this procedure are met.
4. Field measurement equipment used by ASL will be secured at all times, as feasible, based on field conditions. To include not leaving equipment in vehicles overnight.
5. Operating instructions and/or manuals from the manufacturer will be available for each piece of equipment, when possible.
6. Equipment used for field measurements will be handled, transported, shipped, stored and operated in a manner that prevents damage, gross contamination and deterioration. Equipment will be handled and maintained in accordance to the manufacturer's operating instructions. Decontamination of equipment will be in accordance to procedures described in ASL SOP 015 Field Equipment Cleaning and Decontamination.

2.2 PURCHASING EQUIPMENT

Equipment covered in this procedure is purchased through project needs or with the direct authorization of a senior ASL Manager. The initiator of a purchase is responsible for identifying the correct piece of equipment, obtaining a quote or price, possible sources and any other associated information that helps identify the correct item to be purchased. The sources identified must be capable of providing the equipment according to the defined specifications. Once the purchase of the equipment is approved by management the order may proceed.

2.3 RECEIVING EQUIPMENT

Anyone can accept delivery of equipment orders. Once the item has been received the ordering party is responsible for an initial inspection to ensure that it is the correct item and functional. If the items are acceptable, the invoice may be approved for payment. Ensure that a copy of the invoice is retained for the job records.

If any equipment is found to be unsuitable for use, action may be taken to correct that problem. The item may be returned to the supplier and/or replacement parts provided.

2.4 EQUIPMENT INVENTORY

Each ASL office will have an individual designated to keep track of equipment stored at that location, and maintain awareness of where that equipment is being used. These individuals are also responsible for ensuring that the equipment based out of their office is maintained in a usable condition at all times by checking equipment when it is returned from the field.

2.5 EQUIPMENT LABELING AND MARKING

All equipment will have boxes or an appropriate storage device. These boxes will be marked with the type and serial number of the equipment stored within. Each box will also have the company name and address as well as a phone number in case the equipment should be lost.

2.6 EQUIPMENT MAINTENANCE

Maintenance will consist of preventative care and corrective repair. Both approaches should be used to keep equipment in working order. Each item of field measurement equipment will be checked by a qualified individual prior to use. Critical spare parts, which cannot be easily obtained while in the field, will be sent out with the equipment during field investigations.

Equipment maintenance will include software upgrades for certain instruments. ASL management will assign staff to serve as a point of contact for equipment, such as GPS or Sondes that may require periodic software upgrades in order to collect field measurements. The point of contact will ensure that software upgrades are conducted on all equipment. The point of contacts will maintain a list of the equipment which will include the serial number and storage location of the equipment.

2.7 REPAIR AND RE-CERTIFICATION FOR USE

Equipment known or suspected to be defective will be taken out of service and clearly labeled, preferably with a red tag, until it has been repaired and shown by calibration, verification or testing to function properly.

Equipment damaged on a project becomes that projects responsibility to repair, either through in house expertise or through shipment to a vendor. Spare parts needed fall under the projects Field Supplies and Equipment budget.

2.8 REQUIRED MAINTENANCE

The designated personnel are responsible for ensuring that equipment maintenance is performed in-house or by an outside service.

2.9 EQUIPMENT CALIBRATION

Prior to being used in the field, measurement equipment will be visually inspected and a calibration, calibration verification or performance check will be conducted to ensure it is in working condition. A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. When practicable, equipment requiring calibration will be labeled to indicate the status of calibration and the date when re-calibration is due. Calibration acceptance criteria based on data quality objectives will be established on a case by case basis for each field study. Project Managers will be responsible for ensuring the acceptance criteria are met. Calibration and measurement requirements are found in individual measurement procedures.

All reasonable measures will be taken to safeguard equipment from adjustments which would invalidate the measurements following calibration of the equipment. Field investigators will handle, transport and store equipment in accordance to manufacturer recommendations. Periodic calibration or performance checks will be conducted during field investigations to ensure that equipment calibration has not been adversely impacted between measurement locations.

2.10 EQUIPMENT PERFORMANCE CHECKS

New equipment will be calibrated or verified by qualified personnel to verify that it is adequate to perform its intended function, and calibrated before release for use in the field. Records of calibration or verification will be maintained in the equipment log books.

If equipment leaves the direct control of ASL for a period of time, the designated personnel will ensure that the function and, where necessary, the calibration status of the equipment is checked and shown to be satisfactory before the equipment is returned to service.

3. REFERENCES

ASL 2013. Standard Operating Procedure 015 Field Equipment Cleaning and Decontamination.

US EPA 2007. Guidance for the Preparation of Standard Operating Procedures. EPAQA/G-6, EPA/600/B-07/001.

EPA Region 4 2013. Operating Procedure SESDPROC-108-R4, Equipment Inventory and Management.

Aerostar SES LLC
Standard Operating Procedure 028P
Field Sampling Protocols to Avoid Cross-Contamination at Perfluorinated Compounds (PFCs) Sites

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1.0 GENERAL INFORMATION

Purpose

This standard operating procedure (SOP) describes the procedure and considerations to be taken into account by Aerostar SES LLC (ASL) employees when collecting soil, sediment, surface water, and groundwater samples at sites with potential releases of perfluorinated compounds (PFCs).

Scope and Application

This procedure applies to all ASL personnel and subcontractors who collect or otherwise handle samples of soil, sediment, surface water, and groundwater for analysis of PFCs. This SOP should be reviewed by all on-site personnel prior to implementation of field activities.

This procedure was developed using the following

- Transport Canada, May 2013. *Perfluorochemical (PFC) Field Sampling Protocol.*
- Delta Consultants, February 2010. *Report of Investigation Activities at Select Firefighting Foam Training Areas and Foam Discharge Sites in Minnesota.*
- Minnesota Pollution Control Agency (MPCA), October 2008. *Closed Landfill Program Sampling Protocol for Monitoring Wells.*

2.0 GENERAL

Given the low detection limits associated with PFC analysis and the many potential sources of trace levels of PFCs, field personnel are advised to act on the side of caution by strictly following these protocols, frequently replacing nitrile gloves, and rinsing field equipment to help mitigate the potential for false detections of PFCs. Specific items related to field sampling are discussed below.

3.0 RESPONSIBILITIES

Project Manager

The Project Manager will provide the Quality Project Plan (QPP) and installation-specific work plan, which include the sampling requirements for each site. The Project Manager will report deviations to this procedure to the Quality Control (QC) Manager and the client’s Contracting Office Representative (COR).

Field Manager

The Field Manager will ensure that samples are collected in accordance with the QPP, installation-specific work plans, and applicable SOPs. The Field Manager will also be required to make rational and justifiable decisions when deviations from these procedures are necessary because of field conditions or unforeseen issues and report the deviations to the Project Manager.

Quality Control Manager

The QC Manager will be responsible for conducting field audits during sampling activities. During these audits, the QC Manager will ensure that field crews are adhering to the QPP including sampling techniques, field documentation, sample packaging, chain of custody documentation procedures, and equipment calibration.

Field Personnel

Field personnel assigned to sampling activities are responsible for completing their tasks according to specifications outlined in the QPP, installation-specific work plans, applicable SOPs, and other appropriate procedures. Field personnel are responsible for reporting deviations from procedures to the Field Manager.

4.0 PROCEDURES/CONSIDERATIONS

The following are procedures/considerations to be made during field activities at potential PFC release sites. A summary of the prohibited and acceptable items for PFC sites is included in Table 1. A checklist, provided as Attachment 1, will be used daily prior to the commencement of fieldwork to ensure the field team is in compliance with this protocol.

Field Equipment

- **Do not use Teflon®-containing materials** (e.g., Teflon® tubing, bailers, tape, plumbing paste, or other Teflon® materials) since Teflon® contains fluorinated compounds.
- High-density polyethylene (HDPE), low-density polyethylene (LDPE), and silicon materials are acceptable for sampling. Samples should not be stored in containers made of LDPE materials.
- ASL will use peristaltic pumps for groundwater sample collection at depths shallower than 25 feet. ASL will use ProActive SS Pumps with PVC leads or Geotech SS Geosub pumps for groundwater sample collection at depths greater than 25 feet. These pumps are stainless steel and will minimize introductions of PFCs. However, for sample depths greater than 150 feet, a Grundfos RediFlo pump (or similar) may be used due to pumping limitations of the all stainless steel pumps.
- When using liners to collect soil samples during direct-push technology (DPT) or conventional drilling methodologies, acetate liners are to be used.
- To avoid plastic coating or glue materials, **do not use waterproof field books**. Field reports will be documented on loose paper held by masonite or aluminum clipboards using a pen or pencil. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable. Sharpies®/markers may be used.
- **Post-It Notes are not allowed** on PFC project sites.
- **Do not use markers other than Sharpies®markers.** Ballpoint pens will be used when documenting field activities in the field log and on field forms as well as labeling sample containers and preparing the Chain of Custody.
- **Do not use chemical (blue) ice packs** during the sampling program. This includes the use of ice packs for the storage of food and/or samples.

Field Clothing and Personal Protective Equipment

- **Do not wear water resistant, waterproof, or stain-treated clothing** during the field program. Field clothing made of synthetic and natural fibers (preferably cotton) are acceptable. Field clothing should be laundered avoiding the use of fabric softener. Preferably, field gear should be cotton construction and well laundered (a minimum of 6 times from time of purchase). New clothing may contain PFC related treatments. **Do not use new clothing** while sampling or sample handling.
- **Do not wear clothing or boots containing Gore-Tex™** during the sampling program as it consists of a PFC membrane.
- All safety footwear will consist of steel-toed boots made with polyurethane and polyvinyl chloride (PVC).
- **Do not wear Tyvek® clothing** on-site since it contains fluorinated compounds.

- Disposable nitrile gloves must be worn at all times. Further, a new pair of nitrile gloves will be donned prior to the following activities at each sample location:
    - Decontamination of re-usable sampling equipment;
    - Prior to contact with sample bottles or water containers;
    - Insertion of anything into the well (e.g. HDPE tubing, HydraSleeve bailer, etc.);
    - Insertion of silicon tubing into the peristaltic pump;
    - Completion of monitor well purging, prior to sample collection;
    - Handling of any quality assurance/quality control samples including field blanks and equipment blanks; and,
    - After the handling of any non-dedicated sampling equipment, contact with non-decontaminated surfaces, or when judged necessary by field personnel.

Sample Containers

- Different laboratories may supply sample collection containers of varying sizes dependent on the type of media to be sampled (e.g., soil, groundwater, etc.). All samples should be collected in polypropylene or HDPE bottles. The screw cap will be made of polypropylene or HDPE and may be lined or unlined. However, if lined, the liner may not be made of Teflon® or contain PFCs.
- Container labels will be completed using pen after the caps have been placed back on each bottle.
- Glass containers should also be avoided due to potential loss of analyte through adsorption.

Wet Weather

- Field sampling occurring during wet weather (such as rainfall and snowfall) should be conducted while wearing appropriate clothing that will not pose a risk for cross-contamination. Teams will avoid synthetic gear that has been treated with water-repellant finishes containing PFCs. Use rain gear made from polyurethane and wax-coated materials.
- Teams should consider the use of a gazebo tent, which can be erected overtop of the sample location and provide shelter from the rain. It should be noted that the canopy material is likely a treated surface and should be treated as such; therefore, gloves should be worn when moving the tent, changed immediately afterwards and further contact with the tent should be avoided until all sampling activities have been finished and the team is ready to move on to the next sample location.

Equipment Decontamination

Field sampling equipment, including oil/water interface meters and water level indicators, that are utilized at each sample location will require cleaning between uses. Alconox® and Liquinox® soap is acceptable for use since the Material Safety Data Sheets do not list fluorosurfactants as an ingredient. However, **Decon 90 will not be used** during decontamination activities. Water used for the final rinse during decontamination of sampling equipment will be laboratory certified “PFC-free” water.

For larger equipment (e.g., drill rigs), decontamination will be conducted with potable water using a high-pressure washer and then rinsed using potable water.

Personnel Hygiene

- Only 100% natural ingredient moisturizers, hand cream, cosmetics, or other related products will be used by field personnel as part of their personal cleaning/showering routine on the morning of a sampling event, as these products may contain surfactants and represent a potential source of PFCs contamination. If PFC-free products are unavailable, then these product will not be used on the morning of the sampling event.

- Many manufactured sunblock and insect repellants contain PFCs and should not be brought or used on-site. Sunblock and insect repellants that are used on-site should consist of 100% natural ingredients. A list of acceptable sunscreens and insect repellents are listed in Table 1.
- For washroom breaks, field personnel will leave the exclusion zone and then remove gloves and overalls. Field personnel should wash as normal with extra time for rinsing with water after soap use. When finished washing, the use of a mechanical dryer is preferred and the use of paper towel for drying is to be avoided (if possible).

Food Considerations

- No food or drink will be brought on-site, with the exception of bottled water and hydration drinks (such as Gatorade® and Powerade®), which will only be allowed to be brought and consumed within the staging area.

Visitors

- Visitors to the site are asked to remain outside of the exclusion zone during sampling activities.

5.0 Tiered Approach to Assist with Field Decisions

In evaluating whether products contain PFCs and are suitable for use in the field, the tiered approach presented in Table 2 will be used to assist with field decisions. Any member of the field team should contact the Project Manager, Technical Lead, or Project Chemists with questions.

Table 1 Summary of Prohibited and Acceptable Items for PFC Sampling

Prohibited Items	Acceptable Items
Field Equipment	
Teflon® containing materials	High-density polyethylene (HDPE) and Low density polyethylene (LDPE) materials
	Acetate liners
Aluminum Foil	
	Silicon tubing
Waterproof field books	Loose paper (non-waterproof)
Plastic clipboards, binders, or spiral hard cover notebooks	Aluminum ore Masonite field clipboards
	Sharpies®, ballpoint pens
Post-It Notes	
Chemical (blue) ice packs	Regular ice
Field Clothing and PPE	
New clothing or water resistant, waterproof, or stain-treated clothing, clothing containing Gore-Tex™	Well-laundered clothing, defined as clothing that has been washed 6 or more times after purchase, made of synthetic or natural fibers (preferable cotton)
Boots containing Gore-Tex™	Boots made with polyurethane and PVC
Tyvek®	Cotton Clothing
Only 100% natural ingredient moisturizers, hand cream, cosmetics, or other related products will be used by field personnel as part of their personal cleaning/showering routine on the morning of sampling	**Sunscreens -** Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are “free” or “natural” **Insect Repellents -** Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics **Sunscreen and insect repellant -** Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon®-lined caps	Lined or unlined HDPE or polypropylene caps
Rain Events	
Waterproof or resistant rain gear	Gazebo tent that is only touched or moved prior to and following sampling activities
Equipment Decontamination	
Decon 90	Alconox® and/or Liquinox®
Water from an on-site well	Potable water from municipal drinking water supply
Food Considerations	
All food and drink, with exceptions noted on the right	Bottled water and hydration drinks (i.e. Gatorade® and Powerade®) to be brought and consumed only in the staging area

Table 2 Tiered Approach to Assist with Field Decisions

Tier and Description	Action
Tier 1: Products that *will come into direct contact* with field samples include, but are not limited to, sampling equipment, sample containers, and well construction materials	These products will undergo the greatest scrutiny and requires chemist's input to help evaluate the materials as a possible source of contamination[A] and as possible sampling or storage materials or both.
Tier 2: Products that *will not come into direct contact* with samples, but could be *reasonably expected to contain PFCs*, such as waterproof or nonstick products	Project team/affected person can review the Safety Data Sheet (SDS)[B] and if it shows PFCs, product should not be used. If product SDS does not indicate PFCs, confirm with chemist before use
Tier 3: Products that *will not come into direct contact* with samples and are *not expected to contain PFCs*, such as ballpoint pens, zipper bags, and body braces	Project team/affected person can review SDS and if no PFCs, then appropriate to use

[A] Tier 1 products will undergo the closest scrutiny. It may be necessary to have Tier 1 products analyzed for PFCs to confirm that a specific batch or lot number does not contain PFCs. Alternate products will need to be evaluated/used if PFCs are identified in the product.

[B] SDS Check: To evaluate product SDS and/or manufacturing specs, check if the product contains anything with "fluoro" in the name or the acronyms TPE, FEP, ETFE, and/or PFA. If fluorinated compounds are not listed in the manufacturing specs and/or on the SDSs, product can be used.

Aerostar SES LLC
Standard Operating Procedure 029P
Providing Contaminant-Free Source Water at Perfluorinated Compounds (PFCs) Sites

January 2016
(Revision 1)

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and limit trace perfluorinated compound (PFC) detections introduced through low-level PFC contamination in the laboratory-supplied water used for field blanks, equipment blanks, and decontamination of sampling equipment; ambient PFC contamination from atmospheric conditions or sample containers; or decontamination procedures. The following procedures will be used to provide traceable PFC-free water for equipment decontamination, field blanks, and equipment blanks.

2.0 SCOPE

This procedure applies to all Aerostar SES LLC (ASL) personnel and subcontractors who use or provide PFC-free water for field blanks, equipment blanks, and equipment decontamination at sites under investigation for PFCs.

3.0 DEFINITIONS

Per the Department of Defense *Quality Systems Manual for Environmental Laboratories Version 5.0* (July 2013), water will be defined as being PFC-free if there are no target analyte detections at concentrations equal to or greater than half the limits of quantification (LOQs) specified in Table 1. Target analyte detections at or greater than half the LOQ will disqualify all the water in the associated batch from being used for equipment decontamination, field blanks, or equipment blanks.

4.0 GENERAL

Given the low detection limits associated with PFC analysis and the many potential sources of trace levels of PFCs, laboratory and field personnel are advised to act on the side of caution by strictly following these protocols.

Table 1 Perfluorinated Compounds Analytical and Action Limits

Analytes	Acronym	LOD (ng/L)	LOQ (ng/L)	Action Limits (ng/L)
Perfluorohexanoic acid	PFHXa	16	20	NL
Perfluoroheptanoic acid	PfHpA	16	20	NL
Perfluorooctanoic acid	PFOA	16	20	400
Perfluorononanoic acid	PFNA	16	20	NL
Perfluorodecanoic acid	PFDA	16	20	NL
Analytes	**Acronym**	**LOD (ng/L)**	**LOQ (ng/L)**	**Action Limits (ng/L)**
Perfluorobutanesulfonic acid	PFBS	16	20	NL
Perfluorohexanesulfonic acid	PFHxS	16	20	NL
Perfluoroheptanesulfonic acid	PFHpS	16	20	NL
Perfluorooctanesulfonic acid	PFOS	16	20	200
Perfluorodecanesulfonic acid	PFDS	16	20	NL

NL = not listed. No action limit has been defined for this compound.
LOD = limit of detection
ng/L = nanograms per liter

5.0 RESPONSIBILITIES

Analytical Laboratories

Project analytical laboratories will be responsible for providing ASL with PFC-free water to use for field and equipment blanks on sites being investigated for PFCs. The laboratories must certify that each batch of deionized water is PFC-free following the procedures specified below before shipment to the field. Procedures to be used for certification of the PFC-free water are:

1) If the laboratory provides water from its internal ultrapure water system, that water must be used for the routine preparation of method blanks for PFC analysis, and the laboratory must:
    a. Provide copies of their control charts showing that PFC concentrations in the method blanks are consistently less than the concentrations specified in Section 6 below with each shipment of water;
    b. Fill a bottle from each “manufacturers lot” of bottles/caps with the laboratory’s PFC-free water, and analyze an aliquot of water from that bottle to show that the water in the bottle meets the requirements of Section 6 below; and,
    c. Assign a unique Batch Number to each shipment of PFC-free water to ASL, and maintain a record of the preparation date and bottle/cap lot number used to prepare that PFC-free

water batch. If multiple bottle types (such as cubicle containers for large volumes and 125 milliliter bottles for rinsate blanks) are used, separate batch numbers should be used for each bottle type.

2) If the laboratory provides purchased ultrapure water to ASL for equipment decontamination and blanks, the laboratory must analyze an aliquot of each manufacturer's batch before the water is shipped to ASL. If target analytes are detected in the water at concentrations equal to or greater than half the LOQs specified in Table 1, the water must be considered contaminated, and not shipped to ASL. The manufacturer name and batch or lot number will be used for purposes of maintaining traceability of purchased water.

If target analytes are not detected at concentrations equal to or greater than half the LOQs specified in Table 1, the water is suitable for shipment to ASL. The laboratory must provide a certificate of analysis with results for the water batch to the ASL's Project Chemist, or designee, before the water is shipped to the field. Each batch of PFC-free water must be clearly marked with a unique batch identification number.

ASL Field Personnel

Prior to use, the field crew will collect a field blank from each batch of PFC-free water by pouring an aliquot of the water into a sample container. Before sample collection, field crews will decontaminate the equipment using the PFC-free water as a final rinse. During sample collection, field crews will collect equipment blanks at a frequency of one equipment blank per day of sampling for each type of sampling equipment.

ASL field crews will clearly associate field blanks and equipment blanks with both the associated laboratory water batch identification number and associated field samples on daily field forms and/or in an electronic sample tracker. The ASL Chemist will maintain records and will chart results of the source water, equipment blank, and field blank analytical data. ASL will evaluate the data to identify any trends or anomalies that warrant a change of this or field sampling procedures.

6.0 EVALUATION

This procedure will provide documentation that the source water used for equipment rinsing and blanks is PFC-free, with PFC levels less than 1/40 the project action limit for perfluorooctanoic acid (PFOA), less than 1/20 the project action limit for perfluorooctanesulfonic acid (PFOS), or less than half the LOQ for analytes without project action limits. ASL will track analyte concentrations in the water from shipment from the laboratories, to the field, and ultimately to the water's use to rinse sampling equipment. This will eliminate concern about the PFC-free water itself as a source of contamination, and facilitate evaluation and identification of sources or actions that contribute to cross-contamination, so that the project team can adjust procedures if needed. The blanks dataset will be used as part of ASL's overall quality control assessment of ambient sources of PFC contamination relative to sample concentrations.

Appendix D

Field Forms

Campobello SOP CAM SOP-00894 / 6 **Campobello**

Determination of Perfluorinated Compounds in Water and Soil by LC-MS-MS

Maxxam Analytics International Corporation
6740 Campobello Road
Mississauga, Ontario
905-817-5700

Document Identity

Document Status and Ownership

Current Status	**Approved - Released**		
Approval Date	November 7, 2014	**Release Date**	November 7, 2014
Version Author	Sin Chii Chia	**Version Manager**	Adam Robinson

Document Categorization

Change Categorization

Campobello Departments	Environmental

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Release and Audit Schedule

Release Schedule	When Approved ☐ **Allow Administrator to Release Document Early**
Expiration Schedule	When Superseded or Obsoleted
Audit Schedule	12 Month(s)

Special Handling on Release

☑ **Update Completed Trainee Records**

Insert Text

- CAM SOP-00894/6
- EPA Method 537
- MOE method PFC-3457_Sept 2008
- Appendix A: DoD-DOE QSM_Table 15
- CTA_CAM SOP-00894

Associated Documents

Document Control Documents

- Corporate WI Publish to All COR WI-00012 : Definitions
- Corporate WI Publish to All COR WI-00015 : Corporate Procedure for Balance Calibrations and Verifications
- Corporate WI Publish to All COR WI-00017 : Corporate Procedure for Volumetric Verification
- Corporate WI Publish to All COR WI-00018 : Determination of Estimation of Analytical Uncertainty of Measurement
- Corporate WI Publish to All COR WI-00050 : Environmental Chemistry Method Validation
- Corporate WI Publish to All COR WI-00055 : Corporate Procedure for Control Charting
- Campobello SOP CAM SOP-00101 : Disposal of Samples

- Campobello SOP CAM SOP-00621 : Glassware Washing
- Campobello WI CAM WI-00004 : Chemical Labelling
- Campobello WI CAM WI-00008 : Monitoring Temperatures
- Campobello WI CAM WI-00010 : Handling of Analytical Standards
- Campobello WI CAM WI-00018 : Waste Disposal
- Campobello WI CAM WI-00095 : Environmental Method Validation (NELAC + DOD requirements)
- Campobello WI CAM WI-00506 : Sciex API 4000
- Campobello FCD CAM FCD-00328 : Bench Level Planned Deviation or Non-Conformance Form
- Campobello FCD CAM FCD-01126 : Worksheet Data Validation Checklist - Extractable Organics
- Ultra Trace Air Toxics FCD BRL FCD-00002 : Internal Data Validation Checklist
- Maxxam Environment Health and Safety WIs MEHS WI-00013 : Corporate Environmental, Health and Safety Guide

Reason for Change

Date of Change July 17, 2008 **Version** 1
Section Changed new
Change Made initial release of new SOP into QSI

Date of Change October 22, 2009 **Version** 2
Section Changed 12.5, 12.6
Change Made 12.5 Changed Spk 0 to Blank, corrected weight of soil
12.6 Corrected weight of soil

Date of Change March 18, 2010 **Version** 3
Section Changed 4.1, 12.5, 12.6, 12.8, 15.2, 15, 16
Change Made 4.1 Added in testcodes
12.5, 12.6 Corrected QC and matrix spike concentration for soil, changed QC spike concentration
12.8 Changed expiry of mobile phase buffer
15 Updated QC requirements
16 Updated section
Added Header
Corrected spelling and document references throughout
Added associated documents

Date of Change August 9, 2011 **Version** 4
Section Changed Entire Document, Title, 1.0, 2.0, 3.0, 4.0, 5.0, 7.0, 8.0, 9.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0
Change Made Entire Document, font and format changes to reflect Maxxam's re-branding.
Title, changed title to reflect inclusion of additional PFC compounds.
1.1 Scientific principle updated to describe newly validated procedure and inclusion of additional parameters.
2.3 Calibration range was modified to reflect newly validated method.
3.0 Definitions list expanded.
4.2 Primary reference changed to MOE.
4.3 Deviations to reference method updated.
4.4 Additional reference (EPA 537) added.
5.1 Regulatory criteria (Health Canada) added.
7.0 Sample containers and minimum sample size updated to reflect current practices.
8.0 Interferences were expanded upon. No glass containers was added.
9.0 Section header changed to Method Performance.
9.1 Typical detection limits in water and soil were added for all compounds.
9.2 New reporting limits for all compounds were added.
11.0 Additional apparatus and materials were added to reflect current practices.
12.1 Preparation procedure updated to include additional reagents used in current practices.
12.2 New preparation procedures added for standard preparation and quality control samples.
13.1 SPE procedure added for aqueous samples.
13.2 Direct analysis of aqueous samples modified to reflect currect practices.
13.3 Extraction procedure of soil samples modified to reflect current practices.
14.0 Format changes to section.
14.1 Calibration performance criteria added.
14.2 Typical run format updated.
14.3 Chromatographic conditions modified to reflect current practices.
14.5 MRM transitions of additional compounds added.
15.0 Section reformatted.
15.2 Corporate control chart work instruction (COR WI-00055) now referenced.
16.0 Section reformatted.
16.1 Updated and clarified calculations.
16.2 Updated and clarified reporting procedures and confirmation criteria.

Date of Change March 14, 2014 **Version** 5
Section Changed 1.0, 2.3, 3.0, 4.2, 4.3, 6, 7.2, 9, 11, 12.0, 12.1, 12.2, 12.3.4, 13.0, 13.1, 13.4, 14.0, 14.2, 14.3, 14.5, 15.2.3, 15.2.4, 15.2.5, 15.2.6, 15.2.7, 16.1
Change Made
1.0 Updated to include current practices (addition of leaching procedure for soil samples and 3 new compounds)
2.3 Tables added providing the calibration range for both high and low level aqueous and soil anlayses

3.0 Expanded definitions list
4.2 Updated reference method to USEPA 537
4.3 Updated deviations from new reference method
6 Updated safety section
7.2 Updated minimum sample size for water based on revised method
9 Updated DLs for all parameters based on most recent validation. Added DLs for the 3 new parameters (PFDS, PFTrDA & PFTeDA). Added RDLs for soils analyzed by aqueous leaching method
11 Updated materials/equipment list to reflect current practices
12.0 Changed reference document for verification of volumetric devices to COR WI.
12.1 Updated solvent/reagents list to reflect current practices
12.2 Added information on preparation of soil standards, QCs and internal standards required by aqueous leaching method, reformatted section.
12.3.4 Included preparation procedures for initial calibration standard (formally referred to as CCV)
13.0 Moved preparation procedures for QC samples to this section. Added prearation procedures for matrix spike duplicate (DoD requirement)
13.1 Identified SPE eluates as Fraction 1 & Fraction 2
13.4 Added aqueous leach procedure for soil samples
14.0 Reformatted section. Moved calibration acceptance criteria to section 15
14.2 Modified typical run format
14.3 Updated chromatographic conditions to reflect current practices
14.5 Added MRM transitions for new parameters (PFDS, PFTrDA, PFTeDA & 13C2PFTeDA)
15.0 Updated calibration and QC acceptance criteria to be consistant with DoD QSM (march 2013)
15.2.3 Corrected MS recovery calculation formula by addition of brackets
15.2.4 Added acceptance criteria for MS duplicate
15.2.5 Corrected RPD calculation formula by addition of brackets
15.2.6 Moved RRT acceptance criteria to this section
15.2.7 Added acceptance criteria for internal standard response (as per DoD QSM - march 2013)
16.1 Added formula for calculating matrix equivalent concentrations from solution concentrations
Attached CTA
Associated documents reviewed

Date of Change November 7, 2014 **Version** 6

Section Changed 1.0, 2.3, 4.1, 4.3, 4.4, 7.0, 9.1, 9.2.1, 11.0, 11.3, 12.1, 12.2, 12.2.3, 12.3, 12.3.4, 12.4, 12.5, 13.0, 13.1.5, 13.1.6, 13.2.11, 13.2.21, 13.2.22, 13.2.23, 13.2.25, 13.2.26, 13.4.12, 14.1, 14.2, 14.4, 15.0,15.2.6, 15.2.7, 15.2.8, 18.0

Change Made Added Table of Contents
1.0 Updated to include addition of 7 new compounds in water
2.3 Updated to include calibration range for new compounds
4.1 Added new testcode
4.3 Added information to section
4.4 Added additional reference
7.0 Updated section on sample preservation
9.1 Updated section to include typical DLs
9.2.1 Updated section to include new RDLS
11.0 Reformatted and renumbered section to include chemicals/solvents.
11.3 Added information to laboratory equipment
12.1 Removed chemicals/solvents from section, added preparation of 20 mM TBAS, updated preparation of reconstitution solution.
12.2 Updated section to include new compounds
12.2.3 Moved procedures for preparation of calibration standards to Tables 1-6 (Section 18.0)
12.3 Updated section to include new compounds
12.3.4 Moved procedures for preparation of ICV to Tables 4-8 (Section 18.0)
12.4 Internal standards renamed as mass-labelled internal standards, new compounds addedded
12.5 Added section on injection internal standards
13.0 Updated section to include new compounds, use of LCMS (or HPLC) grade water and renaming of internal standards as mass-labeled internal standards
13.1.5 Changed solvent to methanol to reflect most recent method validation
13.1.6 Updated to include addition of injection internal standard
13.2.11 Modified approximate sample volume to be added to SPE cartridge
13.2.21 Increaased drying time to reflect most recent method validation
13.2.22 Added step to wipe down needle guides
13.2.23 Updated method to include addition of 20mM TBAS to fraction 1 eluates
13.2.25 Added tolerance limits to drying temperature, added information on volatility of analytes
13.2.26 Modified reconstitution step to include addition of injection internal standards
13.4.12 Added tolerance limits to drying temperature
14.1 Renumbered section, added acquisition methods
14.2 Modified typical run format
14.4 Updated and moved information on analyte mass transitions to Table 9 (Section 18.0)
15.0 Summarized and moved acceptance criteria to Table 10 (Section 18.0), updated corrective actions
15.2.6 Added information and updated acceptance criteria for recovery of mass-labeled surrogates
15.2.7 Added acceptance criteria for injection internal standards
15.2.8 Updated relative retention time criteria
18.0 Added new section (Tables)
Associated documents reviewed

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DETERMINATION OF PERFLUORINATED COMPOUNDS IN WATER AND SOIL BY LC-MS-MS

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1.0 INTRODUCTION

1.1 Scientific Principle

The SOP describes the quantitative analysis of 23 perfluorinated compounds in water and 16 perfluorinated compounds in soil by liquid chromatography-tandem mass spectrometry (LC/MS/MS).

Water samples are typically first analyzed directly using a high calibration range (High Level Analysis). Samples containing high concentrations of PFCs may be reported using this method. Samples that contain low or non-detectable levels of PFCs using high level analysis are then analyzed using a lower calibration range (Low Level Analysis) in order to achieve lower reporting limits. In low level analysis, water samples are extracted using weak anion exchange solid phase extraction (SPE) cartridges prior to analysis by LC/MS/MS.

Soil samples are typically first analyzed using a low calibration range (Low Level Analysis). Samples are homogenized, mixed with an ion pairing agent, extracted with methyl tert-butyl ether, evaporated to dryness and reconstituted in solution for instrumental analysis. Soil samples containing high concentrations of PFCs may be analyzed using a high calibration range (High Level Analysis) by extracting soil samples with 70/30 acetonitrile/water prior to instrumental analysis.

Chromatographic separation is achieved using a C18 reverse phase liquid chromatography column. Isotopically labeled internal standards are added during sample processing to monitor method performance and compensate for any matrix effects. Each PFC is quantified by isotope dilution method using a multi-point calibration curve.

2.0 SCOPE

2.1 Applicability

The procedure is applicable to the determination and confirmation of perfluorinated compounds (PFCs) in water and soil samples.

2.2 Responsibilities

It is the responsibility of the Department Managers and Supervisors to ensure that documents are written and reflect the procedures performed at Maxxam. It is the responsibility of all staff to ensure that the procedures outlined in this document are followed. The Manager or Supervisor must approve any deviations from the SOP. The procedure used, and approval is recorded as a Policy Deviation Form in Compliant Pro or on CAM FCD-00328.

2.3 Calibration Range

2.3.1 Low level Analysis:

Matrix	Range
Aqueous	0.02/0.05 – 1.1/2.75 µg/L
Solids (Soils)	0.1 – 5.0 µg/kg

2.3.2 High Level Analysis:

Matrix	Range
Aqueous	0.80/2.0 – 50/125 µg/L
Solids (Soils)	5.0 – 250 µg/kg

3.0 DEFINITIONS

Refer to COR WI-00012 “Definitions”. Additional definitions are listed below.

3.1 LC/MS/MS: Liquid chromatography – tandem mass spectrometry.

3.2 Precursor ion: Also synonymous with parent ion, is an electrically charged molecular moiety that may dissociate to form fragments (daughters), of which one or more may be electrically charged, and one or more neutral species.

3.3 Product ion: Also synonymous with daughter ion, is an electrically charged ion resulting from the collision of a precursor ion with an inert gas in the mass spectrometer.

3.4 MRM: Multiple reaction monitoring. The mode of operating a mass spectrometry system so that an ion of a given mass (a precursor) must fragment (dissociate) to give a product ion of a specific mass in order for a response to be detected.

3.5 SPE: Solid phase extraction

3.6 RODI Water (DiH_2O): Reverse osmosis deionized water

3.7 C of A: Certificate of Analysis

3.8 IS: Internal Standard

3.9 DoD: Department of Defense

4.0 REFERENCE METHOD

4.1 Test Codes:

Water:	PFOSALCM-W
Soil:	PFOSALCM-S
Leachate:	PFOSLCM-LC

4.2 Primary Reference:

USEPA 537, Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS), version 1.1, Sept/2009.

4.3 Deviations:

4.3.1 Sample volume for SPE in the reference method is 250 mL whereas this method uses a sample volume of 20 mL.

4.3.2 Additional internal standards are used in this method. Native compounds are quantified by isotope dilution (ID) and isotopically mass-labeled compounds are quantified by an internal standard method whereas, EPA 537 uses the internal standard quantification method exclusively.

4.3.3 The SPE sorbent in the reference method is polystyrenedivinylbenzene (SDVB) whereas this method employs Waters WAX ion-exchange SPE sorbent.

4.3.4 The reference method does not contain any protocols for direct analysis of aqueous samples for determining “high level” samples.

4.3.5 New mass spectrometer and chromatographic conditions were optimized for use with the AB SCIEX 5500 Qtrap System.

4.3.6 The reference method does not contain any protocols for determination of PFC’s in solid (soil) matrices. The soil protocol described in this SOP is based on the Ontario Ministry of the Environment method PFC-E3457A (Sec 4.4).

4.4 Additional References:

4.4.1 The Determination of Perfluorinated Alkyl Compounds (PFCs) in Environmental Matrices by Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS). Method code PFC-E3457A, version 1.0, Ontario Ministry of the Environment, Sept/2008.

4.4.2 Quality Systems Manual for Environmental Laboratories, Version 5.0. Department of Defense, July, 2013.

4.5 Instrument Manuals:

4.5.1 Analyst™ DVD Manual (Contains Analyst™ Software Guide, 5500 Qtrap Hardware Guide, Turbo V Ion Source Guide and the Peripheral Devices Setup Guide).

4.5.2 Agilent 1200 Infinity Series LC Hardware DVD Manual.

5.0 REGULATORY CRITERIA

5.1 In August, 2010, Health Canada issued the following provisional drinking water guidance values (DWGV) for PFOS and PFOA:

PFOS = 0.7 μg/L
PFOA = 0.3 μg/L

6.0 SAFETY & DISPOSAL

General Safety requirements for this SOP are provided in the attached critical task analysis (CTA). In addition to the CTA, additional guidance on Maxxam's Environment, Health and Safety (EHS) program are found in various Safe Work Procedures, Safety Policies, and the Safety Guide (See MEHS WI-00013). Chemical wastes and sample disposal protocols are outlined in the Corporate Environmental Waste Management Policy (MEHS WI-00069).

6.1 The use of personal protective equipment (PPE), including safety glasses and lab coats are mandatory in all Maxxam labs. It is the responsibility of the analyst to read and understand the CTA attached to this SOP and ensure that any additional identified hazard controls are used (e.g. nitrile gloves, splash goggles, fume hoods, respirators, etc).

6.2 Material safety data sheets for all chemical reagents are available to personnel using this method. Training on the interpretation of MSDS sheets is provided during WHMIS training upon hire. Staff performing this method shall review the associated MSDS sheets for chemicals used in this procedure and ensure they understand the associated hazards and safety controls required to work safely with each chemical.

6.3 General information for chemical waste and sample disposal is described in the Health and Safety work instructions. Disposal of all samples, extracts and reagents must be done in accordance with local, provincial and federal laws and regulations. Chemical wastes and sample disposal protocols are described in CAM WI-00018 "*Waste Disposal*".

7.0 SAMPLE HANDLING, PRESERVATION, HOLDING TIME

7.1 Sample Container:

7.1.1 Water samples should be collected in polypropylene or polyethylene bottles with an unlined plastic cap.

7.1.2 Soil samples should be collected in polypropylene or polyethylene jars/bottles with an unlined plastic cap.

It is highly recommended that PFC specific sample containers from the Maxxam-Mississauga location be used for collection.

7.2 Minimum Sample Size:

7.2.1 The minimum sample size required for water analysis is 100 mL.

7.2.2 The minimum sample size required for soil is 50 g.

7.3 Preservation:

Water: Preservation is not required.

If residual chlorine is present or suspected in the samples, they may be preserved with Trizma® (5 g/L).

Water samples should not be filtered.

Soil: Preservatives are not required.

7.4 Storage Conditions:

After samples are logged in, they are stored in a refrigerator. Samples are retained according to CAM SOP-00105 after reporting. Samples may be retained for longer periods at the client's request at an additional cost.

7.5 Hold Time:

Sample holding time is 28 days.

8.0 INTERFERENCES

8.1 Care should be taken when handling samples for analysis and ensuring that the compounds being tested for are not introduced into the samples during sample preparation or analysis.

8.2 No Teflon® or PTFE should be used in the collection, processing or analysis of PFCs as it is a potential source of interference.

8.3 Glass containers should also be avoided in all phases of the collection, processing and analysis, as the potential exists for loss of analyte due to adsorption.

8.4 Large amounts of organic matter or inorganic ions in samples / sample extracts may cause ion suppression in the electrospray LC/MS/MS source.

9.0 METHOD PERFORMANCE

9.1 Method Detection Limit (DL) / Limit of Detection (LOD):

Method detection limits are determined using COR WI-00050 (Environmental Chemistry Method Validation) and CAM WI-00095 (for DoD/NELAC requirements). Current method detection limits are maintained in Compliant Pro.

9.2 Reporting Detection Limit (RDL) / Limit Of Quantification (LOQ):

Reporting Limits are defined in the test codes in MaxLIMS. Data less than these values are reported as “<” or "ND". Sample dilution factors are applied to these values and reported accordingly.

9.2.1 Water Analysis

Parameter	Abbreviation	RDL (µg/L) (Low Level Analysis)	RDL (µg/L) (High Level Analysis)
Perfluorobutanoic acid	PFBA	0.02	0.8
Perfluorobutanesulfonate	PFBS	0.02	0.8
Perfluoropentanoic acid	PFPeA	0.02	0.8
Perfluorohexanoic acid	PFHxA	0.02	0.8
Perfluorohexanesulfonate	PFHxS	0.02	0.8
Perfluoroheptanoic acid	PFHpA	0.02	0.8
Perfluoroheptanesulfonate	PFHpS	0.02	0.8
Perfluorooctanoic acid	PFOA	0.02	0.8
Perfluorooctanesulfonate	PFOS	0.02	0.8

Perfluorononanoic acid	PFNA	0.02	0.8
Perfluorodecanoic acid	PFDA	0.02	0.8
Perfluorodecanesulfonate	PFDS	0.02	0.8
Perfluoroundecanoic acid	PFUnA	0.02	0.8
Perfluorododecanoic acid	PFDoA	0.02	0.8
Perfluorotridecanoic acid	PFTrDA	0.02	0.8
Perfluorotetradecanoic acid	PFTeDA	0.02	0.8
Perfluorooctanesulfonamide	PFOSA	0.02	0.8
N-methylperfluorooctanesulfonamide	MeFOSA	0.05	2.0
N-ethylperfluorooctanesulfonamide	EtFOSA	0.05	2.0
N-methylperfluorooctanesulfonamidoethanol	MeFOSE	0.05	2.0
N-ethylperfluorooctanesulfonamidoethanol	EtFOSE	0.05	2.0
6:2 Fluorotelomersulfonate	6:2FTS	0.05	2.0
8:2 Fluorotelomersulfonate	8:2FTS	0.05	2.0

9.2.2 Soil Analysis

Parameter	Abbreviation	RDL (µg/kg) (Low Level Analysis)	RDL (µg/kg) (High Level Analysis)
Perfluorobutanoic acid	PFBA	0.1	5.0
Perfluorobutanesulfonate	PFBS	0.1	5.0
Perfluoropentanoic acid	PFPeA	0.1	5.0
Perfluorohexanoic acid	PFHxA	0.1	5.0
Perfluorohexanesulfonate	PFHxS	0.1	5.0

Perfluoroheptanoic acid	PFHpA	0.1	5.0
Perfluorooctanoic acid	PFOA	0.1	5.0
Perfluorooctanesulfonate	PFOS	0.1	5.0
Perfluorononanoic acid	PFNA	0.1	5.0
Perfluorodecanoic acid	PFDA	0.1	5.0
Perfluorodecanesulfonate	PFDS	0.1	5.0
Perfluoroundecanoic acid	PFUnA	0.1	5.0
Perfluorododecanoic acid	PFDoA	0.1	5.0
Perfluorotridecanoic acid	PFTrDA	0.1	5.0
Perfluorotetradecanoic acid	PFTeDA	0.1	5.0
Perfluorooctanesulfonamide	PFOSA	0.1	5.0

9.3 Measurement of Uncertainty

Measurement of Uncertainty will be calculated according to COR WI-00018. The uncertainty value presents the variability of the result due to both random and systematic causes. The calculations for measurement of uncertainty will be determined on a location basis. Measurement Uncertainty must be determined only once, unless there is a major change to method or instrument.

10.0 GLASSWARE CLEANING/PREPARATION

10.1 Refer to procedure CAM SOP-00621.

11.0 APPARATUS AND MATERIALS

11.1 Chemicals / Solvents:

11.1.1 Ammonium Acetate ($NH_4C_2H_3O_2$), reagent grade (Sigma-Aldrich, p/n: A7262)

11.1.2 Sodium Carbonate (Na_2CO_3), anhydrous, ACS grade (Sigma-Aldrich p/n: 222321)

11.1.3 Sodium Hydroxide (NaOH), ACS grade
(Fisher Scientific, p/n: S318)

11.1.4 Tetrabutylammonium hydrogensulfate (TBAS), ($(C_4H_9)_4NHO_4S$)
(Sigma-Aldrich, p/n: 155837)

11.1.5 Acetonitrile (CH_3CN), reagent grade
(Fisher Scientific, p/n: A996-4)

11.1.6 Ammonium hydroxide (NH_4OH), ACS grade
(Fisher Scientific, p/n: FLA669)

11.1.7 Formic Acid (HCOOH), reagent grade
(Sigma-Aldrich, p/n: F0507)

11.1.8 Methanol (CH_3OH), reagent grade
(Fisher Scientific, p/n: A4544MXB)

11.1.9 Methyl tert-butyl Ether ($CH_3OC(CH_3)_3$), reagent grade
(Fisher Scientific, p/n: E127-4)

11.1.10 Water, LCMS (or HPLC) Grade
(Fisher Scientific, p/n: W6-4 or W5-4)

11.2 Laboratory Supplies / Consumables:

11.2.1 50 mL disposable screw-capped polypropylene centrifuge tubes
(Fisher Scientific, p/n: 06-443-19)

11.2.2 15 mL disposable screw-cap polypropylene centrifuge tubes
(Fisher Scientific, p/n: 05-539-12)

11.2.3 10 mL (17x100mm) disposable polypropylene culture tubes
(Fisher Scientific, p/n: 351071)

11.2.4 50 mL disposable screw-cap high-speed polypropylene centrifuge tubes, capable of being centrifuged at 13,000rpm
(Fisher Scientific, p/n: 05-529-1D)

11.2.5 Disposable polyethylene transfer pipettes, 3 mL
(Fisher Scientific, p/n: 13-711-7M)

11.2.6 Pipette tips, various sizes

11.2.7 Waters Oasis WAX 3cc solid phase extraction cartridge, 60mg/60μm
(Waters, p/n: 186002492)

11.2.8 Polypropylene snap top vials, 0.3 mL
(Canadian Life Sciences, p/n: V0300P-1232)

11.2.9 Polyethylene vial snap caps (PVDC/Silicone Septa)
(Canadian Life Sciences, p/n: C299-11)

11.2.10 pH indicator strips, pH range 0-6
(VWR, p/n: CA1.09531.0001)

11.2.11 Class A glass volumetric flasks, various sizes, with glass stoppers

11.2.12 Ottawa Sand (Fisher Scientific, p/n: S23-3)

11.3 Laboratory Equipment:

11.3.1 Analytical balance accurate to 0.0001g

11.3.2 Top Loading Balance, electronic, 0.01 g sensitivity

11.3.3 Mechanical shaker for 50 mL polypropylene centrifuge tubes

11.3.4 Centrifuges, bench top with 50 mL tube carriers, capable of 4000 rpm and 13,000 rpm

11.3.5 Vortex mixer

11.3.6 Adjustable pipettes, various sizes

11.3.7 Solid phase extraction sample reservoirs, polypropylene, 20 mL
(Supelco, p/n: 57021)

11.3.8 Solid phase extraction tube adaptors
(Supelco, p/n: 57020-U)

11.3.9 Solid phase extraction vacuum manifold (24 port)
(Supelco p/n: 57250-U)

11.3.10 Stainless steel solvent guide needles (for SPE manifold)
(Supelco, p/n: 57036)

11.3.11 pH Meter (Fisher Scientific Accumet AP61)

11.3.12 Nitrogen evaporation unit

11.3.13 Thermometer

11.4 Analytical Equipment:

11.4.1 Liquid chromatography column, Agilent Poroshell 120 EC-C18, 2.1x75mm, 2.7 μm (Agilent p/n: 697775-092)

11.4.2 Liquid chromatography guard column, Agilent Poroshell 120 EC-C18, 2.1x5mm, 2.7 μm (Agilent p/n: 821725-911)

11.4.3 Agilent 1290 Infinity Series Binary Pump (G4220A)

11.4.4 Agilent 1290 Infinity Series Autosampler (G4226A)

11.4.5 Agilent 1290 Infinity Series Thermostatted Column Compartment (G1316C)

11.4.6 AB SCIEX 5500 Qtrap Tandem Mass Spectrometer

11.4.7 Analyst™ operating software

Note: Equivalent apparatus or materials may be substituted.

12.0 REAGENTS AND STANDARD PREPARATION

Reagents and standards must be prepared as specified in CAM WI-00010. They must be identified in such a way that each solution has a unique ID. This unique ID distinguishes the solution from all other solutions, even (and especially) the same solution prepared on a different day. Refer to CAM WI-00004 for reagent labeling requirements.

Solutions may be prepared in alternate volumes as long as the solute concentrations are maintained. Expiry dates for the solutions are the earliest of that included with the reagent preparation instructions below or any component expiry date. Expiry dates for purchased stock solutions are as provided by the supplier, or according to CAM WI-00010. Refer to CAM WI-00004 for expiry dates of solid and liquid chemicals. Reagents are stored at room temperature unless specified below. Temperatures of refrigerators and freezers are monitored according to CAM WI-00008.

Analytical balances (COR WI-00015) are used for weighing chemicals; pipettes & dispensers, and Class A volumetric flasks are verified according to COR WI-00017 for measuring volumes.

Certificate of Analyses (C of A) are kept for all purchased standards and reagents utilized. The C of A may be scanned and saved in Lotus Notes or a copy may be kept in a workstation binder.

12.1 Reagents:

12.1.1 LCMS (or HPLC) Grade Water at pH 4-5

Add 0.2% formic acid dropwise (~ 3 mL will be required) to approximately 1 L of LCMS (or HPLC) grade water until a pH of 4-5 is achieved. Check pH using a disposable pH indicator strip. Prepare fresh daily.

12.1.2 2 % formic acid in reagent water:

2 mL of formic acid is added to 98 mL of LCMS (or HPLC) grade water. Store at room temperature for up to 2 months.

12.1.3 0.2 % formic acid in reagent water:

0.2 mL of formic acid is added to 99.8 mL of LCMS (or HPLC) grade water. Store at room temperature for up to 2 months.

12.1.4 1 % ammonium hydroxide in methanol solution:

1 mL of ammonium hydroxide is added to 99 mL of methanol. This solution must be prepared fresh daily.

12.1.5 2 % ammonium hydroxide solution:

2 mL of ammonium hydroxide is added to 98 mL of LCMS (or HPLC) grade water. Store at room temperature for up to 2 months.

12.1.6 0.3 % ammonium hydroxide in methanol solution:

0.3 mL of ammonium hydroxide is added to approx. 90 mL of methanol. The solution is topped up to 100 mL in a measuring cylinder. This solution is prepared fresh prior to its use in the preparation of standards.

12.1.7 Sodium carbonate solution, 0.25 M:

Dissolve 26.5 g of sodium carbonate in 1L of LCMS (or HPLC) grade water. Store refrigerated for up to 2 months.

12.1.8 Sodium hydroxide solution, 8 M:

Dissolve 12.8 g of sodium hydroxide in 40 mL of LCMS (or HPLC) grade water. Store at room temperature for up to 1 year.

12.1.9 TBAS solution, 0.5 M:

Dissolve 17.5 g of TBAS in 100 mL of LCMS (or HPLC) grade water. Mix well. Add 8 M sodium hydroxide solution until the solution is approximately pH 10 (adjust by way of a pH meter). Store at room temperature for up to 2 months.

12.1.10 TBAS solution, 20 mM:

Dissolve 0.7 g of TBAS in 100 mL of Methanol. Mix well. Store at room temperature for up to 2 months.

12.1.11 20 mM ammonium acetate solution (mobile phase A)

Dissolve 1.54 g of ammonium acetate in 1L of LCMS (or HPLC) grade water. Store at room temperature for up to 2 months.

12.1.12 50/50 (v/v) Acetonitrile / Methanol solution (Mobile phase B):

Combine 0.5 L of acetonitrile with 0.5 L of methanol. Store at room temperature for up to 2 months.

12.1.13 Reconstitution solution: 115/60 Methanol / LCMS (or HPLC) grade water:

Combine 115 mL of methanol with 60 mL of LCMS (or HPLC) grade water. Store at room temperature for up to 2 months.

12.2 Stock Standard Preparation:

Standard solutions are prepared in glass volumetric flasks that have been scrupulously cleaned. In order to minimize the potential adsorption of PFCs to the glass surface of volumetric flasks, standard solutions should be prepared within a short length of time and transferred immediately to polypropylene screw-capped tubes for storage. Avoid the use of PTFE-coated volumetric flask stoppers by using glass stoppers instead. Soiled volumetric flasks should be rinsed out immediately and soaked in soapy water until they can be washed.

12.2.1 Stock Standard Solutions:

Stock standard solutions may be purchased from Wellington Laboratories as solutions in ampoules (or equivalent). Refer to C of A for purity specifications, storage conditions and expiration dates. All stock standards are provided as 50 μg/mL solutions. PFBS, PFHxS, PFHpS, br-PFOSK, PFDS, 6:2FTS and 8:2FTS stock standards require correction for either the potassium or sodium salt. The following table provides the product codes and concentrations for each anion:

Product Name	Parameter	Product Code	Concentration of Anion (μg/mL)
Perfluoro-n-butanoic acid	PFBA	PFBA	50
Potassium perfluoro-1-butanesulfonate	PFBS	L-PFBS	44.2
Perfluoro-n-pentanoic acid	PFPeA	PFPeA	50
Perfluoro-n-hexanoic acid	PFHxA	PFHxA	50
Sodium perfluoro-1-hexanesulfonate	PFHxS	L-PFHxS	47.3
Perfluoro-n-heptanoic acid	PFHpA	PFHpA	50
Sodium perfluoro-1-heptanesulfonate	PFHpS	L-PFHpS	47.6
Perfluoro-n-octanoic acid	PFOA	PFOA	50
Potassium perfluorooctanesulfonate*	PFOS	brPFOSK	46.4
Perfluoro-n-nonanoic acid	PFNA	PFNA	50
Perfluoro-n-decanoic acid	PFDA	PFDA	50
Sodium perfluoro-1-decanesulfonate	PFDS	L-PFDS	48.2
Perfluoro-n-undecanoic acid	PFUnA	PFUdA	50
Perfluoro-n-dodecanoic acid	PFDoA	PFDoA	50

Perfluoro-n-tridecanoic acid	PFTrDA	PFTrDA	50
Perfluoro-n-tetradecanoic acid	PFTeDA	PFTeDA	50
Perfluoro-1-octanesulfonamide	PFOSA	FOSA-I	50
N-methylperfluoro-1-octanesulfonamide	MeFOSA	N-MeFOSA-M	50
N-ethylperfluoro-1-octanesulfonamide	EtFOSA	N-EtFOSA-M	50
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	MeFOSE	N-MeFOSE-M	50
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	EtFOSE	N-EtFOSE-M	50
Sodium 1H, 1H, 2H, 2H-perfluorooctane sulfonate	6:2FTS	6:2FTS	47.4
Sodium 1H, 1H, 2H, 2H-perfluorodecane sulfonate	8:2FTS	8:2FTS	47.9

**brPFOSK is a mixture of linear and branched isomers*

12.2.2 Preparation of Composite PFC Spiking Solutions:

12.2.2.1 Composite PFC Spiking Solution A (1.0/2.5 ug/mL)

Prepared the spiking solution from the stock standards in a 10 mL volumetric flask according to the table below. Store in a freezer for up to 1 year.

Parameter	Conc. Of Stock Standard (μg/mL)	Vol. Of Stock Standard (μL)	Dilution Volume	Final Conc. (μg/mL)
PFBA	50	200	Dilute to 10 mL with 0.3% NH_4OH in methanol in a volumetric flask	1
PFBS	44.2	226		1
PFPeA	50	200		1
PFHxA	50	200		1
PFHxS	47.3	211		1
PFHpA	50	200		1

PFHpS	47.6	210		1
PFOA	50	200		1
PFOS	46.4	216		1
PFNA	50	200		1
PFDA	50	200		1
PFDS	48.2	207		1
PFUnA	50	200		1
PFDoA	50	200		1
PFTrDA	50	200		1
PFTeDA	50	200		1
PFOSA	50	200		1
MeFOSA	50	500		2.5
EtFOSA	50	500		2.5
MeFOSE	50	500		2.5
EtFOSE	50	500		2.5
6:2-FTS	47.4	527		2.5
8:2-FTS	47.9	522		2.5

12.2.2.2 Composite PFC Spiking Solution B (250/625 ng/mL)

Pipet 2.5 mL of Composite PFC Spiking Solution A into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.2.2.3 Composite PFC Spiking Solution C (100/250 ng/mL)

Pipet 1 mL of Composite PFC Spiking Solution A into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.2.2.4 Composite PFC Spiking Solution D (25/62.5 ng/mL)

Pipet 1 mL of Composite PFC Spiking Solution B into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.2.2.5 Composite PFC Spiking Solution E (10/25 ng/mL)

Pipet 0.4 mL of Composite PFC Spiking Solution B into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.2.3 Preparation of Initial Calibration Standards (ICAL):

Refer to Tables 1-6 for Initial Calibration Standard preparation procedures.

12.3 Preparation of Second Source Standards:

Second source standards are obtained, when possible, from a different manufacturer or the same manufacturer but different lot number from those used for calibration standards. When a second source standard is not available, second standards can be prepared from the same source as the calibration standards, but prepared by a different analyst, or the same analyst on a different day.

12.3.1 Second Source Spiking Solution A (1.0/2.5 µg/mL):

The Second Source Spiking Solution A can be prepared in a similar way to Composite PFC Spiking Solution A (1.0/2.5 µg/mL). Refer to Section 12.2.2.1. Store in a freezer for up to 1 year.

12.3.2 Second Source Spiking Solution B (250/625 ng/mL):

Pipet 2.5 mL of the Second Source Spiking Solution A into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.3.3 Second Source Spiking Solution C (100/250 ng/mL):

Pipet 1 mL of the Second Source Spiking Solution A into a 10 mL volumetric flask and dilute to volume with 0.3% NH_4OH in methanol. Store in a freezer for up to 1 year.

12.3.4 Preparation of Initial Calibration Verification Standard (ICV):

Refer to Tables 4-8 for ICV preparation procedures.

12.4 Preparation of Mass-Labeled Internal Standards (IS):

Mass-labeled stock solutions may be purchased from Wellington Laboratories as solutions in ampoules (or equivalent). The following table provides the product codes and concentrations for each labeled internal standard. Refer to C of A for storage conditions and expiration date.

Product Name	Product Code	Concentration (µg/mL)
Perfluoro-n-[1,2,3,4-$^{13}C_4$]butanoic acid	MPFBA	50
Perfluoro-n-[$^{13}C_5$]pentanoic acid	M5PFPeA	50
Perfluoro-n-[1,2-$^{13}C_2$]hexanoic acid	MPFHxA	50
Sodium perfluoro-1-hexane[$^{18}O_2$]sulfonate	MPFHxS	50
Perfluoro-n-[1,2,3,4-$^{13}C_4$]heptanoic acid	M4PFHpA	50
Perfluoro-n-[1,2,3,4-$^{13}C_4$]octanoic acid	MPFOA	50
Sodium perfluoro-1-[1,2,3,4-$^{13}C_4$]octanesulfonate	MPFOS	50
Perfluoro-n-[1,2,3,4,5-$^{13}C_5$]nonanoic acid	MPFNA	50
Perfluoro-n-[1,2-$^{13}C_2$]decanoic acid	MPFDA	50
Perfluoro-n-[1,2-$^{13}C_2$]undecanoic acid	MPFUdA	50
Perfluoro-n-[1,2-$^{13}C_2$]dodecanoic acid	MPFDoA	50
Perfluoro-n-[1,2-$^{13}C_2$]tetradecanoic acid	M2PFTeDA	50
Perfluoro-1-[$^{13}C_8$]octanesulfonamide	M8FOSA-M	50
N-methyl-d3-perfluoro-1-octanesulfonamide	d-N-MeFOSA-M	50
N-ethyl-d5-perfluoro-1-octanesulfonamide	d-N-EtFOSA-M	50
2-(N-methyl-d3-perfluoro-1-octanesulfonamido)ethan-d4-ol	d7-N-MeFOSE-M	50
2-(N-ethyl-d5-perfluoro-1-octanesulfonamido)-ethan-d4-ol	d9-N-EtFOSE-M	50
Sodium 1H,1H,2H,2H-perfluoro-1-(1,2-$^{13}C_2$)-octane sulfonate	M2-6:2FTS	50

Sodium 1H,1H,2H,2H-perfluoro-1-(1,2-$^{13}C_2$)-decane sulfonate	M2-8:2FTS	50

12.4.1 Preparation of Mass-Labeled IS Spiking Solution A (50/125 ng/mL):

Prepare the mass-labeled IS solution using the mass-labeled stock standards in a 50 mL volumetric flask according to the table below. Store in the freezer for up to 5 years.

Parameter	Conc. Of Stock Standard (µg/mL)	Vol. Of Stock Standard (µL)	Dilution Volume	Final Conc. (ng/mL)
MPFBA	50	50	Dilute to 50 mL with 0.3% NH_4OH in methanol in a volumetric flask	50
MPFPeA	50	50		50
MPFHxA	50	50		50
MPFHxS	50	50		50
MPFHpA	50	50		50
MPFOA	50	50		50
MPFOS	50	50		50
MPFNA	50	50		50
MPFDA	50	50		50
MPFUdA	50	50		50
MPFDoA	50	50		50
MPFTeDA	50	50		50
MPFOSA	50	50		50
D3-MeFOSA	50	125		125
D5-EtFOSA	50	125		125
D7-MeFOSE	50	125		125

D9-EtFOSE	50	125		125
M2-6:2FTS	50	125		125
M2-8:2FTS	50	125		125

12.4.2 Preparation of Mass-labeled IS Solution B (250/625 ng/mL):

Prepare the mass-labeled IS solution using the mass-labeled stock standards in a 10 mL volumetric flask according to the table below. Store in the freezer for up to 5 years.

Parameter	Conc. Of Stock Standard (µg/mL)	Vol. Of Stock Standard (µL)	Dilution Volume	Final Conc. (ng/mL)
MPFBA	50	50	Dilute to 10 mL with 0.3% NH_4OH in methanol in a volumetric flask	250
MPFPeA	50	50		250
MPFHxA	50	50		250
MPFHxS	50	50		250
MPFHpA	50	50		250
MPFOA	50	50		250
MPFOS	50	50		250
MPFNA	50	50		250
MPFDA	50	50		250
MPFUdA	50	50		250
MPFDoA	50	50		250
MPFTeDA	50	50		250
MPFOSA	50	50		250
D3-MeFOSA	50	125		625

D5-EtFOSA	50	125		625
D7-MeFOSE	50	125		625
D9-EtFOSE	50	125		625
M2-6:2FTS	50	125		625
M2-8:2FTS	50	125		625

12.5 Preparation of Injection Internal Standard:

Stock injection internal standard solutions may be purchased from Cambridge Isotope Laboratories (CIL) as solutions in ampoules (or equivalent). The following table provides the catalogue numbers and concentration. Refer to C of A for storage conditions and expiry date.

Compound Name	Abbreviation	Cat. No.	Concentration (µg/mL)
Perfluorohexanoic acid ($^{13}C_6$)	13C6-PFHxA	CLM-8340-1.2	50
Perfluorodecanoic acid ($^{13}C_9$)	13C9-PFDA	CLM-8172-1.2	50

12.5.1 Preparation of Composite Injection Internal Standard Solution (400 ng/mL):

Prepare a composite injection internal standard solution according to the table below in a 10 mL volumetric flask. Store in the freezer for up to 1 year.

Parameter	Conc. Of Stock Standard (µg/mL)	Vol. Of Stock Standard (µL)	Dilution Volume (mL)	Final Conc. (ng/mL)
13C6-PFHxA	50	80	Dilute to 10 mL with 0.3% NH_4OH in methanol in a volumetric flask	400
13C9-PFDA	50	80		400

13.0 SAMPLE PREPARATION

13.1 Aqueous Sample Preparation (High Level Analysis):

Note: All samples must be aqueous. If analysis is not started at once samples are stored in the refrigerator.

13.1.1 Homogenize each sample by gently mixing the sample bottle by hand.

13.1.2 Prepare the following Quality Control Samples and extract along with the unknown field samples:

13.1.2.1 Matrix (Method) Blank:

Aliquot 750 µL of LCMS (or HPLC) grade water into a 15 mL polypropylene tube.

13.1.2.2 Spiked Blank (Laboratory Control Sample - LCS):

Aliquot 750 µL of LCMS (or HPLC) grade water into a 15 mL polypropylene tube. Fortify the sample with 75 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 25/62.5 µg/L.

13.1.2.3 Matrix Spike:

Select an unknown field sample and transfer a 750 µL aliquot into a 15 mL polypropylene tube. Fortify the sample with 75 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 25/62.5 µg/L.

13.1.2.4 Matrix Spike Duplicate (for DoD Jobs only):

Transfer an additional 750 µL of the unknown field sample selected as the matrix spike above into a 15 mL polypropylene tube. Fortify the duplicate sample with 75 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 25/62.5 µg/L.

13.1.3 Aliquot 750 µL of each field sample into labeled 15 mL disposable polypropylene culture tubes. Select one sample and perform an additional 750 µL aliquot for duplicate analysis.

Note: A sample duplicate is not required for DoD jobs, refer to Matrix Spike Duplicate (Sec. 13.1.2.4).

13.1.4 Add 100 µL of Mass-Labeled IS Solution A (50/125 ng/mL) to all QCs and field samples.

13.1.5 Pipet 500 µL of methanol to all QC and field samples and vortex carefully.

13.1.6 Pipet 180 µL of each sample to 0.3 mL polypropylene vials and add 20 µL of Injection Internal Standard solution (400 ng/mL). Cap with polyethylene snap caps. Vortex to mix.

13.2 Aqueous Sample Preparation (Low Level Analysis):

Note: All samples must be aqueous. If analysis is not started at once samples are stored in the refrigerator.

13.2.1 Homogenize each sample by gently mixing the sample bottle by hand.

13.2.2 Prepare calibration standards and ICV according to Tables 2 and 6 respectively. Extract these along with the unknown field samples.

13.2.3 Prepare the following Quality Control samples and extract along with the unknown field samples:

13.2.3.1 Matrix (Method) Blank:

Transfer 20 mL of LCMS (or HPLC) grade water (adjusted to pH 4-5) into a 50 mL polypropylene tube.

13.2.3.2 Spiked Blank (Laboratory Control Sample – LCS):

Transfer 20 mL of LCMS (or HPLC) grade water (adjusted to pH 4-5) into a 50 mL polypropylene tube. Fortify the sample with 40 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 0.5/1.25 µg/L.

13.2.3.3 Matrix Spike:

Transfer 20 mL of an unknown field sample into a 50 mL polypropylene tube. Fortify the sample with 40 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 0.5/1.25 µg/L.

13.2.3.4 Matrix Spike Duplicate (for DoD Jobs only):

Transfer an additional 20 mL of the unknown field sample selected as the matrix spike above into a 50 mL polypropylene tube. Fortify the duplicate sample with 40 µL of PFC Spiking Solution B (250/625 ng/mL) to give a final concentration of 0.5/1.25 µg/L.

13.2.4 Transfer 20 mL of each field sample into 50 mL polypropylene tubes. Select one sample and transfer an additional 20 mL into a 50 mL polypropylene tube for duplicate analysis.

Note: A sample duplicate is not required for DoD jobs, refer to Matrix Spike Duplicate (Sec. 13.2.3.4).

13.2.5 Add 100 µL of Mass-Labeled IS Solution A (50/125 ng/mL) to all standards, QCs and field samples and swirl gently to mix.

13.2.6 Adjust the pH of the unknown field samples (and the Matrix Spike and duplicate) to between pH 4-5 using 0.2% formic acid, 2% formic acid and/or 2% ammonium hydroxide. *(To prevent cross contamination, the use of disposable pH indicator strips is recommended)*

13.2.7 Prepare the SPE manifold by labeling and attaching 3cc/60mg/60µm Oasis WAX SPE cartridges to every other flow valve.

13.2.8 Ensure that the solvent guide needles in the SPE manifold have been replaced with stainless steel ones.

13.2.9 Condition each cartridge with:

- 3 mL of 1% Ammonium hydroxide in methanol
- 3 mL of methanol
- 3 mL of LCMS (or HPLC) grade water

Elute each to waste by gravity.

13.2.10 Close the SPE manifold flow control valves.

13.2.11 Add approximately 2.5 mL of each sample to the corresponding labeled SPE cartridge using a disposable polyethylene pipette.

13.2.12 Attach an SPE tube adaptor and 20 mL reservoir to the top of each SPE cartridge.

13.2.13 Fill each reservoir with the corresponding sample then open the SPE manifold control valve. For difficult samples, a low vacuum (~1 mL/min) may be used to pass these samples through the cartridges. Retain the 50 mL sample tubes and caps for rinsing in Step 13.2.16.

13.2.14 Once samples have passed through the reservoirs, close SPE manifold control valves such that each SPE cartridge barrel still contains the liquid sample.

13.2.15 Pipet 2 mL of methanol into each 50 mL polypropylene sample tube.

13.2.16 Rinse the walls and caps of each sample tube with the methanol.

13.2.17 Using a disposable polyethylene transfer pipet, transfer the methanol wash to each corresponding sample reservoir, rinsing the walls of the reservoir in the process.

13.2.18 Pipet 3 mL of 0.2% formic acid into each reservoir to dilute the methanol rinse.

13.2.19 Open SPE manifold flow control valves and allow samples to flow through completely.

13.2.20 Remove reservoirs and tube adaptors from the SPE cartridges.

13.2.21 Wash each cartridge with 2 mL of 2% formic acid. Dry the cartridges under maximum vacuum for 10-15 minutes.

13.2.22 Place labeled polypropylene tubes into manifold rack to collect the eluate (Fraction 1). Using clean laboratory tissues, wipe any liquid droplets off each stainless steel needle guide (do not cross-contaminate samples). Elute each cartridge with 3 mL of methanol, using vacuum to elute the last drops from the SPE cartridges.

Note: If PFOSA, MeFOSA, EtFOSA, MeFOSE or EtFOSE are compounds of interest, this fraction should be collected for analysis. If not, it may be passed to waste.

13.2.23 Add 100 µL of 20 mM TBAS solution to each fraction 1 eluate.

13.2.24 Remove the first set of elution tubes and place a second set of labeled polypropylene tubes into the manifold rack. Elute each cartridge with 3 mL of 1% NH_4OH in methanol, using vacuum to elute the last drops from the SPE cartridges (Fraction 2).

Note: All compounds except those noted in 13.2.22 are eluted into Fraction 2.

13.2.25 Dry down the eluates under a gentle stream of nitrogen at 45^{o}C (±5^{o}C) until just dry. *Over drying of fraction 1 can result in low recoveries due to the volatility of these compounds.*

13.2.26 Reconstitute each sample with 175 µL of reconstitution solution and 25 µL of injection internal standard solution. Vortex to mix.

13.2.27 Transfer each sample to labeled 0.3 mL polypropylene vials for LC/MS/MS analysis. Cap vials with polyethylene snap caps.

***Note**: Reservoirs, adaptors and stainless steel guide needles should be soaked in soapy water immediately after the extraction until they can be washed.*

13.3 Soil Sample Preparation (High Level Analysis):

Note: Homogenize approx. 50 g of sample using a stainless steel spatula or scoopula before weighing out.

13.3.1 Prepare the following Quality Control samples:

13.3.1.1 Matrix (Method) Blank:

Weigh 0.5-0.6 g of Ottawa Sand into a 50 mL polypropylene centrifuge tube.

13.3.1.2 Spiked Blank (Laboratory Control Sample – LCS):

Weigh 0.5-0.6 g of Ottawa Sand into a 50 mL polypropylene centrifuge tube. Fortify the sample with 62.5 µL of PFC Spiking Solution A (1 µg/mL) to yield a matrix equivalent concentration of 125 µg/kg.

13.3.1.3 Matrix Spike:

Weigh 0.5-0.6 g of an unknown field sample into a 50 mL polypropylene centrifuge tube. Fortify the sample with 62.5 µL of PFC Spiking Solution A (1 µg/mL) to yield a matrix equivalent concentration of 125 µg/kg.

13.3.1.4 Matrix Spike Duplicate (for DoD jobs only):

Weigh an additional 0.5-0.6 g of the unknown field sample selected as the matrix spike above into a 50 mL polypropylene centrifuge tube. Fortify the duplicate sample with 62.5 µL of PFC Spiking Solution A (1 µg/mL) to yield a matrix equivalent concentration of 125 µg/kg.

13.3.2 Weigh 0.5-0.6 g of each field sample into labeled 50 mL polypropylene centrifuge tubes. Select one sample and perform an additional weighing for duplicate analysis.

Note: A sample duplicate is not required for DoD jobs, refer to Matrix Spike Duplicate (Sec. 13.3.1.4).

13.3.3 Add 50 µL of Mass-Labeled IS Solution B (250 ng/mL) to each QC and field sample.

13.3.4 Add 2.5 mL of (70/30) Acetonitrile/RODI water solution to each tube.

13.3.5 Vortex each sample vigorously and allow samples to extract for 2 hours on a mechanical shaker.

13.3.6 Centrifuge samples for 10 minutes at 4000 rpm (ambient temperature).

13.3.7 Transfer approximately 200 µL of each sample supernatant to a labeled 0.3 mL polypropylene vial. Cap with polyethylene snap caps. Vortex to mix.

13.4 Soil Sample Preparation (Low Level Analysis):

Note: Homogenize approx. 50 g of sample using a stainless steel spatula or scoopula before weighing out.

13.4.1 Prepare calibration standards and ICV according to Tables 4 and 8 respectively. Extract these along with the unknown field samples.

13.4.2 Prepare the following Quality Control Samples:

13.4.2.1 Matrix (Method) Blank:

Weigh 5–6 g of Ottawa Sand into a 50 mL polypropylene centrifuge tube.

13.4.2.2 Spiked Blank (Laboratory Control Sample – LCS):

Weigh 5-6 g of Ottawa Sand into a 50 mL polypropylene centrifuge tube. Fortify the sample with 125 µL of PFC Spiking Solution C (100 ng/mL) to yield a matrix equivalent concentration of 2.5 µg/kg.

13.4.2.3 Matrix Spike:

Weigh 5-6 g of an unknown field sample into a 50 mL polypropylene centrifuge tube. Fortify the sample with 125 µL of PFC Spiking Solution C (100 ng/mL) to yield a matrix equivalent concentration of 2.5 µg/kg.

13.4.2.4 Matrix Spike Duplicate (For DoD jobs only):

Weigh an additional 5-6 g of the unknown field sample selected as the matrix spike into a 50 mL polypropylene centrifuge tube. Fortify the sample with 125 µL of PFC Spiking Solution C (100 ng/mL) to yield a matrix equivalent concentration of 2.5 µg/kg.

13.4.3 Weigh 5-6 g of each field sample into labeled 50 mL polypropylene centrifuge tubes. Select one sample and perform an additional weighing for duplicate analysis.

Note: A sample duplicate is not required for DoD jobs, refer to Matrix Spike Duplicate (Sec. 13.4.2.4).

13.4.4 Add 50 µL of Mass-Labeled IS Solution A (50 ng/mL) to all standards QCs and field samples.

13.4.5 Add 5 mL of RODI water to each tube. Allow the water to soak into the sample.

13.4.6 Add 4 mL of 0.25 M sodium carbonate solution to each tube and swirl to mix.

13.4.7 Add 1 mL of 0.5 M TBAS solution to each tube and swirl to mix.

13.4.8 Add 5 mL of methyl tert-butyl ether (MTBE) to each tube. Cap and mix vigorously for approx. 5 minutes.

13.4.9 Centrifuge the tubes for 10 minutes at 4000 rpm (ambient temperature).

13.4.10 Transfer the MTBE (top) layer to a labeled 15 mL polypropylene culture tube using a disposable polyethylene transfer pipette. Ensure none of the aqueous reagents or sample is transferred along with the MTBE.

13.4.11 Repeat steps 13.4.8 to 13.4.10.

13.4.12 Reduce the combined MTBE extract until just dryness under a gentle stream of nitrogen between 45^{o}C (±5^{o}C).

13.4.13 Reconstitute each sample with 200 µL of reconstitution solution. Vortex to mix.

13.4.14 Transfer each sample to a labeled 0.3 mL polypropylene vial for LC/MS/MS analysis.

14.0 ANALYTICAL DETERMINATION

14.1 Analysis:

14.1.1 Configure the LC/MS/MS for PFC analysis according to the chromatographic and mass spectrometer conditions below (Sec 14.2-14.5). Refer to CAM WI-00506 for LC/MS/MS start up procedure, system performance check(s) and performance optimization.

14.1.2 Calibration Frequency:

An initial calibration is performed daily, prior to the analysis of test samples. Refer to Sec 15.1 for acceptance criteria.

14.1.3 Acquisition Methods:

PFC_F2.dam

PFC_F1.dam

PFC_Soil.dam

PFC_Water-High.dam

14.2 Typical Run Format:

1. Solvent (optional, typically water)
2. Matrix (Method) Blank
3. Initial Calibration (Cal Stds 1-6, in ascending order)
4. Initial Calibration Verification Standard (ICV)
5. Continuing Calibration Verification (CCV) Standard (i.e. Std 4)
6. Matrix Spike
7. Matrix Spike Duplicate (if applicable)
8. Spiked Blank/LCS
9. Test samples 1-20 (including sample duplicate, if applicable)

10. End analysis with Continuous Calibration Verification (CCV) Std (i.e Std 4)

    Note: For DoD Jobs, the CCV must be analyzed after every tenth field sample and at the end of the analysis

14.3 Chromatographic Conditions:

14.3.1 Aqueous Samples (High Level Analysis & Fraction 2 of Low Level Analysis) and Soils (High Level and Low Level Analyses):

Mobile phase A (MPA):	20 mM Ammonium Acetate solution
Mobile phase B (MPB):	(50/50) Acetonitrile / Methanol
Elution mode:	Gradient (refer to profile below)

Time (min)	% A	% B
0.0	60	40
0.5	60	40
1.2	20	80
2.5	0	100
3.0	0	100
3.1	60	40
4.0	60	40

Flow rate:	0.5 mL/min
Column:	Agilent Poroshell 120 EC-C18, 2.1x75 mm, 2.7 µm
Guard Column:	Agilent Poroshell 120 EC-C18, 2.1x5mm, 2.7 µm
Column Temperature:	35°C
Run time:	4 minutes
Typical injection vol.	2.0 µL

14.3.2 Aqueous Samples (Fraction 1 of Low Level Analysis):

Mobile phase A (MPA):	20 mM Ammonium Acetate solution
Mobile phase B (MPB):	(50/50) Acetonitrile / Methanol
Elution mode:	Isocratic (15% MPA / 85% MPB)
Flow rate:	0.6 mL/min
Column:	Agilent Poroshell 120 EC-C18, 2.1x75 mm, 2.7 µm
Guard Column:	Agilent Poroshell 120 EC-C18, 2.1x5mm, 2.7 µm
Column Temperature:	35°C
Run time:	1.5 minutes
Typical injection vol.	2.0 µL

14.4 Mass Spectrometer Settings:

Mass analyzer	Qtrap 5500
Ion source	Turbo IonSpray
Polarity	Negative
Scan type	MRM
Curtain gas (CUR)	20
Collision gas thickness (CAD)	Medium
IonSpray voltage (ISV)	-4000
Ion source gas (GS1)	50.0
Ion source gas (GS2)	50.0
Temperature (TEM)	575
Entrance potential (EP)	-10
Declustering potential (DP)	Compound dependent, refer to Table 9
Collision energy (CE)	Compound dependent, refer to Table 9
Collision cell exit potential (CXP)	Compound dependent, refer to Table 9

Mass spectrometric conditions should be used as guidelines and may be adjusted for the purpose of optimizing mass resolution, sensitivity and may differ slightly for each individual instrument

14.4 MS/MS Method Ions:

Refer to Table 9 for Ions.

15.0 QUALITY CONTROL REQUIREMENTS

15.1 Calibration:

15.1.1 Initial Calibration:

Establish the initial calibration curve (Sec 12.2.3) by plotting the area ratio for each standard against the concentration using an isotope dilution calibration method.

A first-order linear regression calibration model (i.e., y = mx + b function) is used.

y = Standard peak area ratio (peak area of native analyte / peak area of mass-labeled IS compound)
x = Standard concentration (μg/L or μg/kg)
m = Slope
b = Intercept

Acceptance Criteria: Refer to Table 10

A minimum of 5 calibration standards are used to generate the curve and should be analyzed with each analytical sequence.

Corrective Action(s):

- If the acceptance criteria cannot be met and the problem appears to be associated with a single standard, that standard may be re-analyzed (once). Replacing the standard may be necessary in some cases.
- Re-prepare and re-analyze the initial calibration (if a new calibration is prepared, all of the results from the original analysis should be discarded).
- Narrowing the calibration range by removing data points from either extreme ends of the range is permissible. There must still be a minimum of five standards remaining for establishing linearity.

15.1.2 Initial Calibration Verification (ICV):

After the calibration standards have been analyzed and prior to analyzing test samples, the accuracy of the calibration must be verified by the analysis of an ICV standard (Sec 12.3.4).

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Re-analyze the ICV.
- Prepare and analyze a new ICV.
- Evaluate the initial calibration.

15.1.3 Continuing Calibration Verification (CCV):

Once the calibration curve has been established, the continuing accuracy must be verified by analysis of a CCV (i.e STD 4) at the end of the analytical sequence (maximum of 20 samples).

Note: For DoD samples, the continuing accuracy of the calibration should be verified after every tenth field sample and at the end of the sequence.

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Correct the problem and re-establish continuing calibration. Samples that are not bracketed by acceptable CCV runs must be re-analyzed.

15.2 Quality Control - Sample Preparation and Analysis:

The effect of the matrix on method performance (precision, accuracy, method sensitivity and interference) is evaluated through the analysis of QC samples (including a method blank, spiked blank, matrix spike and matrix spike duplicate or sample duplicate) in each analytical batch of 20 samples or less. The QC samples are subjected to the same analytical procedures (Sec 13) as those used on field samples.
For Department of Defense (DoD) related projects, refer to Appendix A for QC requirements and acceptance criteria.

15.2.1 Method Blank:

Acceptance Criteria: Analyte concentration < ½ RDL

Corrective Action(s):

- A potential contamination may exist. The analysis should be terminated, the problem corrected and the samples re-extracted and analyzed. If sufficient sample is not available for re-analysis, any positive sample data must be flagged as possibly contaminated to the level found in the method blank.

15.2.2 Spiked Blank (SPK) / Laboratory Control Sample (LCS):

$$\text{Spike Recovery (\%)} = \frac{\text{Measured amount in spiked blank}}{\text{Amount of spike added}} \times 100$$

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Check for calculation errors.
- Re-analyze the spike.
- Flag the data in Tester’s comments.

15.2.3 Matrix Spike (MS):

$$\text{MS Recovery (\%)} = \frac{(\text{Spiked sample result} - \text{Native sample result})}{\text{Amount of spike added}} \times 100$$

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Check for calculation errors.
- If % recovery is outside the control limits and all other QC data is within limits, a matrix effect is suspected. Flag the associated data in the Tester's comments.
- If the % recovery cannot be calculated due to high analyte concentration (Concentration of the unknown sample used in the preparation of the matrix spike is > 1/2 the fortification level of the matrix spike) the matrix spike is reported as NC (Not Calculated) and the data is flagged in Tester's comments.

15.2.4 Matrix Spike Duplicate (MSD):

$$\text{RPD (\%)} = \frac{(\text{MS result} - \text{MSD result})}{(\text{MS result} + \text{MSD result})/2} \times 100$$

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- The corrective actions listed for the matrix spike are also applicable to the matrix spike duplicate.
- Check samples for homogeneity, if not homogeneous, flag the data in Tester's comments.

15.2.5 Laboratory Duplicate:

$$\text{RPD (\%)} = \frac{(\text{sample result} - \text{duplicate result})}{(\text{sample result} + \text{duplicate result})/2} \times 100$$

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Check for calculation errors.

- Check samples for homogeneity, if not homogeneous, flag the data in Tester's comments.

15.2.6 Mass-Labeled Surrogate Compound Recovery:

Using the ICAL, regress the area ratio for each applicable mass-labeled surrogate against its concentration using the injection internal standard as the quantitation reference as indicated in Table 9. Mass-labeled surrogate compounds and injection internal standards are in each calibrator at a constant concentration. The regression will simplify to a single point calibration (linear through zero) because the concentrations are constant.

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- If an injection error is suspected, re-inject suspect sample(s). If the re-injection produces an acceptable mass-labeled compound recovery, report the re-injected sample results.
- If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from a matrix effect. Flag the associated data in the Tester's comments.
- For failed QC samples, re-prepare and re-analyze the entire batch. If sufficient sample is not available for re-analysis, flag the data in Tester's comments.

15.2.7 Injection Internal Standard Response:

The injection internal standards are quantified by external standard. Regress the area against the concentration of the injection internal standards. The injection internal standards are in each calibrator at a constant concentration. The regression will simplify to a single point calibration (linear through zero) because the concentrations are constant.

Acceptance Criteria: Refer to Table 10

Corrective Action(s):

- Re-inject suspect sample(s). If the re-injection produces an acceptable response, report the re-injected sample results.
- If responses are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from a matrix effect. Flag the associated data in the Tester's comments.

- For failed QC samples, re-prepare and re-analyze the entire batch. If sufficient sample is not available for re-analysis, flag the data in Tester’s comments.

15.2.8 Relative Retention Time:

$$\textit{Relative Retention Time (RRT)} = \frac{\textit{Analyte Retention Time}}{\textit{Internal Standard Retention Time}}$$

Acceptance Criteria:
The relative retention time between native PFC analytes and their corresponding mass-labeled internal standards must be within ±2% of the mean relative retention time in the ICAL.

Corrective Action(s):

- Re-inject suspect sample(s).
- Dilute suspect sample(s) and re-analyze.
- If recoveries are acceptable for QC samples, but not field samples, the field samples may be considered to suffer from a matrix effect. Flag the associated data in the Tester’s comments.
- For failed QC samples, re-prepare and re-analyze the entire batch. If sufficient sample is not available for re-analysis, flag the data in Tester’s comments.

15.3 Control Charting:

Control charts are generated according to COR WI-00055. Each time a Spiked Blank is analyzed, the % recoveries of PFOS, PFOA and PFOSA in the spiked blank are plotted manually on the control chart(s). The charts(s) are monitored for out of control points and/or the development of trends. Take action, if necessary, and document on the control chart(s).

PFC control charts can be found on the common network drive:

G:\Scientific Services\LCMSMS\Control Charts

15.4 Non Conformance:

All method non-conformances, QC failures or method deviations due to unusual sample matrix, are documented on the worksheet data validation checklist (CAM FCD-01126 or BRL FCD-00002 for DoD Jobs).

16.0 DATA INTERPRETATION AND CALCULATIONS

16.1 Calculations

Instrument software calculates concentrations from the calibration curve. Incorporate the dilution factor into final concentration calculations.

Water (μg/L): Concentration = Extract Conc (ug/L) X DF

Soil (ug/kg): Concentration = $\dfrac{\text{Extract Conc (ug/kg) X TW X DF}}{\text{Dry sample weight (g)}}$

Where: DF = Dilution factor
TW = Theoretical weigh (g)
Dry sample weight = the weight of the sample after moisture has been calculated (g).

16.2 Reporting:

The quantitative values shall be reported in appropriate units, microgram per liter (μg/L) for water samples and microgram per kilogram (μg/kg) for soil samples. Data must be reported to 3 significant figures. The analyst must not extrapolate beyond the established calibration range. If an analyte result exceeds the range of the initial calibration curve, the sample may be re-extracted using a smaller sample volume/weight.

The results for a positive sample can be reported if the following conditions are met:

16.2.1 The supervisor/manager or a qualified designate approves the instrument and analysis performance.

16.2.2 The calibration (Sec. 15.1) and quality control (Sec. 15.2) performance criteria have been satisfied.

16.3 Data Storage and Retrieval:

16.3.1 Paper Records: Raw and calculated data, including LIMS work sheet, calibrations and QC results are stored numerically, by worksheet number, in folders in the laboratory as space permits. These files are archived off-site for long-term storage.

16.3.2 Electronic Media: Acquired data is stored on the local hard drive and will be backed up on the network drive as needed. The acquired data stored on the network drive will be archived on CD at a later date or when required.

17.0 MAINTENANCE

For maintenance requirements and additional instrument information, refer to CAM WI-00506.

18.0 TABLES

Table 1: Initial Calibration Standard Preparation – High Level Aqueous Analysis

Table 2: Initial Calibration Standard Preparation – Low Level Aqueous Analysis

Table 3: Initial Calibration Standard Preparation - High Level Soil Analysis

Table 4: Initial Calibration Standard Preparation – Low Level Soil Analysis

Table 5: Initial Calibration Verification (ICV) Standard Preparation – High Level Aqueous Analysis

Table 6: Initial Calibration Verification (ICV) Standard Preparation – Low Level Aqueous Analysis

Table 7: Initial Calibration Verification (ICV) Standard Preparation – High Level Soil Analysis

Table 8: Initial Calibration Verification (ICV) Standard Preparation – Low Level Soil Analysis

Table 9: Ions – Analytes and Internal Standards

Table 10: QC Acceptance Criteria and Quantitation References

Table 1: Initial Calibration Standard Preparation – High Level Aqueous Analysis

Calibration Standards are prepared fresh daily in polypropylene culture tubes according to the following table, and vortexed well. Pipet 180 µL of each calibration standard to a 0.3 mL polypropylene vial and add 20 µL of Injection Internal Standard solution (400 ng/mL). Cap with polyethylene snap caps and vortex to mix.

	CS1	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**
	0.8/2.0 µg/L	3.0/7.5 µg/L	7.0/17.5 µg/L	20/50 µg/L	35/87.5 µg/L	50/125 µg/L
	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)
PFC Spiking Standard **A** (1000 ng/mL)	-	-	-	-	-	37.5
PFC Spiking Standard **B** (250 ng/mL)	-	-	21	60	105	-
PFC Spiking Standard **D** (25 ng/mL)	24	90	-	-	-	-
Mass-Labeled IS Solution A (50 ng/mL)	100	100	100	100	100	100
LCMS (or HPLC) grade water	750	750	750	750	750	750
Methanol	500	500	500	500	500	500

Table 2: Initial Calibration Standard Preparation – Low Level Aqueous Analysis

Calibration Standards are prepared fresh daily in 50 mL polypropylene tubes according to the following table then extracted along with the low level aqueous samples.

	CS1	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**
	0.02/0.05 µg/L	0.06/0.15 µg/L	0.15/0.375 µg/L	0.4/1.0 µg/L	0.7/1.75 µg/L	1.1/2.75 µg/L
	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)	Vol Req'd (µL)
PFC Spiking Standard **B** (250 ng/mL)	-	-	-	32	56	88
PFC Spiking Standard **E** (10 ng/mL)	40	120	300	-	-	-
LCMS (or HPLC) grade water (pH 4-5)	20 mL	20 mL	20 mL	20 mL	20 mL	20 mL

Table 3: Initial Calibration Standard Preparation – High Level Soil Analysis

Calibration Standards are prepared fresh daily in polypropylene culture tubes according to the following table, then vortexed and transferred to 0.3 mL polypropylene vials fitted with polyethylene snap caps.

	CS1	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**
	5.0 μg/kg	15 μg/kg	35 μg/kg	100 μg/kg	175 μg/kg	250 μg/kg
	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)
PFC Spiking Standard **A** (1000 ng/mL)	-	-	-	50	87.5	125
PFC Spiking Standard **C** (100 ng/mL)	25	75	175	-	-	-
Mass-Labeled IS Solution B (250 ng/mL)	50	50	50	50	50	50
(70/30) Acetonitrile/Water	2500	2500	2500	2500	2500	2500

Table 4: Initial Calibration Standard Preparation – Low Level Soil Analysis

Calibration Standards are prepared fresh daily in 50 mL polypropylene tubes according to the following table then extracted along with the low level soil samples.

	CS1	**CS2**	**CS3**	**CS4**	**CS5**	**CS6**
	0.1 μg/kg	0.3 μg/kg	0.7 μg/kg	2.0 μg/kg	3.5 μg/kg	5.0 μg/kg
	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)	Vol Req'd (μL)
PFC Spiking Standard **C** (100 ng/mL)	-	-	35	100	175	250
PFC Spiking Standard **E** (10 ng/mL)	50	150	-	-	-	-
Ottawa Sand	5 g	5 g	5 g	5 g	5 g	5 g

Table 5: Initial Calibration Verification (ICV) Standard Preparation – High Level Aqueous Analysis

The ICV is prepared fresh daily in a polypropylene culture tube according to the following table, and vortexed well. Pipet 180 µL of the ICV to a 0.3 mL polypropylene vial and add 20 µL of Injection Internal Standard solution (400 ng/mL). Cap with a polyethylene snap cap and vortex to mix.

ICV (25/62.5 µg/L)	Vol Req'd (µL)
Second Source Spiking Standard B (250/625 ng/mL)	75
Mass-Labeled IS Solution A (50/125 ng/mL)	100
LCMS (or HPLC) grade water	750
Methanol	500

Table 6: Initial Calibration Verification (ICV) Standard Preparation – low Level Aqueous Analysis

The ICV is prepared fresh daily in a polypropylene culture tube according to the following table then extracted along with the low level aqueous samples.

ICV (0.5/1.25 µg/L)	Vol Req'd (µL)
Second Source Spiking Standard B (250 ng/mL)	40
LCMS (or HPLC) grade water (pH 4-5)	20 mL

Table 7: Initial Calibration Verification (ICV) Standard Preparation – High Level Soil Analysis

The ICV is prepared fresh daily in a polypropylene culture tube according to the following table, then transferred to a 0.3 mL polypropylene vial fitted with a polyethylene snap cap.

ICV (125 µg/kg)	Vol Req'd (µL)
Second Source Spiking Standard A (1000 ng/mL)	62.5
Mass-Labeled IS Solution B (250 ng/mL)	50
Injection Internal Standard B (250 ng/mL)	50
(70/30) Acetonitrile/Water	2500

Table 8: Initial Calibration Verification (ICV) Standard Preparation – Low Level Soil Analysis

The ICV is prepared fresh daily in a polypropylene centrifuge tube according to the following table then extracted along with the low level aqueous samples.

ICV (2.5 µg/kg)	Vol Req'd (µL)
Second Source Spiking Standard C (100 ng/mL)	125
Ottawa Sand	5.0 g

Table 9: Ions – Analytes and Internal Standards

Compound	Abbreviation	Precursor Ion (m/z)	Product Ion (m/z)	Declustering Potential (DP)	Collision Energy (CE)	Collision Cell Exit Potential (CXP)
Native PFCs						
Perfluorobutanoic acid	PFBA	212.9	169.0	-30	-14	-13
Perfluorobutanesulfonate	PFBS	298.9	79.9	-140	-65	-12
Perfluoropentanoic acid	PFPeA	262.9	218.9	-37	-12	-18
Perfluorohexanoic acid	PFHxA	313.0	269.0	-35	-13	-13
Perfluorohexanesulfonate	PFHxS	398.9	79.9	-150	-80	-12
Perfluoroheptanoic acid	PFHpA	362.0	319.0	-37	-14	-14
Perfluoroheptanesulfonate	PFHpS	449.8	79.9	-150	-100	-12
Perfluorooctanoic acid	PFOA	413.1	369.0	-35	-15	-17
Perfluorooctanesulfonate	PFOS	498.8	79.9	-150	-80	-8
Perfluorononanoic acid	PFNA	462.9	419.0	-35	-15	-19
Perfluorodecanoic acid	PFDA	513.0	469.1	-35	-16	-21
Perfluorodecanesulfonate	PFDS	598.9	79.9	-90	-100	-12
Perfluoroundecanoic acid	PFUnA	562.9	519.0	-44	-17	-24
Perfluorododecanoic acid	PFDoA	612.9	569.0	-44	-18	-25
Perfluorotridecanoic acid	PFTrDA	663.0	619.0	-45	-18	-27
Perfluorotetradecanoic acid	PFTeDA	713.0	669.0	-50	-20	-30
Perfluorooctane sulfonamide	PFOSA	497.9	78.0	-150	-70	-8
N-methylperfluorooctane sulfonamide	MeFOSA	511.9	169.0	-110	-35	-13
N-ethylperfluorooctane sulfonamide	EtFOSA	526.0	169.0	-120	-35	-13
N-methylperfluorooctane sulfonamidoethanol	MeFOSE	616.0	59.0	-50	-71	-9
N-ethylperfluorooctane sulfonamidoethanol	EtFOSE	630.0	59.0	-33	-71	-9
6:2 Fluorotelomersulfonate	6:2FTS	427.0	407.0	-70	-32	-18
8:2 Fluorotelomersulfonate	8:2FTS	526.9	507.0	-35	-38	-21
Mass-Labeled Internal Standards						
$^{13}C_4$-Perfluorobutanoic acid	MPFBA	216.9	172.0	-35	-13	-16
$^{13}C_5$-Perfluoropentanoic acid	MPFPeA	267.9	223.0	-30	-12	-16
$^{13}C_2$-Perfluorohexanoic acid	MPFHxA	314.9	270.0	-35	-13	-13
$^{18}O_2$-Perfluorohexanesulfonate	MPFHxS	402.9	84.0	-105	-60	-8
$^{13}C_4$-Perfluoroheptanoic acid	MPFHpA	366.9	322.0	-37	-14	-14

$^{13}C_4$-Perfluorooctanoic acid	MPFOA	416.9	372.0	-35	-15	-17
$^{13}C_4$-Perfluorooctanesulfonate	MPFOS	502.9	79.9	-150	-80	-8
$^{13}C_5$-Perfluorononanoic acid	MPFNA	467.9	423.0	-35	-15	-19
$^{13}C_2$-Perfluorodecanoic acid	MPFDA	514.9	470.0	-35	-16	-21
$^{13}C_2$-Perfluoroundecanoic acid	MPFUnA	564.9	520.0	-44	-17	-24
$^{13}C_2$-Perfluorododecanoic acid	MPFDoA	614.9	570.0	-44	-18	-25
$^{13}C_2$-Perfluorotetradecanoic acid	MPFTeDA	714.9	669.9	-50	-20	-30
$^{13}C_8$-Perfluorooctane sulfonamide	MPFOSA	505.8	77.9	-95	-90	-12
N-methyl-d_3-perfluorooctanesulfonamide	D3-MeFOSA IS	514.9	168.9	-110	-37	-16
N-ethyl-d_5-perfluorooctanesulfonamide	D5-EtFOSA IS	531.0	168.9	-120	-38	-16
N-methyl-d_3-perfluorooctanesulfonamidoethanol-d_4	D7-MeFOSE IS	623.1	59.0	-50	-71	-9
N-ethyl-d_5-perfluorooctanesulfonamidoethanol-d_4	D9-EtFOSE IS	639.1	59.0	-33	-75	-9
$^{13}C_2$-Fluorotelomersulfonate (6:2)	M2-6:2FTS	429.0	80.9	-70	-73	-9
$^{13}C_2$-Fluorotelomersulfonate (8:2)	M2-8:2FTS	528.9	80.9	-35	-85	-10
Mass-Labeled Injection Internal Standards						
$^{13}C_6$-Perfluorohexanoic acid	13C6-PFHxA	318.9	274.0	-34	-13	-23
$^{13}C_9$-Perfluorodecanoic acid	13C9-PFDA	521.9	477.1	-28	-17	-23

Table 10: QC Acceptance Criteria and Quantitation Reference

Compound	Abbreviation	Quant Type	Recovery (%) ICAL[1], ICV & CCV		Recovery (%) QCs & Samples			Quantitation Reference
			Low	High	Low	High	%RPD	
Native PFCs								
Perfluorobutanoic acid	PFBA	ID	75	125	70	130	30	MPFBA
Perfluorobutanesulfonate	PFBS	ID	75	125	70	130	30	MPFHxS
Perfluoropentanoic acid	PFPeA	ID	75	125	70	130	30	MPFPeA
Perfluorohexanoic acid	PFHxA	ID	75	125	70	130	30	MPFHxA
Perfluorohexanesulfonate	PFHxS	ID	75	125	70	130	30	MPFHxS
Perfluoroheptanoic acid	PFHpA	ID	75	125	70	130	30	MPFHpA
Perfluoroheptanesulfonate	PFHpS	ID	75	125	70	130	30	MPFHpA
Perfluorooctanoic acid	PFOA	ID	75	125	70	130	30	MPFOA
Perfluorooctanesulfonate	PFOS	ID	75	125	70	130	30	MPFOS
Perfluorononanoic acid	PFNA	ID	75	125	70	130	30	MPFNA
Perfluorodecanoic acid	PFDA	ID	75	125	70	130	30	MPFDA
Perfluorodecanesulfonate	PFDS	ID	75	125	70	130	30	MPFDA
Perfluoroundecanoic acid	PFUnA	ID	75	125	70	130	30	MPFUnA
Perfluorododecanoic acid	PFDoA	ID	75	125	70	130	30	MPFDoA
Perfluorotridecanoic acid	PFTrDA	ID	75	125	70	130	30	MPFTeDA
Perfluorotetradecanoic acid	PFTeDA	ID	75	125	70	130	30	MPFTeDA
Perfluorooctane sulfonamide	PFOSA	ID	75	125	70	130	30	MPFOSA
N-methylperfluorooctane sulfonamide	MeFOSA	ID	75	125	70	130	30	D3-MeFOSA IS
N-ethylperfluorooctane sulfonamide	EtFOSA	ID	75	125	70	130	30	D5-EtFOSA IS
N-methylperfluorooctane sulfonamidoethanol	MeFOSE	ID	75	125	70	130	30	D7-MeFOSE IS
N-ethylperfluorooctane sulfonamidoethanol	EtFOSE	ID	75	125	70	130	30	D9-EtFOSE IS
6:2 Fluorotelomersulfonate	6:2FTS	ID	75	125	70	130	30	M2-6:2FTS
8:2 Fluorotelomersulfonate	8:2FTS	ID	75	125	70	130	30	M2-8:2FTS
Mass-Labeled Surrogate Compounds [2]								
$^{13}C_4$-Perfluorobutanoic acid	13C4PFBA	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_5$-Perfluoropentanoic acid	13C5PFPeA	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_2$-Perfluorohexanoic acid	13C2PFHxA	IS	75	125	70	130	30	13C6-PFHxA
$^{18}O_2$-Perfluorohexanesulfonate	18O2PFHxS	IS	75	125	70	130	30	13C6-PFHxA

$^{13}C_4$-Perfluoroheptanoic acid	13C4PFHpA	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_4$-Perfluorooctanoic acid	13C4PFOA	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_4$-Perfluorooctanesulfonate	13C4PFOS	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_5$-Perfluorononanoic acid	13C5PFNA	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_2$-Perfluorodecanoic acid	13C2PFDA	IS	75	125	50	150	30	13C6-PFHxA
$^{13}C_2$-Perfluoroundecanoic acid	13C2PFUnA	IS	75	125	50	150	30	13C6-PFHxA
$^{13}C_2$-Perfluorododecanoic acid	13C2PFDoA	IS	75	125	50	150	30	13C6-PFHxA
$^{13}C_2$-Perfluorotetradecanoic acid	13C2PFTeDA	IS	75	125	50	150	30	13C6-PFHxA
$^{13}C_8$-Perfluorooctane sulfonamide	13C8PFOSA	IS	50	150	50	150	30	13C9-PFDA
N-methyl-d$_3$-perfluorooctanesulfonamidoethanol-d$_4$	D7-MeFOSE	IS	50	150	50	150	30	13C9-PFDA
N-ethyl-d$_5$-perfluorooctanesulfonamidoethanol-d$_4$	D9-EtFOSE	IS	50	150	50	150	30	13C9-PFDA
$^{13}C_2$-Fluorotelomersulfonate (6:2)	13C2-6:2FTS	IS	75	125	70	130	30	13C6-PFHxA
$^{13}C_2$-Fluorotelomersulfonate (8:2)	13C2-8:2FTS	IS	75	125	70	130	30	13C6-PFHxA
Mass-Labeled Injection Internal Standards								
$^{13}C_6$-Perfluorohexanoic acid	13C6-PFHxA	ES	50	150	50	150	30	
$^{13}C_9$-Perfluorodecanoic acid	13C9-PFDA	ES	50	150	50	150	30	

Quantitation Methods:

ID = Isotope Dilution
IS = Internal Standard
ES = External Standard

[1] Recovery criteria of unlabeled (native) compounds in lowest calibration standard is 70-130%

[2] Typical mass-labeled surrogate recovery values. In-house limits may be set once sufficient data has been generated.