Work Plan
For Supplemental PFAS Investigations
Gerald R. Ford International Airport (GRR)

Prepared for:
Gerald Ford International Airport
Grand Rapids, MI

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1 Introduction

This work plan describes investigation activities at the Gerald R Ford International Airport (identified in this plan by its airport code "GRR" or "Airport"), planned as part of proposed activities under the Municipal Airports Grant program administered by the Michigan Departments of Transportation (MDOT) and Environment, Great Lakes, and Energy (EGLE). The proposed investigation activities in this work plan are intended primarily to further delineate the extent and distribution of per- and poly-fluoroalkylated substances (PFAS) in soil from past use of aqueous film-forming foam (AFFF) at five locations at GRR.

1.1 Background

AFFF containing PFAS was reportedly used historically for training and isolated firefighting purposes at GFIA. For an uncertain period of time, ending in the mid-1990s, the Airport maintained a firefighting training area (the FFTA) at which AFFF was used as part of the training, and AFFF containing PFAS was used for at least a portion of this time period. Two additional areas were also identified at which airport emergency response personnel performed testing and calibration of firefighting equipment as required by the Federal Aviation Administration (FAA). This FAA-required testing involved dispensing limited quantities of AFFF onto paved areas at Ramp 5 and the Aircraft Rescue Firefighting (ARFF) building. The final two known AFFF use locations include two emergency response incidents, one that occurred on Runway 26L in the early 1990s and the other that occurred on Taxiway D in the early 2000s. The specifics of AFFF used at the two emergency response incidents are not currently known.

The Airport has completed several prior investigation activities focused on the FFTA, Ramp 5, and ARFF at their own expense, including soil and groundwater sampling. The primary findings of those efforts are summarized in Section 1.3 below.

In 2019, GRR conducted a Short-Term Stormwater Characterization Study (STSWCS) in the 011 drainage area to assess PFAS concentrations in stormwater discharges. The findings of that study were reported to EGLE in December 2019.[1] Data from the study and follow-up investigations indicate that soils from the vicinity of the ARFF Ramp may be contributing some level of perfluorooctanesulfonic acid (PFOS) to the Outfall 011 drainage system. EGLE has expressed concern that soils may be contributing PFAS to stormwater discharges from other parts of the airfield during dry weather conditions. As part of this proposed work, the Airport plans to evaluate dry weather flows and collect samples (if flow is present during these conditions) in drainage areas 004 and 007.

There was also a former waste handling facility located on what is now the southern portion of airport property. The former Cascade Resource Recovery, Inc. (CRRI) site was designed and licensed to receive, treat, and dispose of hazardous wastes and operated from April 1982 to March 1983.[2] According to a 1991

[1] Short-Term Stormwater Characterization Study Report Prepared for GFIA. LimnoTech, December 30, 2019.
[2] Closure Plan Amendment. January 5, 1989. Cascade Resource Recovery Inc. EPA I.D. No. MID000718700

Federal Highway Administration Environmental Impact Statement[3], CRRI operated for a year and received approximately 15,000 cubic yards of waste. Based on other information reviewed to date, that was the only waste accepted during the short operational life of the facility. The EIS also notes that: the facility was closed in 1984 by the State of Michigan and remained closed for an extended period of time; the operator pursued a Clean Closure Certification during which all wastes were inventoried, analyzed, removed, and deposited in an approved hazardous waste disposal facility; and, the soil, surface water, and groundwater were extensively monitored for several years until September 27, 1989 when Michigan Department of Natural Resource's Director, David F. Hales, issued a Clean Closure Certification. GFIA did not take ownership of this property until 1994. As part of this proposed work, GRR plans to compile available information to provide further understanding of the site, its operations, and closure activities.

1.2 Investigation Location

The location of the investigation areas covered by this work plan are shown in Figure 1. The FFTA was located near the northeast corner of the airport. The ARFF and Ramp 5 areas are located in the central part of the airport. The emergency response locations are located on Runway 8R/26L between taxiways L and P and on taxiway D between taxiways M and R. The former Cascade Resource Recovery site is located in the southeastern potion of the airport property.

1.3 Previous Investigations

Previous investigation indicates that PFOS and PFOA are present in soil at the three past AFFF use areas previously investigated at GRR. A substantial and extensive clay layer appears to prevent the downward migration of PFOS and PFOA from the former FFTA, indicating thus far that there is no current migration pathway to deep groundwater. Findings indicate additional sampling of soil in the vicinity of the FFTA, ARFF, and Ramp 5 areas is warranted to further delineate the extent and distribution of PFAS impacts in these areas. Previous soil sampling results at the three past AFFF use areas are shown in Figures 2 through 4.

1.4 Investigation Objectives

The main objectives of the investigation described in this work plan are to:

1. Further characterize source areas where past use of AFFF may have resulted in some possible PFAS impacts to the environment.
2. Build on previous sampling and better define, to the extent practical within available funding, the extent and distribution of known PFAS impacts in soil at three past AFFF use areas at the Airport.
3. Conduct dry weather sampling in drainage areas 004 and 007 to evaluate whether any possible PFAS could result from shallow groundwater flows to stormwater outfalls.
4. Review available information related to the former CRRI facility to evaluate site characteristics (soils, groundwater, etc.) and assess whether any potential PFAS impacts could remain after full remediation and closure of the site in the 1980s.

Details of the specific field activities being planned to meet these objectives are provided in Section 2 below.

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[3] Federal Highway Administration Region 5. February 1991. Draft Environmental Impact Statement, Grand Rapids South Beltline from I-196 to I-96 in Ottawa and Kent Counties, Michigan. FHWA-MI-EIS-91-01-D.

1.5 Project Organization

Key project team members are listed below:

- The Airport
- LimnoTech
- Mateco Drilling Company
- SGS North America

1.5.1 GFIA

Airport personnel will be responsible for the following:

- Providing access to investigation areas, including credentialed escorts as needed
- Providing access to water supply to support investigation activities
- Providing storage location(s) for investigation-derived wastes

Mr. Casey Ries, P.E., Engineering & Planning Director, will be the primary GRR point of contact.

1.5.2 LimnoTech

LimnoTech will have general responsibility for overall project planning, implementation and management. In addition, LimnoTech will be responsible for:

- Providing field oversight, including directing contractors, documenting investigation activities and serving as the liaison with Airport operations personnel
- Conducting sample collection and ensuring delivery of the samples to the analytical laboratory
- Conducting data review, including QA review of laboratory-derived data
- Processing the investigation-derived data, including preparing boring logs, geologic cross-sections, maps and reports as needed
- Communicating the results of the investigation to the Airport and its representatives

As project manager, Mr. Cieciek will be the primary point of contact for GRR and subcontractors.

1.5.3 Mateco Drilling Company

Mateco Drilling Company will perform all drilling activities. Mr. Todd Johansen will be the primary Mateco point of contact for Mr. Cieciek. LimnoTech field personnel will coordinate on-site activities directly with the Mateco drilling crew.

1.5.4 SGS North America

SGS North America (SGS-NA) will be responsible for analysis of samples collected during this investigation. Ms. Andrea Colby, project manager for SGS-NA will oversee sample analysis, data validation and quality assurance activities at the laboratory.

Information on the organizational structure, laboratory procedures and qualifications at SGS-NA are provided in the laboratory Quality Assurance Manual (QAM). All laboratory reports will be prepared and submitted to LimnoTech electronically following analysis of each sample batch.

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2 Soil and Groundwater Field Investigation and Sampling Plan

The details of the planned investigation are provided below.

2.1 Health and Safety

A project health and safety plan (HASP) will be prepared for this investigation. A copy of the HASP will be provided to each organization identified in Section 1.5 above. All field staff will have reviewed the site-specific HASP prepared for this investigation and will be aware of the chemical and physical hazards specific to this project prior to initiation of any field activities. In addition, all persons performing field investigative tasks for this project have experience working on similar site investigation projects and have completed OSHA 40-hour HAZWOPER safety training, with 8-hour refresher courses as needed. A copy of the HASP will remain onsite for the duration of field activities.

2.2 Investigation Overview

This investigation will consist of soil borings at each of the five investigation areas. Soil samples will be collected from up to three (3) depths from each boring and shallow groundwater will be sampled, if encountered. The investigation is divided into two phases:

- Phase 1 – Conducting seventy-two (72) direct push soil borings at the FFTA (47), ARFF (16), and Ramp 5 (9). The FFTA borings include six (6) locations along the unnamed tributary north of the railroad that will be sampled using direct push or manual methods, depending on accessibility. Conducting ten (10) manual borings at the emergency response locations at Taxiway D (6) and Runway 26L (4).
- Phase 2 – Based on the soil sampling results from Phase 1, additional soil, groundwater, and/or stormwater sampling will be conducted. Based on available information and for planning purposes, it assumed an additional eight (8) direct push borings will be conducted at locations to be determined.

Boring locations are described in Section 2.3 and the sampling plan for each type of boring is described in Section 2.4.

2.3 Boring Locations

2.3.1 Planned Boring Locations

The planned boring locations under Phase 1 are shown in Figures 5 through 7. The locations are subject to adjustment depending on field conditions. Table 2-1 summarizes the planned soil and groundwater sampling for this investigation. Boring locations may vary from the planned locations depending on utility locations, accessibility, and other conditions encountered in the field. If it appears that a boring location needs to be changed, the decision will be made jointly between the field team leader and the project manager. The boring locations were chosen based on results from previous sampling and limitations of accessibility due to site constraints (grade, forestation, etc.). All boring locations will be recorded in the field using GPS instrumentation with sub-meter accuracy.

Table 2-1. Summary of PFAS Sampling Areas.

Investigation Area	Bore Type	Samples	Targeted Total Depth (ft. below grade)	# Phase 1 Locations	# Phase 2 Locations
FFTA	Shallow (Direct Push)	Up to three (3) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected.	<20	41	t.b.d.
	Shallow (Manual)	Up to two (2) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected	<3	6	t.b.d.
ARFF	Shallow (Direct Push)	Up to three (3) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected.	<20	16	t.b.d.
Ramp 5	Shallow (Direct Push)	Up to three (3) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected.	<20	9	t.b.d.
Taxiway D	Shallow (Manual)	Up to two (2) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected.	<3	6	t.b.d.
Runway 26L	Shallow (Manual)	Up to two (2) soil samples in each boring. If shallow groundwater is encountered, one sample will be collected.	<3	4	t.b.d.

2.4 Sampling Plan

2.4.1 Boring Methods

Borings will be conducted using either direct-push (e.g. Geoprobe) or manual methods. It is expected that manual methods will be used at locations closest to the east branch of the unnamed tributary, at locations on the west side of the west branch of the unnamed tributary, and at the emergency response locations. For the manual borings, a bucket auger and well point will be used. It is expected that the borings will be started using a bucket auger that will be advanced until refusal occurs. For both the direct-push and manual borings, field personnel will observe the soil removed from the boreholes to identify a water-bearing layer of permeable or semi-permeable soil, which may reasonably be expected to yield groundwater in sufficient quantity for sampling. If such a layer is encountered in the direct-push boring, sampling will proceed as described in Section 2.4.2.b. If such a layer is encountered in the manual borings, a 36-inch well point will be set in this soil interval to allow groundwater sampling. Threaded steel pipe will be attached to the well point, extending at least three feet above grade and the borehole will be allowed to collapse naturally around the well point and pipe riser. Soil types encountered in each boring will be logged in the field by an experienced scientist or engineer. Groundwater sampling in these borings will proceed in accordance with Section 2.4.2.

Based on observations from previous investigations on the airfield, the direct push borings are expected to be no more than 20 feet deep. Based on the topography around the tributaries and observations from previous investigations along the unnamed tributary as well as limitations inherent to manual methods, the borings north of the railroad are expected to be no more than 20 feet (direct push) and 10 feet (manual) deep.

2.4.2 Sampling Methods

The methods and procedures for soil and shallow groundwater (if encountered) sampling are described below.

2.4.2.a Soil Sampling

Up to three soil samples will be collected from the direct push borings and up to two samples will be collected from the manual borings. One sample will be collected near surface (upper 1'of soil). The second sample will be collected at the midpoint of the boring or just above the saturated zone, if one is present. The third sample will be collected if groundwater is not encountered, and will be collected near the bottom of the boring just above the clay layer.

All soil samples will be collected by the LimnoTech geologist or engineer. The location of all soil samples will be recorded in the field notes and marked using a handheld GPS device with sub-meter accuracy. The soil sample will be transferred directly into clean sampling jars. Soil sampling will be conducted in accordance with LimnoTech's standard operating procedure (SOP) for soil sampling (attached), modified as necessary and appropriate by LimnoTech's SOP for PFAS sampling (attached).

2.4.2.b Groundwater Sampling

If shallow groundwater is encountered in the direct-push shallow boring, the following procedure will be used. A 1.5" OD rod with a Screen Point 16 water sampler sheath (Geoprobe Systems®) will be deployed to the target depth. The sampler sheath contains a stainless steel screen that can be exposed from sample collection at target depth. For depths less than about 25', a peristaltic pump will be used for sample collection. If shallow groundwater is encountered in the manual shallow borings, a peristaltic pump will be used for sample collection.

Groundwater sampling will be conducted in accordance with LimnoTech's SOP for groundwater sampling (attached), modified as necessary and appropriate by LimnoTech's SOP for PFAS sampling (attached).

2.5 Field Documentation

All field activities will be documented by field personnel designated by the field team leader, using the procedures described in LimnoTech's SOP for field documentation (attached), as modified for PFAS sampling by LimnoTech's SOP for PFAS sampling (attached). Upon completion of investigation activities, field documentation will be stored with other project files at LimnoTech's office in Ann Arbor or at another location designated by the project manager. Further detail on field documentation is contained in Section 4.1.2.

2.6 Sample Documentation

Sample documentation includes assignment of a unique sample identification number at the time of sampling, which is subsequently used through the chain of custody to the final laboratory report.

2.6.1 Sample Identification

Samples will be designated with a unique identification that includes the boring identification number, the media type and the depth interval (in feet below ground surface) from which the sample is collected. Media types will be designated by “SS” for soil samples, “SW” for surface water, and “GW” for groundwater samples. An example sample identification code is given below, for a soil sample collected at 10 to 12 feet below ground surface from boring B2020-01:

B2020-01SS(10-12)

This unique identification system will eliminate the potential for confusion between sample results.

2.6.2 Chain of Custody

At the time of sampling, field sampling personnel will initiate a chain of custody (COC) using the COC form provided by the analytical laboratory. The COC is discussed in more detail in Section 4.1.1.

2.7 PFAS Analysis

Samples will be submitted to SGS-NA’s Orlando laboratory for analysis of PFAS using modified Method 537 (liquid chromatography, double mass spectrometry) utilizing isotope dilution. All twenty-eight (28) PFAS parameters on Michigan’s analyte list will be reported.

2.8 Investigation-Derived Waste

The investigation activities in this Work Plan are expected to generate the following types of investigation-derived waste (IDW):

- Used expendable materials related to sampling (e.g., nitrile gloves)
- Excess soil material generated during boring

Used expendable materials will be placed in sealed trash bags for disposal at a licensed solid waste facility. Environmental media (soil and groundwater (if encountered)) and decontamination water will be stored in drums at a secure location and characterized for proper disposal.

3 Dry Weather Stormwater Sampling

To assess whether there is any potential for shallow groundwater to contribute any PFAS to certain existing stormwater discharges, an evaluation of dry weather flow conditions will be conducted at drainage areas 004 and 007. To ensure collection of dry weather flow representative of potential airfield contributions, observations will be made during a period at least 72 hours after measurable precipitation as reported by the National Weather Service Grand Rapids station (https://www.weather.gov/grr/, https://w1.weather.gov/data/obhistory/KGRR.html). If flow is observed, a sample will be collected and submitted for the analysis of PFAS. Samples will be collected in accordance with LimnoTech's SOPs for PFAS sampling (attached). The absence of PFAS will help to confirm the Airport's existing belief that all prior PFAS contamination resulted in the area of the Airport that is now drainage area 011.

Samples will be submitted to SGS-NA's Orlando laboratory for analysis of PFAS using modified Method 537 (liquid chromatography, double mass spectrometry) utilizing isotope dilution. All twenty-eight (28) PFAS parameters on Michigan's analyte list will be reported.

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4 Former Cascade Resource Recovery Site Review

Available information on the former CRRI site will be reviewed to provide further understanding of the site. Information to be reviewed is expected to include the closure report and other records available from EGLE through the Freedom of Information Act (FOIA). Particular attention will be paid to site investigation information that may provide insight on soil characteristics and groundwater depths. The intent of the review is to increase understanding of the site soil characteristics and groundwater flow direction (if possible). Records obtained will be reviewed and evaluated for information related to the potential for any possible or remaining PFAS impacts. Findings will be summarized in a memorandum.

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5 Data Quality Objectives

Data quality objectives (DQOs) are quantitative and qualitative criteria intended to ensure that the data collected during the investigation are of an adequate level of quality for their intended uses.

5.1 Investigation Data Quality Objectives

The following specific DQOs have been identified for this investigation:

1. Analytical results for groundwater, soil, and surface water samples must accurately represent actual groundwater, soil, and surface water chemical quality.
2. Analytical results for groundwater, soil, and surface water samples should be of sufficient quality to inform the conceptual site model and for comparison to regulatory criteria.
3. Analytical results must meet quality control requirements for accuracy, precision, completeness and comparability.

5.2 Data Quality Indicators

Data quality indicators (DQIs) are measures that are used to assess data quality and to verify that DQOs are met. The four DQIs (accuracy, precision, completeness and comparability) are discussed below.

5.2.1 Accuracy

Accuracy reflects the degree of bias in a measurement. To determine accuracy, a laboratory or field value is compared to a known or true concentration. Accuracy is determined by such QC indicators as matrix spikes, surrogate spikes, laboratory control samples (blank spikes) and performance samples. Accuracy will be assessed using percent recovery, calculate das follows:

$\%R = 100 \times (A-B)/C$

Where:

%R = percent recovery

A = analyte concentration from spiked sample

B = analyte concentration from unspiked sample

C = analyte concentration of spike added

For this investigation, acceptable %R will be 80% - 120%.

5.2.2 Precision

Precision is a measure of the reproducibility of data measurements under similar conditions and is typically assessed by measuring the degree of mutual agreement between or among independent measurements of the same sample. The common measure of precision is the relative percent difference (RPD), calculated as follows:

$RPD = 100 \times (X_1 - X_2)/[(X_1 + X_2)/2]$

Where: X_1 = original sample value

X_2 = duplicate sample value.

RPD relates to the analysis of duplicate laboratory or field samples. Typically, field precision is assessed by co-located samples, field duplicates, or field splits and laboratory precision is assessed using laboratory duplicates, matrix spike duplicates, or laboratory control sample duplicates.

For this investigation target RPD limits will be 40%. RPDs will not be calculated if the observed concentration is less than five times the reporting limit in either the sample or field duplicate.

5.2.3 Completeness

Completeness measures the quantity of valid data obtained during the investigation, compared to the quantity of valid data expected. For this investigation, it is expected that all data will be valid. Completeness is calculated as follows:

Completeness = 100 x (number of valid samples obtained)/(number of samples collected)

The completeness goal for this investigation is 95%.

5.2.4 Comparability

Comparability expresses the confidence with which one data set can be compared to another. For this investigation, comparability will be assessed by documenting conformance to the work plan and noting any significant deviations. The data quality assurance review will also be considered in assessing data comparability. It should be noted that the current lack of a standardized methodology for the analysis of PFAS in soil and groundwater matrices may need to be considered in comparing data generated from different analytical laboratories.

6 Quality Assurance/Quality Control

This section outlines the quality assurance/quality control (QA/QC) measures that will be used during investigation activities.

6.1 Sample Handling and Custody

6.1.1 Field Sampling Custody

The objective of field sample custody is to assure that samples are traceable and are not compromised between sample collection and receipt by the analytical laboratory. A person will have custody of a sample when the samples are:

- In their physical possession;
- In their view after being in their possession;
- In their personal possession and secured to prevent tampering (such as in a locked office or vehicle); and
- In a restricted area accessible only to authorized personnel and the person is one of the authorized personnel.

Chain of custody documentation will consist of chain-of-custody (COC) forms. One copy of the COC will be retained by the field sampling personnel and subsequently placed on file along with other documentation of field activities. The remaining copies of the COC will be placed inside the sample cooler. Each time the samples change custody (with the exception of commercial delivery services) the COC will be signed by both the new and former responsible parties.

6.1.2 Field Log Books

Field log books serve as a daily record of events, observations, and measurements during field activities. All information pertinent to monitoring activities is recorded in the log books and will include:

- Name and title of author
- Name(s) of field crew personnel
- Name of site and project code
- Description of sample location
- Number and volume of samples taken
- Date and time of collection
- Sample identification numbers
- Sampling method
- Preservatives used
- Field measurements (temperature, dissolved oxygen)
- Field observations (weather conditions, flow appearance, etc.)

6.1.3 Chain-of-Custody Forms

Completed COC forms will be required for all samples to be analyzed. COC forms will be prepared by the field sampling crew during the daily sample collection events. The COC form will contain the following information:

- Unique sample identification number
- Sample location
- Sample date and time
- Sample description
- Sample type
- Sample preservation
- Analyses required

The original COC form will accompany the samples to the laboratory. The COC forms will remain with the samples at all times and will be signed by a representative of the laboratory upon receipt of the samples.

6.2 Quality Control Requirements

6.2.1 Field Duplicates

Field duplicates (splits) will be collected and analyzed to check the precision or reproducibility of sampling and analytical procedures. Field duplicates are defined as two separate samples collected at a single location and time, labeled with separate identification codes so the laboratory cannot identify the samples as duplicates. Duplicate samples will be collected at the rate of approximately 10 percent. The duplicate samples will be handled and analyzed by the laboratory exactly the same as all other samples.

6.2.2 Field Blanks

Field blanks will be analyzed to check for chemical constituent infiltration and sample bottle contamination originating from sample transport and storage. A field blank will consist of analyte-free water (supplied by the laboratory) poured into a sample bottle at the sample site and preserved according to the parameters to be analyzed. Field blanks will be collected at the rate of approximately 10 percent.

6.2.3 Equipment Blanks

Equipment blanks will be collected and analyzed to check for cross-contamination potential between samples or from sampling equipment. An equipment blank will consist of analyte-free water (supplied by the laboratory) poured over a sampling device or drawn through sample tubing and into a sample bottle at the sample site and preserved according to the parameters to be analyzed. At least one equipment blank will be collected for each sampling device type used during the investigation.

6.3 Special Precautions: PFC-Free Equipment, Supplies, Materials and Clothing

Special precautions shall be employed to minimize the possibility of sample cross-contamination related to the low PFAS detection limits and the widespread use of PFAS in consumer products and industrial processes, including:

- Conduct sampling beginning in areas of known or suspected lowest concentrations and progressing to areas of highest concentrations;
- Water used for equipment cleaning/rinsing will be sampled periodically to evaluate potential PFAS content;
- Drilling and sampling equipment and materials (e.g., field filters, sample tubing, pumps, lubricants, O-rings, pipe-thread pastes, tapes, sealants) should be free of polytetrafluoroethylene (PTFE), ethylene tetrafluoroethylene (ETFE), and fluorocarbon-based products; and
- Personal protective equipment, clothing, and hygiene products should be free of PFAS (e.g., fluoropolymer linings used on Tyvek, Nomex, and Viton materials, GoreTex linings, water resistant/waterproof/stain resistant treatments, sunblock, insect repellants, cosmetics/hand creams, food packaging protective of water and grease). All equipment, materials, supplies and clothing used during field activities must be free of perfluorinated chemicals (PFCs) in accordance with the guidelines presented in the PFAS Sampling protocol.

An SOP for PFAS sampling is contained in Appendix A.

6.4 Data Assessment

QA review of all data will be conducted and documented before the data are used for any decisions or published in any way other than the original laboratory reports.

6.4.1 Laboratory Data Review and Validation

Laboratory QA review will be conducted in accordance with the laboratory Quality Assurance Plan (QAP). Upon receipt of the laboratory report for each sample batch, the project QA reviewer will verify that internal laboratory QA was conducted.

6.4.2 LimnoTech Data Review and Validation

When data are received from the analytical laboratory, they will be evaluated by the project QA reviewer to determine if they meet project requirements. Specific items to be reviewed during data validation are:

- Chain of custody completeness
- Holding times
- Duplicate analyses data
- Field and equipment blank data
- Precision and accuracy data
- Matrix spike and matrix spike duplicate data
- Surrogate standards (where applicable)
- Overall data assessment

The project QA reviewer will document the QA review of each data set in writing.

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Figures

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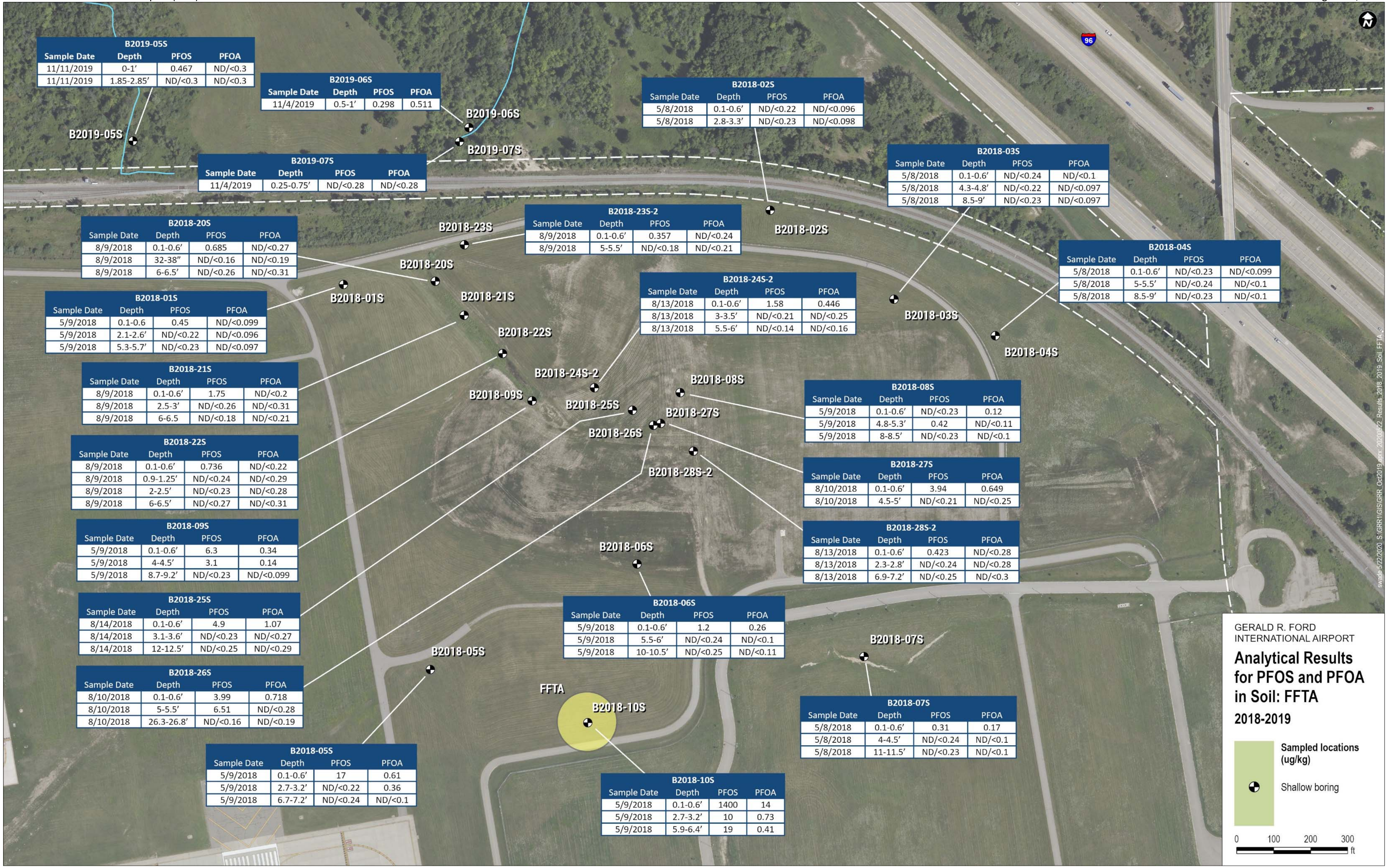
Figure 1. PFAS Investigation Areas. NOTE: Sampling locations subject to change based on observed field conditions.



B2019-05S

Sample Date	Depth	PFOS	PFOA
11/11/2019	0-1′	0.467	ND/<0.3
11/11/2019	1.85-2.85′	ND/<0.3	ND/<0.3

B2019-06S

Sample Date	Depth	PFOS	PFOA
11/4/2019	0.5-1′	0.298	0.511

B2019-07S

Sample Date	Depth	PFOS	PFOA
11/4/2019	0.25-0.75′	ND/<0.28	ND/<0.28

B2018-02S

Sample Date	Depth	PFOS	PFOA
5/8/2018	0.1-0.6′	ND/<0.22	ND/<0.096
5/8/2018	2.8-3.3′	ND/<0.23	ND/<0.098

B2018-03S

Sample Date	Depth	PFOS	PFOA
5/8/2018	0.1-0.6′	ND/<0.24	ND/<0.1
5/8/2018	4.3-4.8′	ND/<0.22	ND/<0.097
5/8/2018	8.5-9′	ND/<0.23	ND/<0.097

B2018-20S

Sample Date	Depth	PFOS	PFOA
8/9/2018	0.1-0.6′	0.685	ND/<0.27
8/9/2018	32-38″	ND/<0.16	ND/<0.19
8/9/2018	6-6.5′	ND/<0.26	ND/<0.31

B2018-23S-2

Sample Date	Depth	PFOS	PFOA
8/9/2018	0.1-0.6′	0.357	ND/<0.24
8/9/2018	5-5.5′	ND/<0.18	ND/<0.21

B2018-04S

Sample Date	Depth	PFOS	PFOA
5/8/2018	0.1-0.6′	ND/<0.23	ND/<0.099
5/8/2018	5-5.5′	ND/<0.24	ND/<0.1
5/8/2018	8.5-9′	ND/<0.23	ND/<0.1

B2018-01S

Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6	0.45	ND/<0.099
5/9/2018	2.1-2.6′	ND/<0.22	ND/<0.096
5/9/2018	5.3-5.7′	ND/<0.23	ND/<0.097

B2018-24S-2

Sample Date	Depth	PFOS	PFOA
8/13/2018	0.1-0.6′	1.58	0.446
8/13/2018	3-3.5′	ND/<0.21	ND/<0.25
8/13/2018	5.5-6′	ND/<0.14	ND/<0.16

B2018-21S

Sample Date	Depth	PFOS	PFOA
8/9/2018	0.1-0.6′	1.75	ND/<0.2
8/9/2018	2.5-3′	ND/<0.26	ND/<0.31
8/9/2018	6-6.5	ND/<0.18	ND/<0.21

B2018-08S

Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6′	ND/<0.23	0.12
5/9/2018	4.8-5.3′	0.42	ND/<0.11
5/9/2018	8-8.5′	ND/<0.23	ND/<0.1

B2018-22S

Sample Date	Depth	PFOS	PFOA
8/9/2018	0.1-0.6′	0.736	ND/<0.22
8/9/2018	0.9-1.25′	ND/<0.24	ND/<0.29
8/9/2018	2-2.5′	ND/<0.23	ND/<0.28
8/9/2018	6-6.5′	ND/<0.27	ND/<0.31

B2018-27S

Sample Date	Depth	PFOS	PFOA
8/10/2018	0.1-0.6′	3.94	0.649
8/10/2018	4.5-5′	ND/<0.21	ND/<0.25

B2018-09S

Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6′	6.3	0.34
5/9/2018	4-4.5′	3.1	0.14
5/9/2018	8.7-9.2′	ND/<0.23	ND/<0.099

B2018-28S-2

Sample Date	Depth	PFOS	PFOA
8/13/2018	0.1-0.6′	0.423	ND/<0.28
8/13/2018	2.3-2.8′	ND/<0.24	ND/<0.28
8/13/2018	6.9-7.2′	ND/<0.25	ND/<0.3

B2018-25S

Sample Date	Depth	PFOS	PFOA
8/14/2018	0.1-0.6′	4.9	1.07
8/14/2018	3.1-3.6′	ND/<0.23	ND/<0.27
8/14/2018	12-12.5′	ND/<0.25	ND/<0.29

B2018-06S

Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6′	1.2	0.26
5/9/2018	5.5-6′	ND/<0.24	ND/<0.1
5/9/2018	10-10.5′	ND/<0.25	ND/<0.11

B2018-26S

Sample Date	Depth	PFOS	PFOA
8/10/2018	0.1-0.6′	3.99	0.718
8/10/2018	5-5.5′	6.51	ND/<0.28
8/10/2018	26.3-26.8′	ND/<0.16	ND/<0.19

B2018-07S

Sample Date	Depth	PFOS	PFOA
5/8/2018	0.1-0.6′	0.31	0.17
5/8/2018	4-4.5′	ND/<0.24	ND/<0.1
5/8/2018	11-11.5′	ND/<0.23	ND/<0.1

B2018-05S

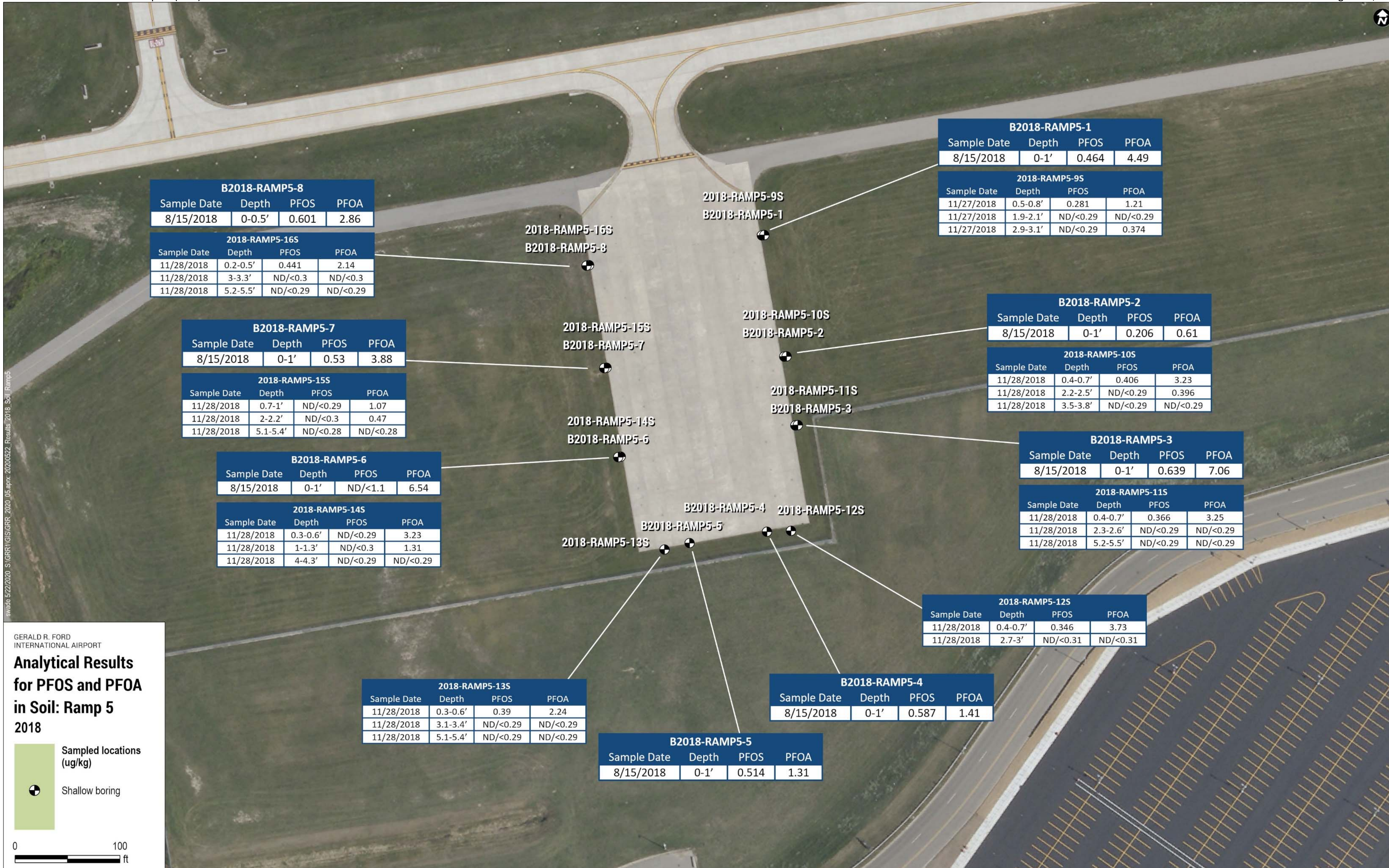
Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6′	17	0.61
5/9/2018	2.7-3.2′	ND/<0.22	0.36
5/9/2018	6.7-7.2′	ND/<0.24	ND/<0.1

B2018-10S

Sample Date	Depth	PFOS	PFOA
5/9/2018	0.1-0.6′	1400	14
5/9/2018	2.7-3.2′	10	0.73
5/9/2018	5.9-6.4′	19	0.41

Figure 2. Previous FFTA Soil Results.

Figure 3. Previous ARFF Soil Results.



B2018-RAMP5-1

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.464	4.49

2018-RAMP5-9S

Sample Date	Depth	PFOS	PFOA
11/27/2018	0.5-0.8′	0.281	1.21
11/27/2018	1.9-2.1′	ND/<0.29	ND/<0.29
11/27/2018	2.9-3.1′	ND/<0.29	0.374

B2018-RAMP5-8

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-0.5′	0.601	2.86

2018-RAMP5-16S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.2-0.5′	0.441	2.14
11/28/2018	3-3.3′	ND/<0.3	ND/<0.3
11/28/2018	5.2-5.5′	ND/<0.29	ND/<0.29

B2018-RAMP5-2

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.206	0.61

2018-RAMP5-10S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.4-0.7′	0.406	3.23
11/28/2018	2.2-2.5′	ND/<0.29	0.396
11/28/2018	3.5-3.8′	ND/<0.29	ND/<0.29

B2018-RAMP5-7

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.53	3.88

2018-RAMP5-15S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.7-1′	ND/<0.29	1.07
11/28/2018	2-2.2′	ND/<0.3	0.47
11/28/2018	5.1-5.4′	ND/<0.28	ND/<0.28

B2018-RAMP5-3

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.639	7.06

2018-RAMP5-11S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.4-0.7′	0.366	3.25
11/28/2018	2.3-2.6′	ND/<0.29	ND/<0.29
11/28/2018	5.2-5.5′	ND/<0.29	ND/<0.29

B2018-RAMP5-6

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	ND/<1.1	6.54

2018-RAMP5-14S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.3-0.6′	ND/<0.29	3.23
11/28/2018	1-1.3′	ND/<0.3	1.31
11/28/2018	4-4.3′	ND/<0.29	ND/<0.29

2018-RAMP5-12S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.4-0.7′	0.346	3.73
11/28/2018	2.7-3′	ND/<0.31	ND/<0.31

2018-RAMP5-13S

Sample Date	Depth	PFOS	PFOA
11/28/2018	0.3-0.6′	0.39	2.24
11/28/2018	3.1-3.4′	ND/<0.29	ND/<0.29
11/28/2018	5.1-5.4′	ND/<0.29	ND/<0.29

B2018-RAMP5-4

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.587	1.41

B2018-RAMP5-5

Sample Date	Depth	PFOS	PFOA
8/15/2018	0-1′	0.514	1.31

Figure 4. Previous Ramp 5 Soil Results.

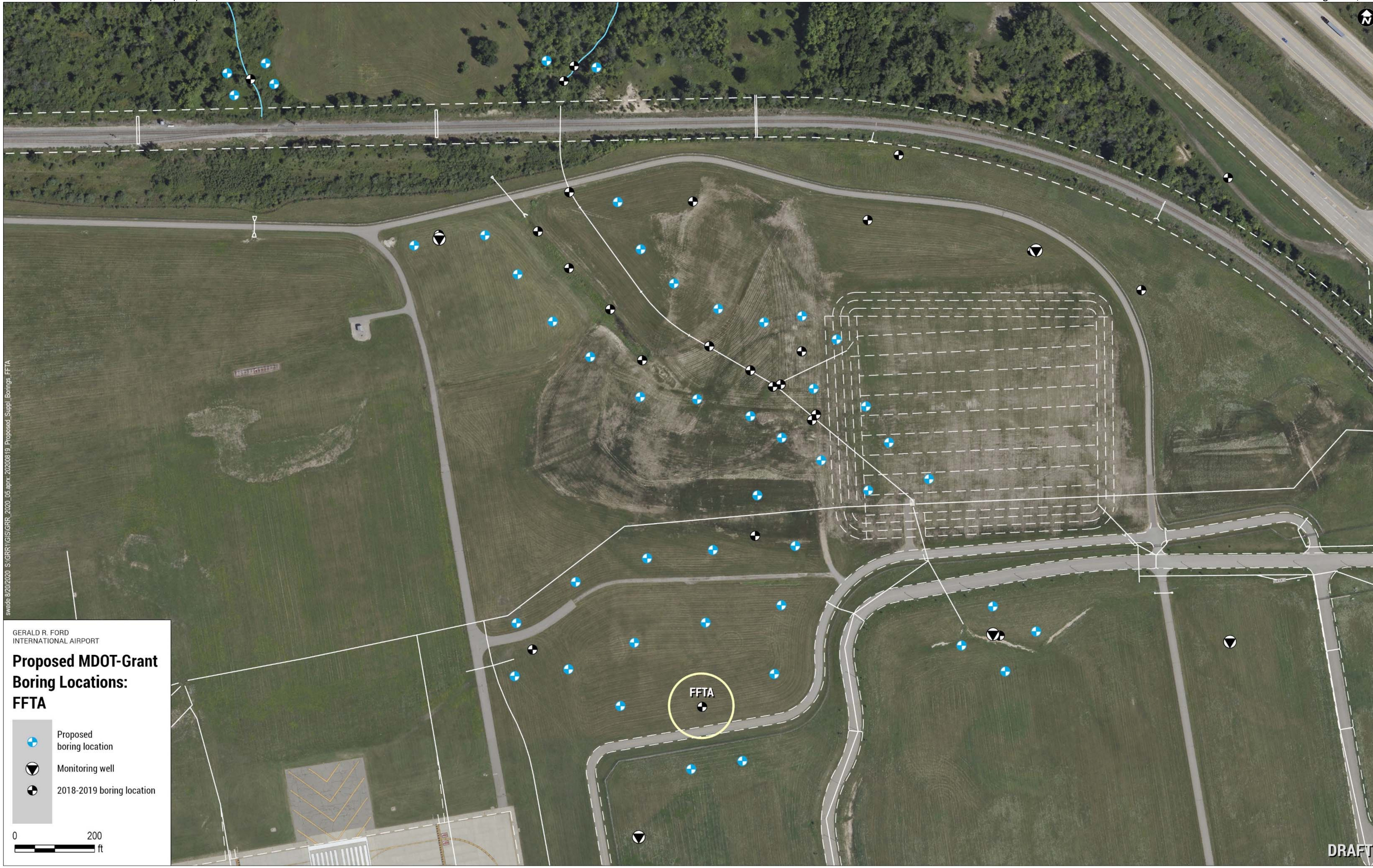


Figure 5. FFTA Boring Locations.

Figure 6. ARFF Boring Locations.

Figure 7. Ramp 5 Boring Locations.

APPENDIX A
Standard Operating Procedures

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I. INTRODUCTION

This standard operating procedure (SOP) is applicable to the collection of representative samples for analysis of per- and polyfluoroalkyl substances (PFAS; also referred to as and subsets of perfluorinated chemicals (PFCs)). The procedures described are intended to be applicable to most environmental media and sampling methods, although they were developed with an emphasis on water samples (e.g., drinking water, ground water, surface water). These typically applicable procedures have been adapted from a number of sources and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations, as long as the goal of collecting representative samples is maintained. The actual procedures used should be documented in the field notes, especially if changes are made. This SOP is designed to be used in conjunction with another SOP that describes the specific sampling methods for a specific environmental medium.

PFAS are a large group of chemicals used in many consumer, commercial, and industrial products and processes, and include water-, stain-, and oil-repelling coatings and fire-fighting foams. Some chemicals in this group (e.g., perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA)) have been identified as persistent, bioaccumulative, and toxic chemicals. PFOS, PFOA, and their known precursors were largely phased out in the United States in the mid-2000s and early 2010s. Sample analytical reporting for PFAS analytes is usually at very low concentrations (parts per trillion, ppt), which can exacerbate problems with cross-contamination of samples.

There are two primary interferences or potential problems with representative sampling. These include cross contamination of samples and improper sample collection. Following proper decontamination procedures and minimizing disturbance of the sample site will minimize these problems as follows:

- Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment for each location. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Equipment Cleaning SOP.
- Conduct sampling beginning in areas of known or suspected lowest concentrations and progressing to areas of highest concentrations.
- Improper sample collection can involve using contaminated equipment, disturbance of stream or impoundment substrate, and sampling in an obviously disturbed area.

To collect a representative sample, the hydrology and morphometrics of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sampling locations and depths. In addition, water quality indicator data may be collected, if necessary, in water bodies to determine if stratification is present. Measurements such as dissolved oxygen, pH, temperature, and redox potential can indicate if strata exist which would affect analytical results.

II. MATERIALS

A wide range of products commonly used in site investigations are known or suspected to contain PFAS. It is critical that the sampling program design consider as many sources of PFAS contamination as practicable to minimize cross contamination during a sampling event. All field equipment, supplies, materials and personnel clothing used during sampling operations shall be PFAS free as noted below and in Tables 1 and 2.

- All sampling, monitoring and drilling equipment (e.g., field filters, tubing, pumps, lubricants, packers, transducers, liners, O-rings, pipe-thread pastes, tapes, sealants, valves, and wiring) must be constructed of materials that are free from the following:
  a) Polytetrafluoroethylene (PTFE), trademark Teflon®;
  b) Ethylene tetrafluoroethylene (ETFE), trademark Tefzel®;
  c) Polyvinylidene fluoride (PVDF), trademark Kynar®;
  d) Fluorinated ethylene propylene (FEP), trademark Neoflon®.
- Personal protective equipment, clothing, and hygiene products should be free of PFAS (e.g., fluoropolymer linings used on Tyvek, Nomex, and Viton materials, GoreTex linings, water resistant/waterproof/stain resistant treatments, sunblock, insect repellants, cosmetics/hand creams, food packaging protective of water and grease).
- Sample containers should be polypropylene or HDPE and/or as specified/provided by the laboratory; do not use glass to avoid analyte adsorption.
- Sample transfer to the laboratory should be conducted at 4ºC ± 2ºC or as specified by the laboratory using ice in double-bagged polyethylene plastic; do not use chemical- or gel-based cooling products.
- Use only laboratory-supplied PFAS-free water for preparation of field reagent blanks and equipment blanks.
- Water from any other sources, including public water supplies, used for any other purposes must be pre-determined to be PFAS-free.
- Deionized (DI) water will not be used to clean equipment due to the possible contamination from polytetrafluoroethylene material used in the DI water purification system.

III. PREPARATIONS

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider sample volume, depth, deployment circumstances (shore, wading, boat, currents), type of sample, sampler composition materials, and analyses to be conducted.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.
- If collecting sediment or near-shore soil samples, develop procedures that will eliminate interferences with collection of representative water samples.
- The field team leader will work with field personnel to assure compliance with PFAS-free guidelines (see Table 1) prior to commencement of field activities. Table 2 provides a list of prohibited and acceptable items for a PFAS field investigation. Daily compliance inspections will be conducted prior to beginning field

activities. Corrective action will include removal of noncompliance items or workers from the site until in compliance.

IV. GENERAL SAMPLE COLLECTION PROCEDURES

1. Record pertinent data on the field log (see attached Surface Water Sampling Field Log, or equivalent).
2. Label all sample containers with the date, time, well number, site location, sampling personnel, and other requested information.
3. Don appropriate personal protective equipment (as required by the Health and Safety Plan).
    - Do not sample without powderless nitrile gloves.
4. Clean all sampling equipment prior to sample collection according to the procedures described in Section V.
5. Sample collection (see Tables 1 and 2 for complete lists of acceptable and unacceptable attire, materials, etc.):
    - The sample cap should never be placed directly on the ground during sampling.
    - Markers (Sharpie® or otherwise) are to be avoided.
    - Bottles should only be opened immediately prior to sampling.
    - Dust and fibers must be kept out of sample bottles.
    - Ballpoint pens may be used to label sample containers.
    - Samples should be double-bagged using resealable low density polyethylene (LDPE) bags (e.g. Ziploc®.
    - If possible, collect PFAS samples prior to collecting samples for other, non-PFAS analytes (e.g., VOCs) or field parameters (temperature, pH, etc.).
6. For samples requiring field filtering, use the appropriate PFAS-free equipment and, if possible, collect the sample directly into the sample container.
7. If field preservation is required (see SAP and/or QAPP), place appropriate preservative into the sample container prior to sample collection. Note the preservative used on the sample container and sampling log.
8. Quality control samples are normally specified and described (i.e., collection procedures, frequencies) in the work plans (SAP and/or QAPP), and for PFAS sampling they may include trip blanks, field reagent blanks, field equipment blanks, field duplicate samples, and matrix spike/matrix spike duplicate samples. These samples should be collected in the following manner:
    - Trip blanks should be prepared by the laboratory using PFAS-free water at the time sample bottleware is prepared for delivery to the field. Trip blank containers shall be of the same type of sample container as those used for investigative samples collected for PFAS analysis. A laboratory-supplied trip blank (comprised of the same sample containers, containing the same reagents, preservatives and other consumables used for investigative PFAS analysis) shall be placed in the environmental sample cooler immediately after the first sample collected for PFAS analysis is placed in the cooler. Trip blank samples shall be given a sample date and time of when the trip blank is placed in

the environmental sample cooler. Trip blank samples shall accompany investigatory sample containers collected for PFAS analysis from collection, during the duration of the sample event, and during shipment to the laboratory. At no time after preparation and prior to arriving at the laboratory shall trip blanks be opened.

- Field reagent blanks should be collected using two appropriate laboratory-supplied containers (one containing PFAS-free water and the other empty). During the sampling event, field personnel transfer the preserved PFAS-free water from one container into the other container, screw on the laboratory-supplied caps, and place the sample containers into the cooler for submittal with the samples collected that day.
- Field equipment or rinse blanks should be collected by pouring PFAS-free water through/over the decontaminated sampling device into the sample container in the field, preserved and shipped to the laboratory with the field samples. Generally, equipment blanks are only collected if reusable sampling equipment is employed.
- Field duplicate samples should be collected into two distinct sample containers at the same time or immediately following one another in accordance with procedures described in the SAP or QAPP. Each sample of a field duplicate pair employs the same type of sample container, preservatives and other additives used. If blind duplicate samples are specified, one of the duplicate samples should be labelled so that it does not identify the other sample of the duplicate pair to the laboratory. For example, one sample of the duplicate pair would be labelled following the normal protocol, while the second would be labelled with a sample ID of "DUPLICATE" and a blank line placed in the location, date and time boxes of the sample label. It is important that the duplicate pair samples are identified separately in the field notes with information including location, sample ID (as entered on the sample container label and COC), sample date and time so that analytical results can be paired after received from the laboratory.
- Matrix spike (MS) and matrix spike duplicate (MSD) samples include two additional volumes of sample material collected in the field at the same time as an investigative sample (similar to field duplicate sampling), or may be collected by the laboratory from an existing investigative sample submitted from the field.

9. Record sample collection information on the field log and store the samples in an iced cooler according to the PFAS-free guidelines described herein and in the Standard Operating Procedure for the Shipping and Handling of Samples.
10. Handle, pack, and ship samples according to the PFAS-free guidelines described herein and in Standard Operating Procedure for the Shipping and Handling of Samples.
    - Do not use chemical or blue ice.
    - Refresh with regular ice double bagged in Ziploc® bags
    - Chain of Custody should be bagged in Ziploc® storage bags and taped to the inside of the cooler lid.

- The cooler should be taped closed with a custody seal and shipped by overnight courier.

V. EQUIPMENT DECONTAMINATION

Field sampling equipment used multiple times can become contaminated with PFAS. Decontamination procedures should be implemented to prevent cross-contamination.

The following procedures must be followed:

- Do not use Decon 90®
- Laboratory supplied PFAS-free water is preferred for decontamination.
- Water from any other sources, including public water supplies, used for any other purposes must be pre-determined to be PFAS-free.
- Deionized (DI) water will not be used to clean equipment due to the possible contamination from polytetrafluoroethylene material used in the DI water purification system.
- Alconox®, Liquinox® and Citranox® can be used for equipment decontamination.
- Sampling equipment can be scrubbed using a polyethylene or PVC brush to remove particulates.
- Decontaminated sampling equipment should be triple rinsed using PFAS-free water.

VI. EQUIPMENT-SPECIFIC SAMPLE COLLECTION PROCEDURES

See appropriate equipment- and medium-specific sample collection SOP and/or sampling equipment operation manual, as specified in the SAP or QAPP.

Table 1. PFAS-Free Guidelines.

PFAS-Free Guidelines (source: USEPA, DoD and ITRC)
Field Clothing and PPE: (see reference at bottom for acceptable products)
No clothing or boots containing Gore-Tex™
All safety boots made from polyurethane and PVC
No materials containing Tyvek®
Field crew has not used fabric softener on clothing
Field crew has not used cosmetics, moisturizers, hand cream, or other related products this morning
Field crew has not applied unauthorized sunscreen or insect repellant
Field Equipment:
No Teflon® or LDPE containing materials on-site
All sample materials made from stainless steel, HDPE, acetate, silicon, or polypropylene
No waterproof field books on-site
No plastic clipboards, binders, or spiral hard cover notebooks on-site
No adhesives (Post-It Notes) on-site
No Sharpies and permanent markers allowed; regular ball point pens are acceptable
No aluminum foil allowed
Keep PFAS samples in separate cooler, away from sampling containers that may contain PFAS
Coolers filled with regular ice only. No chemical (blue) ice packs in possession
Sample Containers:
All sample containers made of HDPE or polypropylene
Caps are unlined and made of HDPE or polypropylene
Wet Weather Gear:
Wet weather gear made of polyurethane and PVC only
Equipment Decontamination:
"PFC-free" water on-site for decontamination of sample equipment. No other water sources to be used.
Only Alconox and Liquinox to be used as decontamination materials
Food Considerations:
No food or drink on-site with exception of bottled water and/or hydration drinks (e.g., Gatorade, Powerade) that is available for consumption only in the staging area
Reference-NHDES https://www.des.nh.gov/organization/divisions/waste/hwrb/documents/pfc-stakeholder-notification-20161122.pdf

Table 2. Prohibited and Acceptable Items for Perfluorinated Compound (PFC) Field Investigations.

PPE, Clothing, Hygiene Products	PFC Concerns	Approved Alternative
Steel-toed boots	Boots may not contain Gore-Tex. Many waterproof boots are lined with Gore-Tex and are prohibited.	Steel-toed boots made with polyurethane and polyvinyl chloride (PVC)
Clothing	Water resistant, waterproof, or stain-treated clothing should be avoided. (EDQW 2016)	Clothing made of synthetic or natural fibers should be worn. Non-new cotton is preferred. Field gear should be laundered a minimum of six times prior to use, avoiding use of fabric softeners. Cotton overalls may be provided for use.
Rain Gear	Most rain gear is coated with a Gore-Tex lining and contains fluoropolymers.	Rain gear made from polyurethane and wax-coated materials may be worn (U.S. Navy 2015; EDWQ 2016).
Gloves	Nitrile gloves are specified for use in EPA Method 537.	Only nitrile gloves should be used. These should be changed often as outlined in EDQW 2016. Recommended powderless nitrile gloves.
Protective clothing	Fluoropolymer linings are used on Tyvek, Nomex, and Viton materials (U.S. Navy 2015; EDWQ 2016)	Avoid these materials. Select alternative protective clothing that does not contain fluoropolymers.
Sunblock and insect repellant	Many manufactured sunblocks and repellants contain PFCs.	Avoid use. If necessary, use of a 100% natural ingredient product may be used upon approval.
Cosmetics, moisturizers, hand creams, etc.	Many of these products contain surfactants and represent a potential source for PFCs.	Use of these products should be avoided prior to a sampling event. Acceptable products may include: ***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
Food and drink	Food packaging often contains PFCs as a protectant from water and grease.	No food or drink shall be brought on-site, except for bottled water and hydration drinks. No blue ice packs should be used. Additionally, hands should be thoroughly washed following consumption of any wrapped fast food or pizza.

General Sampling Equipment and Field Supplies	Approved Alternative
Standard decontamination water or municipal water	Water from a known source that has been analyzed for PFCs and has been determined to be acceptable for the specific sampling program.
Decon 90 detergent	Alconox and Liquinox are the only detergents approved for decontamination (EDQW 2016)
Glass or Teflon-lined sampling bottles and lids	Polypropylene or high-density polyethylene (HDPE) sample bottles with an unlined polypropylene HDPE screw cap
Fluoropolymer tubing, valves, and other parts in pumps	HDPE and silicon materials (EDQW 2016)
Teflon tubing, bailers, tape, and plumbing paste	HDPE and silicon materials or disposable equipment
Pumps, packers, transducers, tubing, liners, valves, and wiring with polytetrafluoroethylene or ethylene tetrafluoroethylene	Alternative materials
LDPE HydraSleeves	HDPE HydraSleeves (EDQW 2016)
Aluminum foil	Thin HDPE sheeting
Markers and waterproof pens	Non-waterproof pens (EDQW 2016)
Rite-in-the-rain paper, binders, and plastic clipboards	All field paperwork should be printed on standard paper and placed in a non-water-resistant folder or aluminum clipboard (EDQW 2016)
Post-It Notes	No Post-It Notes should be brought to the site
Chemical (blue) ice packs	Only regular ice should be used for refrigeration on site (EDQW 2016)

Table 2 References

Source Document - Groundwater and PFAS: State of Knowledge and Practice, Section 5: Field Sampling and Analysis, National Groundwater Association Press, 2017 – Draft Copy Not NGWA Board-approved, Not for circulation.

EDQW 2016. Bottle Selection and Other Sampling Considerations When Sampling for Per- and Poly-Fluoroalkyl Substances (PFAS). Revision 1.1.

U.S. Navy 2015a. Perfluorinated Compounds (PFCs) Interim Guidance/Frequently Asked Questions (FAQs). Memorandum from Commander, Naval Facilities Engineering Command, January 29, 2015.

U.S. Navy 2015b. Bureau of Medicine and Surgery, 2015. Testing for Perfluorochemicals (PFCs) in Drinking Water. Memorandum for Commander, Navy Medicine East.

SAMPLE COLLECTION FIELD LOG

Project Name:_______________Project Code:__________Page __ of __

Date	Time	Sample ID	Sample Location	Equipment Used	Samplers	Comments (sample volumes, preservatives, descriptions, weather conditions, other observations, etc.)

Notes:

I. INTRODUCTION

Equipment cleaning areas will be located within or adjacent to a specific work area or as specified in the Health and Safety Plan. The equipment cleaning procedures described in this document include pre-field, in-field, and post-field cleaning of sampling equipment. The sampling equipment consists of soil sampling devices, well construction materials, ground-water sampling devices, water testing instruments, and other activity-specific sampling equipment. All non-disposable sampling equipment will be cleaned after completion of each sampling event. If appropriate, cleaning procedures will be monitored through the analysis of rinse blank samples as described in the project work plan or QAPP. **NOTE: If field activities involve per- and polyfluoroalkyl substances (PFASs) such as PFOS or PFOA, refer to the PFAS sampling SOP for additional measures which supersede this SOP.**

II. MATERIALS

The following materials will be available during equipment cleaning, as needed:

- Personal protection equipment (as required in the Health and Safety Plan);
- Distilled/de-ionized water;
- Non-phosphate detergent (Alconox, Liquinox, or equivalent);
- Tap water;
- Appropriate cleaning solvent (e.g., methanol, hexane, nitric acid);
- High-pressure hot water/steam cleaning unit;
- Wash basins;
- Brushes;
- Polyethylene sheeting;
- Aluminum foil;
- Plastic overpack drum, storage tub, or other suitable storage unit (for bladder or other pumps);
- Large heavy-duty garbage bags;
- Spray bottles (to hold tap water, distilled/de-ionized water, methanol, hexane, or nitric acid); and
- Disposable and/or heavy-duty reusable (PVC, latex or nitrile) gloves.

III. STORAGE OF EQUIPMENT

All cleaned sampling equipment will be stored in a clean environment and, where appropriate, the equipment will be covered/sealed with aluminum foil.

IV. SAFETY PROCEDURES DURING EQUIPMENT CLEANING

1. Personnel will wear the following personal protection equipment at a minimum, when cleaning sampling equipment (e.g., split-spoon sampler, trowels) and larger equipment (e.g., drill rig, augers):

- Safety glasses, goggles, or a splash shield; and
- PVC, latex, or nitrile outer gloves,
- Coated Tyvek® or Saranex® disposable coveralls or rainsuit, optional for small equipment cleaning; and
- Chemical resistant over boots, optional for small equipment cleaning.

2. All solvent rinsing if required, will be conducted in an adequately ventilated area.

3. All solvents transported into the field will be stored and packaged in

appropriate containers with care taken to avoid exposure to extreme heat.

4. Handling of solvents will be consistent with the manufacturer's Material Safety Data Sheets (MSDS).

V. FIELD CLEANING PROCEDURES

A. Cleaning Station

A designated field equipment cleaning station location will be established to conduct all cleaning at each work area of the Site. The field equipment cleaning station will be located away from the immediate work area to minimize adverse impacts from work activities on the cleaning procedures, but close enough so the sampling teams can minimize equipment handling and transport. All heavy equipment such as drill rigs and backhoes will receive an initial cleaning prior to use at the Site and will be cleaned again before leaving the site. The frequency of any additional cleaning will depend on the amount of use the heavy equipment receives and the extent of exposure to dirt and contaminants during the sampling event.

B. Cleaning of Smaller Sampling Equipment

Cleaning of smaller sampling equipment (e.g., split-spoon samplers, bailers, trowels) will be conducted according to the following sequential procedure:

- ♦ Non-phosphate detergent (Alconox, Liquinox, or equivalent) and tap water wash;
- ♦ Tap water rinse;
- ♦ Solvent rinse, if required (e.g., methanol or hexane for organic constituent analysis, nitric acid for inorganic constituent analysis); and
- ♦ Triple distilled/de-ionized water rinse.

The first step in decontamination is physical removal, where gross contaminants such as dust, soils and sediments can be removed through physical means such as wiping, scraping, shaking, and in some cases steam cleaning. Non-phosphate detergent and tap water scrub is intended to remove all visible particulate matter, residual oil and grease, and most but not all contaminants. Surfactants or detergents accumulate at the water to gas, solid, and oils interface, break the adhesive forces between the contaminant and the surface being cleaned, making the contaminants more soluble, allowing the contaminants to be washed away. The tap water rinse is necessary to remove all soapy residues and wash away loosened contaminants. The need for a specific solvent used for the solvent rinse, if required in the work plan or QAPP, will depend upon what the sample will be analyzed for and what contaminants are expected to be present. Some contaminants such as PCBs adhere to surfaces so tightly that a methanol or hexane rinse is required to break the adhesive bonds and adequately decontaminate the sampling equipment. Caution should be used when using solvent rinses to make sure that the chosen solvent is compatible with the sampling equipment and any PPE it will be used upon. It should be noted that most PPE constructed of organic materials could be damaged or dissolved by organic solvents such as alcohols, ethers, ketones, aromatics, straight chain alkanes and common petroleum products. The final rinse of distilled/de-ionized water will be repeated three times. Rinsing removes any remaining contaminants through dilution, physical attraction, and solubilization.

The equipment will then be allowed to air dry.

C. Cleaning of Submersible Pumps

Submersible pumps may be used to evacuate stagnant groundwater from the well casing (e.g., air lift or turbine pumps) or to collect samples (e.g., bladder pump). The pumps will be cleaned and flushed between wells using an external detergent wash and tap water rinse. Steam cleaning may be substituted for pump casing, hose, and cables followed by a flushing with potable water through the pump and tubing or discharge hose. The cleaning process for development and purge pumps can be performed by pumping potable water from a clean plastic over-pack, drum or storage tub until a sufficient amount of water has been flushed through the system. The decontamination process for sampling pumps will consist of filling each of three clean suitable decontamination units sequentially with detergent water, tap water, and distilled/de-ionized water. Placing the sampling pump into each respective decontamination unit and pumping sufficient liquid from each unit through the sampling pump chamber and tubing if appropriate, to flush out any contaminants. It is recommended that disposable tubing be used whenever possible, thus reducing the amount of equipment and time needed for decontamination. In some cases the chosen sampling pump (e.g. QED Micro Purge bladder pump) can easily be disassembled, decontaminated as individual small parts, disposable parts such as bladders and grab plates replaced and them reassembled for use. Such a pump, if appropriate for your sampling situation, would save time when cleaning and provide a more thorough decontamination, since all surfaces of the pump in which sample water has contact can be inspected, cleaned or replaced. If electric power pumps are used, care should be taken to avoid contact with the pump, well casing, pump reel and sample or purge water in direct contact with the pump, while the pump is running to avoid electric shock.

D. Cleaning of Heavy Equipment

Other equipment and materials, such as drill rigs, well casings, tools, and auger flights, associated with sampling events, will be cleaned prior to use. This equipment may retain chemical constituents from sources unrelated to the sampling site such as roadways, storage areas, or material from previous job sites that were not adequately removed. Heavy equipment will be thoroughly steam cleaned and/or manually scrubbed and rinsed upon arrival on site and when moved between sampling locations, as necessary. Drill rig items such as auger flights, wrenches, drill rods, and drill bits will also be cleaned before changing sample locations.

E. Collection and Disposal of used Solvents, Residuals and Rinse Solutions

All solvents, residuals, and rinse waters generated during the cleaning of equipment on-site will be collected, containerized, and stored on-site until arrangements can be made for proper disposal.

I. INTRODUCTION

Documentation of observations, conditions and generated data during field activities is an accepted scientific procedure and a critical component of any investigation. The rigorous documentation methods described in this SOP may be changed, as necessary, depending upon the needs of any particular investigation. Review the project work plans for any specific field documentation guidance. If changes are made to this SOP, document those changes in the field notes.

II. METHODOLOGY

1. Use a new bound logbook for each project.
2. Label logbook cover and binding with project name and code. Label inside cover with site information (name, address, contact(s), phone numbers, etc.). This will serve as a reference when performing fieldwork.
3. Number each page of the logbook sequentially.
4. All entries must be made in indelible ink (black is preferred because it copies well).
5. All corrections or changes should be initialized, dated and marked with a circled error code. Any mistakes should be drawn through with a single line. Commonly error codes that may be used include: RE Recording Error, CE Calculation Error, SE Spelling Error, CL Changed for Clarity, WO Write Over.
6. All entries should be accurate, factual, and unbiased. Never record an opinion.
7. Notes should be detailed but concise.
8. Notes should be written such that the day's activities can be reconstructed at a later date.
9. Date the beginning of each day's notes.
10. Use the 24-hour time format throughout the notes.
11. Complete each day's notes with your signature.
12. Maximize use of each line, crossing out gaps and blank pages so notes cannot be altered.
13. Reference in the logbook when using other forms (e.g., boring logs, sampling forms, etc.).
14. Return logbook to project manager upon completion of fieldwork.

III. MATERIALS

The materials required for this SOP include the following:

- Bound field logbook(s).
- Field forms.
- Black waterproof/indelible ink pen(s).

IV. ITEMS TO INCLUDE IN A LOGBOOK

Field activities can vary widely. Entries in field logbooks will describe activities conducted and may include, but are not limited to, the following:

- Times of arrival and departure for ALL site personnel.
- Personnel on-site and affiliation (LTI and subcontractor, regulatory personnel, visitors/guests, and uninvited intruders).
- List of equipment used on-site (LTI and subcontractor).
- Detailed descriptions of daily activities.
- Locations of structures, features, utilities, etc.
- Conversations with client, contractor, regulatory agencies, office (changes to scope of work, health and safety

issues, and cost/payment issues are especially important).

- ♦ Weather conditions.
- ♦ Documentation of field instrument calibration.
- ♦ Documentation that photos were taken (include date/time of photo, photographer, site name/location, description of photo subject, compass direction taken, photo number).
- ♦ Sample collection and field measurement information including: sample location, description, date/time, methodology, container types, preservatives, instrument type/serial number (reference applicable field form, if applicable).
- ♦ Wastes generated (containers, volumes, matrix, storage locations).
- ♦ Materials used (e.g., water sources, well materials, field reagents, construction materials).
- ♦ Deviations from intended scope of work.
- ♦ Deviations from SOPs if not already indicated in the work plan.

15. Keep notes legible so others can read the logbook.

A bound logbook is the legal documentation of fieldwork performed at a site. Always remember that your notes may be used in litigation.

I. SURFACE/SHALLOW SOIL SAMPLING

A. Introduction

Surface and shallow soil samples will be collected using a hand-driven split-spoon sampler or shelby tube, a stainless steel bucket auger, or a trowel and scoop as determined by the field supervisor depending on the subsurface material. Hand borings will be performed in areas where truck-mounted rigs are unable to gain access. Samples of subsurface material encountered during this operation will be collected at predetermined depth intervals for soils, sediments, and remnant deposit materials, if encountered and as specified in the work plan. **NOTE: If field activities involve per- and polyfluoroalkyl substances (PFASs) such as PFOS or PFOA, refer to the PFAS sampling SOP for additional measures which supersede this SOP.**

B. Materials

The following materials, as required, will be available during surface/shallow soil sampling:

- Personal protective equipment as required by the Health and Safety Plan;
- Cleaning equipment as required in Appendix B;
- Aluminum foil;
- Photo Ionization Detector (PID), if potential for volatile compounds exists;
- Field log;
- Appropriate sample containers and forms;
- Insulated coolers with cold packs or ice;
- Concrete saws, or coring devices;
- Sampling devices (e.g., split-spoon, shelby tube, stainless steel bucket auger, stainless steel scoop or trowel);
- Sampling device extension rods, handle, or hammer-driver;
- Stainless steel spatula, lab spoon, or equivalent (new wooden tongue depressors may also be used); and
- Liners for sampling devices (e.g., brass, stainless steel, Teflon, or butyrate plastic).

Photo 1: Typical hand-driven soil sampling tube.

C. Procedures

The following procedures will be employed to collect surface/shallow samples:

1. Check for utilities in the work area. When working in Michigan, call Miss Dig Utility Locating Service at (800) 482-7171, 48-hours prior to the start of work. Do not proceed until you are confident there is no danger of impacting buried utilities.
2. Don personal protective equipment as required by the Health and Safety Plan.
3. For surface/near surface soil sampling:
   a. Carefully remove the top layer of soil to the specified depth, if required, using a precleaned stainless steel scoop or trowel.
   b. Remove and discard a thin layer of soil from where the sample will be collected using a clean stainless steel scoop or trowel.

c. Carefully remove the desired, representative sample with a precleaned stainless steel spatula, labspoon or equivalent.

4. For shallow subsurface soil sampling:
   a. Hand bore down to the specified depth using a precleaned bucket auger.
   b. Carefully insert a precleaned stainless steel split spoon sampler, shelby tube, or bucket auger to the bottom of the borehole and drive into the soil in a straight and vertical manner to secure a reasonably representative sample.
   c. Remove the sampler and place on a piece of aluminum foil to avoid contact with surrounding soils.
   d. Remove all excess soil from the outside of the sampling device to avoid cross contamination over the sample depth.
   e. Discard the upper 1"-2" of soil in the sampling device to avoid including borehole cave-in or carry down with the sample
5. Place the sample in the appropriate sample container.
6. Record all appropriate information in the field log.
7. Label, handle, pack, and ship the samples consistent with the procedures in the Standard Operating Procedure for Shipping and Handling of Samples.
8. Fill the sampling hole, as required by the work plan, with the discarded soils, bentonite chips, bentonite slurry, or bentonite/portland cement grout.

Photo 2: Typical bucket auger.

II. SOIL BORING SAMPLING

A. Introduction

Soil borings will be completed using the hollow-stem auger drilling method or the Geoprobe method (a hammer-driven hydraulic push probe) to a depth specified by the supervising geologist/engineer. In situations where physical site features limit the use of drill rigs, soil borings will be completed with a hand driven auger, a portable power auger, or a tripod and split-barrel sampler (split-spoon) depending on the required depth and subsurface material.

Samples of subsurface material encountered during the drilling of soil borings will be collected at regular intervals, not to exceed five feet, to the required depth of the boring, or as directed by the supervising geologist. The sampling method employed will be consistent with the American Society of Testing and Materials (ASTM) D1586 - Standard Method for Penetration Test and Split-Barrel Sampling of Soils or ASTM D4700 - Soil Sampling from the Vadose Zone. Relatively undisturbed samples will be collected for geotechnical evaluation, if required, using ASTM D1587 - Thin-walled Tube Sampling of Soils or ASTM D4700.

Upon completion of the boring, if a monitoring well is not to be installed, the bore hole will be backfilled to the surface, as required by the work plan, with soil cuttings, bentonite chips, bentonite slurry, or bentonite/portland cement grout, and the ground surface will be restored.

B. Materials

The following materials shall be available during soil boring sampling:

- Personal protective equipment as required by the Health and Safety Plan;
- Cleaning materials as required in the Standard Operating Procedure for Cleaning Equipment;
- Pre-cleaned drill rig, drill rods, auger flights, probe tubing and samplers;
- Appropriate sample containers and forms;
- Liners for sampling devices, if required;
- Insulated coolers with cold packs or ice;
- D.O.T.-approved drums for the containerization of soil cuttings; and
- Field log.

C. Procedures

1. Check for overhead and underground utilities in the work area. When working in Michigan, call Miss Dig Utility Locating Service at (800) 482-7171, 48-hours prior to the start of work. Do not proceed until you are confident there is no danger of impacting buried utilities.
2. Soil samples will typically be collected at 4 or 5 foot intervals, or as required to provide a profile of the subsurface. A geologist or other qualified person will be on-site during the drilling operations to visually inspect and describe each soil sample and/or drill cuttings. The soil descriptions will be recorded on a standard subsurface log and will include the following information, as appropriate or as specified by the supervising geologist.

- soil type;
- color;
- percent recovery;
- relative moisture content;
- texture;
- grain size and shape;
- consistency;
- standard penetration blow counts, if applicable;
- depth to water tables; and
- any other noteworthy observations.

3. Upon retrieval of sampling device, representative portions of the sample will be placed in appropriate sample containers (taking care to exclude the top 1-2 inches which may consist of cave-in or carry-down material from shallower depths in the borehole).
4. If required, one representative portion of each sample will be placed in a clean jar, covered with aluminum foil, and let stand for several minutes. The head space will then be screened with a photoionization detector (PID) or equivalent field instrument and the relative concentration of total volatile organic compounds (VOCs) in the sample will be recorded on the boring log.
5. Sample containers will be labeled, temporarily stored on site, and transported to the appropriate testing laboratory at the end of the day, whenever possible. The samples will be handled, packed, and shipped in accordance with the procedures set forth in Appendix A.
6. The supervising geologist will be responsible for documenting drilling events in the field log.
7. The drilling contractor will be responsible for obtaining accurate and representative samples and informing the supervising geologist of changes in drilling pressure and keeping a separate

subsurface log of soils encountered, including blow counts [i.e., the number of blows form a soil sampling drive weight (140 pounds) required to drive the split-spoon sampler in 6-inch increments], where applicable.

Photo 3: Geoprobe liner cut open to reveal soil sample. Samples are extracted using clean utensils or gloves from core into appropriate sample containers.

III. METHANOL PRESERVATION FOR VOC SAMPLES

A. Introduction

The sampling and analysis of soils for volatile organic compounds (VOCs) presents unique challenges because exposure of the soil to the atmosphere facilitates volatilization and biodegradation of some compounds. Soil samples to be analyzed for VOCs shall be;

1. Preserved with methanol prior to transport to a lab.
2. Be sampled using an approved "Encore" sampler. Note that these samples have a shorter hold time and are not universally approved for use. Refer to manufacturer's instructions for sampling procedure.

Photo 4: Encore Sampler and "T" handle.

B. Materials

The following materials shall be available during methanol preservation of soil samples:

- Personal protective equipment as required by the Health and Safety Plan;
- Pre-weighed, 40-ml vials containing methanol, (usually provided by laboratory conducting analysis);
- Empty sample containers for dry weight analysis (usually 4 oz. jars)
- Syringe sampler w/plunger or other sampling device which facilitates the measurement of a precise amount of soil, (usually provided by the laboratory conducting analysis);
- Digital scale able to measure grams to the hundredth (if necessary);
- Cooler with ice and packing materials
- Chain of custody forms

C. Procedures

Unless instructed otherwise, use an approximate one-to-one ratio of soil weight to methanol volume for proper preservation. A general guideline is 10 ml of methanol to 10 grams of soil.

Exact procedures for methanol preservation of soil samples will vary based on specific laboratory requirements and/or instructions. Consult laboratory prior to collecting samples:

1. Obtain soil sample as described in previous section. Use a PID (photo ionization detector) to determine the layer (if multiple layers are present) most likely to contain VOCs. In lieu of data from the PID, refer to sampling guidance from the project manager.
2. Place empty syringe sampler on scale and tare so weight reads zero grams.
3. Push syringe sampler into soil and extract. Twisting may be necessary while extracting to keep soil inside syringe sampler.
4. Weigh syringe with soil inside, adding or subtracting soil and re-weighing to achieve 10 grams (or other lab-specified sample quantity).
5. Immediately add soil to sample vial containing methanol and seal tightly. Avoid over tightening, as this can cause methanol leakage. Swirl sample gently for 10 seconds.
6. Fill dry weight container with soil from sample area. Appropriately label, cushion, and place both containers in a Ziploc bag incase breakage occurs during shipment.

Photo 5: Typical methanol preservation kit.

D. Shipping Guidelines

The shipping of methanol is regulated by the U.S. Department of Transportation, Title 49 of the Code of Federal Regulations. The DOT number is UN 1230. The amount of methanol used for sample preservation falls under the exemption for small quantities. Requirements for shipment of samples by common carrier (such as FedEx) are as follows;

- maximum volume of methanol in a sample container cannot exceed 30 ml;
- the sample container cannot be full of methanol;
- sufficient absorbent material must be used to completely absorb sample content;
- each cooler shipped must have less than 500ml of methanol
- the cooler or package weight must not exceed 64 pounds

- each cooler must be identified as containing less than 500 ml methanol

IV. EQUIPMENT CLEANING

Equipment cleaning will be performed at the beginning of the sampling event and between each separate sampling location as described in Standard Operating Procedure for Cleaning Equipment.

V. DISPOSAL METHODS

Personal protective equipment, such as gloves, disposable clothing, and the disposable equipment resulting from personnel cleaning procedures and soil sampling and handling activities will be placed in plastic bags. These bags may be transferred into appropriately labeled 55-gallon drums for appropriate disposal as necessary.

Sample Sub-Surface Log

Site							Project	By	Date	Page ____of____
ID/Location/Notes										
Depth feet/inch/___	Sample Type	Resistance (Blowcount)	Recovery (inches)	PID/GC Units____	Moisture Content	Lithologic Description	Notes			
0										
Completion Depth						Depth to Saturation				

P = Physical sample; A = Analytical sample; NSR = No Sample Recovery; SS = Split Spoon; HA = Hand Auger