Revised Work Plan

CSM Site Investigation: Bennington, Vermont

Prepared for
Saint-Gobain Performance Plastics

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Acronyms

Acronym	Description
ANR	Agency of Natural Resources
ASTM	American Society for Testing and Materials
bgs	below ground surface
CAA	Corrective Action Area
CSM	Conceptual Site Model
DQA	Data Quality Assessment
ELLE	Eurofins Lancaster Laboratories Environmental
EPA	United States Environmental Protection Agency
MNA	Monitored Natural Attenuation
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
PFC	Perfluorochemical
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
ppt	parts per trillion
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
SGPP	Saint-Gobain Performance Plastics
TAL	Target Analyte List
TOP	Total Oxidizable Precursor
TCL	Target Compound List
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
VTDEC	Vermont Department of Environmental Conservation

1.0 Introduction

This Work Plan defines a scope of work to be performed on behalf of Saint-Gobain Performance Plastics (SGPP) to assess conditions in the Town of Bennington and Village of North Bennington, Vermont, for comparison to, and further investigation of, the draft Conceptual Site Model (CSM) of perfluorochemical (PFC) fate and transport developed for the area. The draft CSM has been developed from currently available site-specific data, chemical characteristics of PFCs, and modeling studies of processes relating to PFC fate and transport, as described in the draft Conceptual Modeling Report (Draft CSM Report) (Barr, 2017).

The purpose of this planned scope of work is to further develop the draft CSM, as noted above, by further characterizing the distribution of PFCs, including perfluorooctanoic acid (PFOA), in soil and groundwater across the study area. Investigations undertaken by SGPP, the Vermont Department of Environmental Conservation (VTDEC), and the U.S. Environmental Protection Agency (EPA) to date have provided PFC concentration data on the following:

- Groundwater at the former Chemfab facility on Water Street, at Bennington Landfill, and at water wells throughout the study area;
- Sewage sludge from the Bennington wastewater treatment plant;
- Surface water and sediment; and
- Surficial and shallow subsurface soils at the former Chemfab facility on Water Street and nearby areas.

Based on the available site data and modeling studies performed to date, the study area has been divided into two Corrective Action Areas (CAAs): CAA1 and CAA2. Both CAAs are shown on Figure 1. Study locations proposed in this Work Plan fall in both CAAs. Specific areas of interest in the study area include Bennington Landfill and the former Chemfab facilities on Water Street and Northside Drive (Figure 1). Study locations are proposed at Bennington Landfill for this scope of work, but not at the former Chemfab facilities because there is no property access agreement in place with the property owners at this time. Investigations at the former facilities will be proposed under separate work plans once site access is obtained. Investigation tasks at the former facilities are expected to be similar to those proposed in this Work Plan.

1.1 Proposed Investigation Tasks and Objectives

The following investigation tasks are proposed for this scope of work:

- Surficial and shallow subsurface soil sampling at shallow soil profiles;
- Soil and shallow groundwater sampling at deep soil profiles;
- Monitoring well installation, well development, and sampling at select deep soil profiles;
- Bedrock study at Bennington Landfill and surrounding areas;
- Transducer installation to monitor groundwater elevations in select existing monitoring wells and residential wells;

- Bedrock monitoring well installation, well development, and sampling near the Bennington Landfill; and
- Survey monitoring wells and deep and shallow soil profiles completed as part of this investigation.

As described above, a primary focus of this scope of work is to characterize the distribution of PFCs throughout the study area. Specific data gaps identified in the Draft CSM Report (Barr, 2017) that will be addressed by these investigation tasks include:

- Regional sampling of the upper unsaturated zone soils (O horizon and C horizon mineral zone beneath the root zone) and at depths to the water table. These data will be used to assist in verifying the air deposition model and to potentially assess the correlation between soil and groundwater PFC concentrations. Soil data will be collected in the areas where air deposition is predicted to be a potential source of PFOA concentrations above 20 parts per trillion (ppt) as well as in areas outside of the predicted deposition.

- Installation of monitoring wells at Bennington Landfill to characterize PFC concentrations upgradient and downgradient of the landfill and to verify groundwater flow directions in this area and relative to existing residential wells. These data will be used to further assess the role of the landfill as a source of PFCs to the groundwater system.

Although not specifically identified as data gaps in the CSM Report, data collected as part of these tasks will be used to:

- Identify some of the potential sources across the study area, including in areas of proposed municipal water line extensions;
- Provide information regarding background concentrations of PFCs in soil and groundwater,
- Assess hydrogeologic conditions in areas of limited or no currently available data; and
- Refine understanding of bedrock conditions across a portion of the study area.

Results of the investigation tasks will be evaluated with respect to the current CSM. The CSM will be updated as needed, to identify data gaps and to provide recommendations. The investigation tasks are detailed in the following sections, with tasks focused on Bennington Landfill discussed separately in Section 5.0.

1.2 Sampling and Analytical Methods

A summary of the planned sampling and analyses for each investigative task is provided in Table 1. The tasks will be performed in general accordance with the Quality Assurance Project Plan (QAPP; Appendix A) and Field Sampling Plan (FSP; Appendix B). All samples will be analyzed at Eurofins Lancaster Laboratories Environmental (ELLE) in Lancaster, Pennsylvania with the exception of PFC Precursors which will be analyzed by Test America in Sacramento, California.

Analytical methods are summarized in Table 2. Water samples will be analyzed for the analytes identified for each task described below using the analytical methods identified in the QAPP, including:

- **Target Contaminant List (TCL) volatile organic compounds (VOCs):** EPA Analytical Method SW-846 8260C for Water and Soil and EPA Preparation Methods 5030C (Water) and 5035A (Soil)
- **Target Analyte List (TAL) metals and cations:** EPA Analytical Methods SW-846 6010C and 6020A and EPA Preparation Methods 3005A and 3020A; EPA 9012A (**cyanide**); and EPA 7471 (**mercury**)
- **Anions:** EPA Analytical and Preparation Methods SW-846 (300.0, 300.0/353.2, and SM2320 B-1997)
- **PFCs:** EPA Method 537 Rev 1.1 Modified for Water
- **PFC Precursors:** Total Oxidizable Precursor (TOP) Assay
- **1,4-Dioxane:** EPA Method SW-846 8270C SIM with isotope dilution
- **Ammonia:** EPA 350.1
- **Orthophosphate:** SM 4500P-E
- **Total Kjeldahl nitrogen:** EPA 351.2

All soil samples will be field screened in accordance with the QAPP and analyzed for:

- **PFCs:** EPA Method 537 Rev 1.1 Modified for Soil
- **Total organic carbon (TOC):** Standard Method 5310B, modified 2000,
- **Moisture content:** Standard Method 2540G-97, and
- **pH:** EPA Method 9045D.

Soil cuttings at Bennington Landfill will be screened for waste characterization parameters prior to off-site disposal (see discussion in Section 8.3). The following analyses will be performed as part of that determination:

- **PCB homologues:** EPA Method 1668,
- **Target Analyte List (TAL) metals and cations:** EPA Analytical Methods SW-846 6010C and 6020A and EPA Preparation Methods 3005A and 3020A; EPA 7471 (**mercury**),
- **SVOCs:** EPA Method 8270D, and
- **VOCs**: EPA Method 8260C.

1.2.1 Analysis for PFC Precursors

As indicated above, use of the TOP assay is proposed for select water samples (i.e., those collected at Bennington Landfill). There are many potential sources of PFCs in landfills and these materials often include a very wide range of compounds. The most common analytical methodologies for PFCs (including EPA Method 537) measure a relatively short list of analytes. While the target analyte list varies from laboratory to laboratory, it typically consists of C4 to C12 or C14 perfluoroalkyl compounds (carboxylic acids such as perfluorooctanoic acid (PFOA) and sulfonic acids such as perfluorooctanesulfonic acid (PFOS)). These perfluoroalkyl compounds are not known to transform under environmental conditions;

however, there are potentially thousands of other PFCs (referred to as "precursors" or "precursor compounds") that can transform in the environment to the more commonly analyzed for perfluoroalkyl compounds. Due to the limited target analyte lists for PFCs, traditional lab techniques (e.g., Method 537) alone do not provide information on the total PFC mass that could potentially be present in environmental media.

To characterize the nature of a landfill as a source of PFCs, it is important to understand the total PFC mass present. The TOP assay has been developed to better estimate the total targeted and non-targeted PFC mass (Houtz and Sedlak, 2012). Samples are treated using activated hydroxyl radical oxidation that converts the precursors to their equivalent detectable perfluoroalkyl compounds. By running the analysis for the selected PFC analytes on the samples before and after oxidation, a qualitative indication of the total mass of precursors present in the environmental sample can be made. These precursors represent a potential on-going source of PFCs that may go unrecognized without the TOP assay.

2.0 Bedrock Study of Bennington Landfill Area

Due to the complex nature of bedrock across the study area, a review of bedrock conditions near Bennington Landfill is proposed as discussed below. Bedrock geology across the study area consists of Cambrian-aged carbonate and non-carbonate formations that have been folded and faulted (Kim, 2017). The deformation of these rocks by at least two orogenic events has produced a network of discontinuities and, as a result, it is expected that secondary effective porosity influences bedrock groundwater flow, velocities, and directions over small-to-intermediate spatial scales. It is likely that conditions may be further influenced by kaolinized bedrock influencing bedrock groundwater flow properties. (Kaolinized bedrock is used throughout this Work Plan to refer to altered bedrock materials that have been described as saprolite in previous studies of the Bennington Landfill area (e.g., Kim, 2017 and McLaren/Hart, 1997). The bedrock study described herein will describe the distinction between saprolite and kaolinized bedrock and provide the basis for an interpretation of kaolinized bedrock in the landfill area.)

2.1 Objectives and Rationale

The primary objective of the bedrock study is to inform siting of the proposed bedrock monitoring wells described in Section 5.2.3. The bedrock study will also refine understanding of the nature of bedrock discontinuities, weathered and competent bedrock geology, and hydrogeologic conditions in the Bennington Landfill area. Results of the bedrock study will be used to supplement the field investigation described below and to further refine the draft CSM as necessary.

As described in the Draft CSM Report (Barr, 2017), secondary porosity features in bedrock are represented by an equivalent porosity medium at the scale of the groundwater modeling performed for the study area. At the scale of the model, the equivalent porous medium interpretation allows that the discrete flow pathways are sufficiently dense that they can be represented by a porous medium rather than as individual, discrete flow conduits. The bedrock study proposed herein seeks to identify potential flow pathways at a spatial scale smaller than the study area, i.e., between Bennington Landfill and nearby residential water wells. Such pathways, if determined to exist, would be used to help site bedrock monitoring wells.

2.2 Methods

The bedrock study consists of the following scope items:

- Desktop study of published geologic literature on the bedrock setting,
- Field investigation of bedrock outcrops at and near Bennington Landfill, and
- Installation of transducers to monitor groundwater levels in select residential water wells and landfill monitoring wells completed in bedrock.

2.2.1 Desktop Study

The desktop study will consist of reviewing published available geologic and hydrogeologic literature to assess structural and hydrogeologic characteristics of bedrock beneath the landfill and surrounding area.

Sources for this review include the Vermont Geological Survey, United States Geological Survey, New England Intercollegiate Geological Conference guidebooks, professional journals, and universities, as well as pertinent reports referenced in the Remedial Investigation/Feasibility Study of Bennington Landfill (McLaren/Hart, 1997).

This study will also include desktop mapping of lineament features and trends using remote sensing geomorphic techniques, including interpretation of aerial photographs and satellite imagery of the Bennington Landfill area to identify structural features that may influence bedrock groundwater flow.

2.2.2 Bedrock Outcrop Study

Investigation of exposed bedrock in the Bennington Landfill area will include an initial field reconnaissance to target outcrops at Bennington Landfill and areas south, east, and west of the landfill. This scope includes revisiting outcrops identified in previous bedrock study and mapping efforts (e.g., McLaren/Hart, 1997 and Kim, 2017). It is anticipated that some outcrops may not be accessible due to private property access restrictions.

Once suitable outcrops are located, geologic mapping will be conducted and rock mass characteristics will be collected at each outcrop. The following field data may be collected at each outcrop:

- location (using a handheld GPS)
- representative photographs (outcrop area as well as close-up photographs showing exposed textures, structure, lithology, etc.)
- lithologic description
- collection of representative hand samples
- structural geology features including discontinuity measurements (i.e., joint, fracture, vein, fault, cleavage, and foliation), dip and dip direction (i.e., strike and dip), persistence, aperture, and spacing
- shape
- roughness
- infilling
- groundwater conditions

2.2.3 Transducer Installation

Bedrock groundwater elevations will be measured by installing data-logging pressure transducers (e.g., In-Situ Level TROLLs) in existing bedrock monitoring wells at Bennington Landfill (B-2-3, B-4-3, and B-6-3; Figure 3) and in select residential water wells near Bennington Landfill completed in bedrock. The residential water wells will be identified from candidate locations in consultation with VTDEC and well owners. Coordination with VTDEC to contact well owners and gain access for water-level monitoring is ongoing.

For residential water wells, the transducer will be hung above the well pump within a stilling pipe, open at the bottom, in order for the transducer and associated data cable to remain isolated from the pump, sensor wires, and associated piping.

All transducers will be programmed to collect synoptic groundwater level data on a uniform schedule at fixed 15-minute intervals in order to provide high-resolution water-level data during pumping, recovery, and stable conditions. The water levels recorded by the transducers will be verified by periodic manual measurements concurrent with data downloads.

Wells will be surveyed, as discussed in Section 6.0, so that the recorded water-level data can be converted to groundwater elevations for comparison between wells and to existing regional data (e.g., Kim and Dowey, 2017), enabling a refined interpretation of groundwater flow direction in bedrock near Bennington Landfill.

3.0 Shallow Soil Profiles

Soil samples collected to date (C.T. Male, 2016) have been focused on areas around and to the north of the former Chemfab facility on Water Street and limited to the uppermost two feet of the soil profile. Additional soil samples are proposed to be collected at shallow profiles across the study area. Selection of sampling locations is further discussed below.

3.1 Objectives

As described above, a primary focus of this scope of work is to further characterize the distribution of PFCs in the study area and address specific data gaps identified in the Draft CSM Report (Barr, 2017). Shallow soil profiles are anticipated to:

1) Increase spatial coverage of soil data to reveal any patterns in soil PFC concentrations across the study area.
2) Provide comparison points to assist in verifying the air deposition model of PFCs at the ground surface and at select depths in the unsaturated zone.
3) Provide information regarding background concentrations of PFCs in soil and groundwater in the outer portions of the study area (e.g., in northern Shaftsbury and in the Green Mountains east of Bennington).

To allow a comparison between the measured PFC concentrations and the concentrations simulated by the models described in the Draft CSM Report, samples will be collected both within and outside of the area in which conceptual modeling suggests that air deposition from the former Chemfab facilities may affect concentrations of PFOA in groundwater above the drinking water health advisory level of 20 ppt. Given the conceptual nature of modeling studies, the model-to-data comparison will focus on the ability of the models to represent patterns or trends in the data reflecting the primary processes in PFC fate and transport (e.g., air deposition, unsaturated zone transport).

Background levels will be assessed through statistical analyses of the collected data.

3.2 Methods

3.2.1 Sample Collection, Logging, and Field Screening

The preferred method for collection of shallow, subsurface soil samples for this scope of work utilizes a portable, direct-push soil sampling unit (e.g., Geoprobe®) that is capable of continuous soil sampling. In the event that physical conditions (e.g., wooded areas, drainage areas, etc.) prevent sample collection with a direct-push unit, supplemental sampling techniques will be considered. Potential alternate sampling techniques include a hand auger or a hand-operated portable vibra-coring device. Appropriate sampling techniques may be modified in the field based on possible access limitations.

Soil borings will be advanced to depths up to eight feet below ground surface (bgs) or until reaching saturated conditions, whichever is shallower. Shallow refusal on cobbles/boulders, bedrock, or dense

glacial till is expected at some locations, preventing collection of samples at depth. If refusal is suspected to be due to the presence of a boulder or other feature of limited lateral extent, one or more subsequent attempts will be made to complete the boring at a distance of no more than 30 feet away from the original boring location.

The collected soils will be logged in accordance with American Society for Testing and Materials (ASTM) D2488 (visual-manual method) and screened for signs of obvious environmental impacts (e.g., staining, sheen, odor, discoloration, or the presence of headspace as measured by a photoionization detector), in accordance with the QAPP and FSP (Appendices A and B).

Soil samples will be collected from selected intervals at each profile. The planned sample intervals include the following: 0-6 inches bgs, 6-12 inches bgs, 12-18 inches bgs, 3 feet bgs, and 8 feet bgs. If refusal or saturation is encountered at a depth of less than 8 feet, a sample will be collected at the terminus of the boring. In addition to the planned intervals, soil samples will be collected if highly organic soils are encountered or if field screening indicates signs of obvious environmental impacts. Organic-rich soils will be targeted for sampling because of their likely high retention of aerially deposited PFCs compared to low-organic soils, which means they are more likely to have detectable concentrations of PFCs. Even though organic-rich soils are targeted, there will be natural variability in organic carbon content of the soils and it is anticipated that a wide range in organic composition of the soils will be sampled as part of this investigation. All soil samples will be analyzed for total organic carbon (TOC).

Any groundwater that is encountered within eight feet of ground surface will be sampled using a temporary well and standard groundwater sampling methods. Groundwater elevation will be measured in the temporary well prior to sample collection. If groundwater is encountered while sampling with vibra-coring or hand auger methods, the groundwater depth will be measured, but no sample will be collected.

3.2.2 Sample Analysis

Soil samples collected for this task will be analyzed for PFCs, TOC, soil pH, and moisture content. Any groundwater sampled for this task will be analyzed for PFCs, TAL Metals/Cations (excluding cyanide and mercury), Anions, ammonia, orthophosphate, and total Kjeldahl nitrogen. Analytical methods for these parameters are summarized in Table 2, along with the list of PFC analytes.

3.3 Study Locations and Rationale

Shallow soil samples will be collected at the proposed profiling locations shown on Figure 1 and summarized in Table 3. The profile locations were selected to meet the objectives of increasing the spatial coverage of soil data across the study area. They are located at distances up to 4 miles from the former Chemfab facility on Water Street and up to 4.5 miles from the former Chemfab facility on Northside Drive.

Proposed locations are located approximately on a grid pattern across both CAA1 and CAA2, targeting public roadways for ease of access. Actual locations will be determined based on site conditions, access limitations, and in consultation with VTDEC. Access to the proposed sampling locations will be coordinated with private property owners, VTDEC, the Town of Bennington, and the Town of Shaftsbury.

Targeted areas are those which have been undisturbed since the beginning of air emissions of PFCs in the late 1960s, are away from suspected PFC sources, and for which access can be obtained. However, given the ubiquity of PFC-containing source materials and the expected presence of PFCs at background concentrations due to the significant anthropogenic/household use of these chemicals, the ability to identify specific sources may be limited and some detections of PFCs in these shallow soil samples will likely represent impacts from sources that are not readily identifiable.

3.3.1 Background Sampling

As part of a statewide study to establish background concentrations of select analytes (VTDEC, 2017), soil samples were collected from locations with no known environmental impacts or land use that may contribute to PAHs, arsenic, and lead concentrations in soil. A shallow soil profile will be completed at each the following four locations evaluated in the statewide study for the purpose of further evaluating background PFC soil concentrations in the study area:

- Shaftsbury State Park, located approximately 8 miles north of the former Chemfab facility on Water Street.
- Woodford State Park, located approximately 11 miles east of the former Chemfab facility on Water Street.
- The Lake Raponda boat launch and Molly Stark State Park, both located approximately 22 miles east of the former Chemfab facility on Water Street.

The approximate locations of background sampling are shown on Figure 2.

3.4 Data Analysis

Data collected in the study area will be compared against background data as well as analyzed for spatial and depth trends. Depending on background soil sampling results, individual sample data collected from the study area may be analyzed to determine if samples are statistically different from background, using hypothesis testing. For purposes of this Work Plan, an evaluation of spatial trends (e.g., distance from potential sources versus concentration) may indicate potential sources. Trends with depth may aid in indicating a mechanism of delivery (aerial deposition, infiltration, groundwater, etc.). Additional summary statistics may be tabulated, including average concentration and standard deviation, as it relates to depth and distance. If appropriate, additional statistical analyses may include distributional and outlier analysis. The utility of these analyses are contingent upon the quantity and quality of data collected in the study area.

4.0 Deep Soil Profiles

Deep soil profile locations are proposed across the study area to provide PFC concentration data to greater depths than the shallow soil profiles described in Section 3.0. The deep soil profiles are identical to the shallow soil profiles to the depth of 8 feet bgs, then include sampling at 10-foot intervals to the water table or bedrock, depending on which is shallower.

Permanent monitoring wells will be completed in the unconsolidated aquifer at select deep soil profiles, in anticipation of their inclusion in a long-term Monitored Natural Attenuation (MNA) monitoring program. Water-level monitoring (via manual measurements and/or pressure transducers) and periodic sampling of these wells would be performed as part of the future monitoring program. Details of such a program are beyond the scope of this Work Plan.

4.1 Objectives

1) As described above, a primary focus of this scope of work is to further characterize the distribution of PFCs in the study area and address specific data gaps identified in the Draft CSM Report (Barr, 2017). Deep soil profiles are anticipated to: Increase spatial coverage of soil data to evaluate patterns in soil PFC concentrations across the study area.
2) Provide comparison points for assessing modeled air deposition of PFCs at the ground surface and deeper soils subject to transport through the unsaturated zone to the water table.
3) Provide data to evaluate the concept described in the Draft CSM Report (Barr, 2017) that the PFC mass in the unsaturated zone, if present, is retained primarily in the shallow, organic-rich soil layers, and that concentrations decrease with depth.

4.2 Methods

4.2.1 Drilling and Soil Sampling

The deep soil profiles will be completed using rotosonic drilling methods, allowing for the collection of a nearly-continuous soil core. The profiles will be completed from ground surface to the water table or bedrock, whichever is shallower. The collected soils will be logged in accordance with ASTM D2488 (visual-manual method) and screened for signs of obvious environmental impacts (e.g., staining, sheen, odor, discoloration, or the presence of headspace as measured by a photoionization detector), in accordance with the QAPP and FSP (Appendices A and B).

Soil samples will be collected at the same intervals as the shallow soil profiles to a depth of 8 feet bgs (0-6 inches bgs, 6-12 inches bgs, 12-18 inches bgs, 3 feet bgs, and 8 feet bgs) and then at 10-foot intervals to the terminus of the boring at the water table or bedrock. A soil sample will be collected at the terminus of the boring, just above the water table or bedrock surface. The proposed sample spacing of 10 feet at depth is based on observations for similar projects that PFC concentrations do not vary appreciably within the low-organic, mineral soils expected at depth. Organic-rich soil layers may be targeted for sampling, as they have higher retention of PFCs than low-organic soil layers.

4.2.2 Permanent Monitoring Well Construction, Development, and Sampling

Permanent monitoring wells will be completed in the unconsolidated materials at five deep soil profiles, as conditions allow. Candidate locations for permanent monitoring wells in the unconsolidated aquifer are shown on Figure 1. Actual locations will depend on the results of this investigation, as the water table elevation varies within the unconsolidated materials across the study area.

The monitoring wells will be constructed, developed, and sampled in the following manner:

- The wells will have 10-foot-long polyvinyl chloride (PVC) screens straddling or just below the water table with PVC riser pipes of a nominal two-inch diameter. Filter packs will be installed around the well screens and the borehole annuli above the screened interval will be grouted to the surface.
- Well completion will consist of a protective casing extending approximately three feet above ground surface with locking caps, or of a flush mounted protective casing with a lockable J-plug in the riser. The completion method will be selected based on wellhead conditions and property owner preference.
- Wells will be developed by either purging/surging, jetting, or both methods to produce sediment-free water (turbidity less than 50 NTU).
- A groundwater sample will be collected from each developed well following the groundwater sampling protocol described in the QAPP and FSP.
- Depth to groundwater will be measured following well development and prior to sample collection.

Data-logging pressure transducers will be installed in these wells to record water levels through and potentially beyond the study period. Use of data-logging pressure transducer in the wells may be included in the long-term MNA monitoring program, which is currently being developed.

Bedrock monitoring wells are planned in conjunction with the investigation at the Bennington Landfill as described in Section 5.0. Beyond the landfill-related work, bedrock monitoring wells are not proposed as part of this investigation phase. Based on the results of this investigation, bedrock monitoring well locations will be identified for the dual purpose of characterizing groundwater quality in the bedrock and long-term groundwater monitoring.

4.2.3 Groundwater Sampling from Temporary Well

For the subset of deep soil profiles that encounter groundwater and are not completed as permanent monitoring wells, the groundwater sample at the water table will be collected by installing a temporary well. The temporary well will be developed by pumping/surging, jetting, or both methods to produce sediment-free water (turbidity less than 50 NTU). Once the temporary well has been developed, a groundwater sample will be collected following the groundwater sampling protocol described in the

QAPP. Depth to water will be measured following well development and prior to sample collection. Any offset in elevation between the water-level measurement reference and the surveyed elevation reference described in Section 6.0 (i.e., ground surface) will be measured so that the depth to water can be converted to an elevation. Upon collection of the groundwater sample, the temporary well will be removed and the deep soil profile will be abandoned following VTDEC requirements.

4.2.4 Sample Analysis

Soil samples collected for this task will be analyzed for PFCs, TOC, soil pH, and moisture content.

Groundwater sampled for this task will be analyzed for PFCs, TAL Metals/Cations (excluding cyanide and mercury), Anions, ammonia, orthophosphate, and total Kjeldahl nitrogen. Analytical methods for these parameters are summarized in Table 2, along with the list of PFC analytes.

4.3 Study Locations and Rationale

Approximate locations of the proposed deep soil profiles are shown on Figure 1 and summarized in Table 3. Locations at Bennington Landfill are discussed in Section 5.3.2. The deep soil profiles are located on transects between Bennington Landfill and the former Chemfab facilities and also in each cardinal direction from the former Water Street facility. No deep soil profiles are proposed at the former Chemfab facilities due to current access limitations.

Sampling along transects between Bennington Landfill and the former Chemfab facilities will allow an evaluation of variability in PFC concentrations between these PFC sources. Transects in each cardinal direction from the former Water Street facility will provide data on variability in PFC concentrations for different wind directions, which are predominantly from the west and south. Similar profile transects are not proposed for the former Northside Drive facility due to the long period of time since it was in operation (allowing flushing of deposited mass to the groundwater system).

Actual profile locations will be determined in consultation with VTDEC and will target areas that have been undisturbed since the late 1960s, are away from likely PFC sources, and for which access can be obtained. Disturbance may be identified from available historical aerial photographs and additional field reconnaissance. However, given the ubiquity of PFC-containing source materials and the expected presence of PFCs at background concentrations due to the significant anthropogenic/ household use of these chemicals, the ability to identify specific sources may be limited and some detections of PFCs in these deep soil samples will likely represent impacts from sources that are not readily identifiable.

5.0 Soil Profiles and Monitoring Wells at Bennington Landfill

As indicated in the Draft CSM Report (Barr, 2017), airborne emissions from the former Chemfab facilities cannot be the source of PFOA in groundwater south and southwest of the Bennington Landfill. Based on the results of the modeling, the landfill's disposal history, and the current concentration of PFOA in the landfill leachate, the Bennington Landfill is considered a likely source of the measured PFOA concentrations in residential wells south and southwest of the landfill.

Investigations were performed at Bennington Landfill in 2017 by VTDEC and EPA and included drilling, soil sampling, and monitoring well installation and sampling. These investigations are discussed in Section 7.0. The approximate VTDEC/EPA investigation locations are shown on Figure 3. The results of the investigation are not yet available and are not expected to be available to inform this investigation. Our understanding of the existing monitoring network at the landfill is based primarily on historic records (e.g., McLaren/Hart, 1997). As part of the recent investigations and field reconnaissance with VTDEC representatives, the inventory of existing landfill monitoring wells has been updated to reflect wells that have since been abandoned or re-located. Additional effort to complete the well inventory will be made as part of this investigation.

As part of the VTDEC/EPA investigation, monitoring well sample splits were obtained by SGPP representatives. This split sampling was proposed in a previous version of this Work Plan. Since the split sampling work has been performed, it is summarized in Section 7.0 with a more complete description of the VTDEC/EPA investigation. However, results of this sampling work have not been received as of the date of this Work Plan and were therefore unavailable to inform the additional work proposed herein.

Additional shallow and deep soil sampling and monitoring well installation at Bennington Landfill is planned as part of this scope of work to provide data on potential PFC sources. Monitoring wells will be installed in unconsolidated deposits and bedrock to investigate potential migration pathways in groundwater. Investigation details are presented in the following sections.

5.1 Objectives

The primary objectives for completing additional soil profiles and monitoring wells at the Bennington Landfill are summarized below.

1) Further assess the role of the landfill as a source of PFCs to the groundwater system
2) Collect soil PFC data at depth in areas where potential sources (landfill, etc.) are present.
3) Collect data on PFC concentrations and groundwater flow directions in bedrock.
4) Complement shallow well and soil data collected around the landfill by VTDEC/EPA in May 2017.

The objectives of sampling at the Bennington Landfill focus on confirming that the landfill is a source of PFCs to the residential water wells downgradient of the landfill. It is beyond the scope of this Work Plan to

fully characterize all potential sources at the landfill or the extent of PFC impacts to soil and groundwater associated with the landfill.

5.2 Methods

5.2.1 Shallow Soil Profiles

Shallow soil profiles at the landfill will be advanced to a depth of eight feet bgs or upon reaching saturated conditions, whichever is shallower. It is anticipated that most shallow soil profiles in the vicinity of the landfill can be completed using a portable, direct-push soil sampling unit (e.g., Geoprobe®) that is capable of continuous soil sampling. As noted in Section 3.2.1, alternate sample collection methods may be considered if necessary. If refusal is suspected to be due to the presence of a boulder or other feature of limited lateral extent, additional attempts will be made to complete the boring at a distance of no more than 30 feet away from the original boring location.

The collected soils will be logged in accordance with ASTM D2488 (visual-manual method) and screened for signs of obvious environmental impacts (e.g., staining, sheen, odor, discoloration, or the presence of headspace as measured by a photoionization detector), in accordance with the QAPP and FSP (Appendices A and B).

Soil samples will be collected from selected intervals at each boring. The planned sample intervals include the following: 0-6 inches bgs; 6-12 inches bgs; 12-18 inches bgs, 3 feet bgs; and 8 feet bgs. If refusal is encountered at a depth of less than 8 feet and attempts to reach the target depth at offset locations are unsuccessful, a sample will be collected at the terminus of the boring. In addition to the planned sample intervals, additional soil samples will be collected if highly organic soils are encountered or if field screening indicates signs of obvious environmental impacts. Organic-rich soils will be targeted for sampling because of their likely higher retention of aerially deposited PFCs than low-organic soils, which means they are more likely to have detectable concentrations. It should be noted that there is a higher likelihood of organic soils at depth in and around the landfill as either filling over existing soils or re-working of existing soils likely occurred.

Groundwater encountered within 8 feet of ground surface using Geoprobe® sampling methods will be sampled using a temporary well and standard groundwater sampling methods. If groundwater is encountered while sampling with vibra-coring or hand auger methods, no sample will be collected.

5.2.2 Deep Soil Profiles

Deep soil profiles will be completed using rotosonic drilling methods. The profiles will be completed to the water table or bedrock, whichever is shallower. The collected soils will be logged in accordance with ASTM D2488 (visual-manual method) and screened for signs of obvious environmental impacts (e.g., staining, sheen, odor, discoloration, or the presence of headspace as measured by a photoionization detector), in accordance with the QAPP and FSP (Appendices A and B).

Soil samples will be collected at the same intervals as the shallow soil profiles (0-6 inches bgs, 6-12 inches bgs, 12-18 inches bgs, 3 feet bgs, and 8 feet bgs) and then at 10-foot intervals to the terminus of the boring at the water table or bedrock. A soil sample will be collected at the terminus of the boring, just above the water table or bedrock surface. The proposed sample spacing of 10 feet at depth is based on an observation on similar projects that PFC concentrations do not vary appreciably within the low-organic, mineral soils expected at depth. Organic-rich soil layers may be targeted for sampling, as they have higher retention of PFCs than low-organic soil layers.

5.2.3 Unconsolidated Aquifer Monitoring Wells

Permanent monitoring wells will be completed in the unconsolidated materials (e.g., glaciofluvial sediments, glaciolacustrine sediments and glacial till) at four of the deep soil profile locations at Bennington Landfill, as conditions allow. The monitoring wells will be constructed, developed, and sampled in the following manner:

- Wells completed across the water table will have 10-foot-long PVC screens straddling or just below the water table with PVC riser pipes of a nominal two-inch diameter. Filter packs will be installed around and above the top of the screened intervals and the borehole annuli above the screened interval will be sealed with a layer of bentonite and then grouted to the surface.
- Well completion will consist of a protective casing extending approximately three feet above ground surface with locking caps, or of a flush mounted protective casing with a lockable J-plug in the riser.
- Wells will be developed by either purging/surging, jetting, or both methods to produce sediment-free water (turbidity less than 50 NTU).
- Groundwater samples will be collected from the developed wells following the groundwater sampling protocol described in the QAPP and FSP.
- Groundwater elevations will be measured following well development and prior to sample collection.

5.2.4 Bedrock Monitoring Wells

Bedrock wells will be completed in fractured bedrock using rotosonic drilling methods. The boring will be advanced through the unconsolidated materials and bedrock with an oversized bit (8- to 10-inch nominal diameter) to allow the installation of 6-inch diameter steel casing (welded butt joint or threaded coupling) pipe sections within the oversized borehole. Locations of these bedrock wells will be informed by the results of the bedrock study completed as described in Section 2.0 above.

The target completion depth of the bedrock wells will be consistent with the range of completion depths of nearby residential water wells (approximately 200-300 feet). Similarly, the depth of casing will be informed by casing depths for nearby residential water wells, but will be no more than 10 feet into

unweathered/unaltered bedrock to allow assessment of the fractured portion of the bedrock. Open bedrock intervals in the wells are anticipated to be on the order of 100-150 feet.

Geophysical logging and discrete interval sampling will be performed in the bedrock borehole to identify any significant intervals for flow and the PFC concentrations in those intervals. Intervals to be sampled will be identified from the results of the borehole logging. Fewer than five discrete intervals are expected to be sampled in each bedrock borehole. The geophysical logging methods to be employed include:

- Fluid temperature and resistivity,
- Caliper,
- Natural gamma, spontaneous potential (SP), and single-point resistance (SPR),
- Acoustic and optical borehole imaging, and
- Static and dynamic (pumping) flow logging.

The construction of bedrock monitoring wells will be based on the results of the geophysical logging and discrete interval sampling. The well may be completed with the uncased portion left as an open interval, or the well may be completed as a standard monitoring well, with a 2-inch PVC riser, filter pack, and grouted borehole annulus.

In the event that saturated kaolinized bedrock is encountered while drilling, an additional monitoring well may be completed with a screened interval open to the altered bedrock. The altered bedrock materials in the landfill area are soft relative to unaltered bedrock; the local custom is to complete wells with these "ochre" intervals cased off. In the event that altered bedrock materials lack competency to maintain an open borehole, the well will be completed using a well screen and 2-inch PVC riser and would not be a candidate for discrete interval sampling or the full suite of geophysical logging. Those geophysical logs that can be run within a cased hole (e.g., natural gamma) may be completed for a well constructed with a screened interval.

Logging of bedrock materials will include descriptions of interpreted lithology, mineralogy, and potential fracturing based on visual observation of drill cuttings. Soil samples collected from unconsolidated deposits will be logged in accordance with ASTM D2488 (visual-manual method) and screened for signs of obvious environmental impacts (e.g., staining, sheen, odor, discoloration, or the presence of headspace as measured by a photoionization detector), in accordance with the QAPP and FSP (Appendices A and B). With the exception of the bedrock well proposed near VTDEC/EPA wells MW-100S/100D (Section 5.3.3 and Section 7.0), soil samples for lab analysis will be collected at the same intervals as for the deep soil profiles: 0-6 inches bgs, 6-12 inches bgs, 12-18 inches bgs, 3 feet bgs, and 8 feet bgs and then at 10-foot intervals to the terminus of the boring at bedrock or the water table.

The bedrock wells will be completed, developed, and sampled in the following manner:

- Well completion will consist of a protective casing extending approximately three feet above ground surface with locking caps, or of a flush mounted protective casing with a lockable J-plug in the riser or casing.

- Wells will be developed by either purging/surging, jetting, or both methods to produce sediment-free water (turbidity less than 50 NTU).
- Groundwater samples will be collected from the developed wells following the groundwater sampling protocol described in the QAPP and FSP.
- Depth to water will be measured following well development and prior to sample collection.

5.2.5 Sample Analysis

Soil samples collected for this task will be analyzed for PFCs, TOC, soil pH, and moisture content. Groundwater sampled for this task will be analyzed for PFCs, TCL VOCs, TAL Metals and Cations, Anions, ammonia, orthophosphate, and total Kjeldahl nitrogen, and 1,4-Dioxane. Analytical methods for these parameters are summarized in Table 2, along with the list of PFC analytes. Additional analysis of soil and groundwater may be considered depending on the results of field screening (organoleptic perception, PID screening, etc.) for environmental impacts (odors, staining, etc.).

5.3 Study Locations and Rationale

Planned investigation locations at Bennington Landfill are shown on Figure 4 and summarized in Table 3. Bedrock monitoring wells will be adjusted based on results of the bedrock study discussed in Section 2.0; shallow and deep soil profile locations may be adjusted in the field based on field observations, access, and safety considerations. All investigation locations will be completed outside the limits of the landfill cap, as shown on Figure 4.

5.3.1 Shallow Soil Profiles

The planned shallow soil borings are associated with the following landfill features:

- **wastewater sludge** – approximately three shallow borings will be completed in the suspected location of the former wastewater sludge storage area.
- **landfill waste** – approximately 10 shallow borings will be completed throughout the landfill vicinity. Areas targeted for sampling include: the leachate vault, low-lying or drainage areas, and the composting operations. To provide adequate spatial coverage, at least two borings will be attempted in each general direction from the landfill footprint.
- **leachate collection and treatment system** – approximately two shallow borings will be completed in the area of the former leachate collection and treatment area. This area is also in the vicinity of the historical "Drainage Pond" at the landfill. Samples from these borings may capture potential impacts from this historical feature, as well.

5.3.2 Deep Soil Profiles

Five deep soil profiles will be completed at the Bennington Landfill. The locations of the deep soil profiles are shown on Figure 4. General descriptions and rationale for study locations are provided below:

- One deep soil profile / monitoring well (D06 on Figure 4) will be completed adjacent to the leachate collection vault to evaluate potential leakage below the vault.
- One deep soil profile (D10 on Figure 4) will be completed in an area not associated with any significant known landfill feature.
- One deep soil profile / monitoring well (D08 on Figure 4) will be completed in the vicinity of the former leachate treatment system infiltration gallery. Based on historical records, it appears that carbon was used to treat leachate; however, the effectiveness of carbon treatment as a means to remove PFCs from the leachate is unknown, therefore, it is possible that PFCs may be present beneath the former leachate infiltration gallery.
- One deep soil profile / monitoring well (D09 on Figure 4) will be completed in the vicinity of the former leachate treatment system building since an influent equalization tank was present in the building and has the potential to have leaked.
- One deep soil profile / monitoring well (D11 on Figure 4) in the location of the former wastewater treatment sludge disposal area to evaluate potential infiltration of wastewater containing PFCs. This location is close to the soil borings and well couplet (MW-100S/100D) completed by VTDEC and EPA in April-May 2017 (discussed in Section 7.0). While the location of the proposed deep profile is close to the existing wells, it is necessary to collect these data as part of this investigation to have the full set of proposed analytical parameters in a timeframe consistent with completion of the investigation. Additionally, the well will be paired with a bedrock well, as discussed in the next section.

5.3.3 Bedrock Monitoring Wells

Four bedrock monitoring wells will be installed at or near Bennington Landfill. The approximate locations of well completion are shown on Figure 4; final locations will be selected based on the results of the bedrock study discussed in Section 2.0. Three of the wells will be installed between the landfill and residential water wells to the southwest and southeast; a fourth well will be placed north of the landfill in the general upgradient direction indicated by Kim and Dowey (2017). One bedrock well will be completed close to MW-100S/100D to complement this well couplet.

6.0 Surveying

Surveying will be performed at the soil borings and monitoring wells completed as part of this investigation, and also at the residential wells where pressure transducers are installed. For monitoring and residential wells, the horizontal coordinates and elevations of ground surface and top of well riser or casing (or other water level measurement reference) will be surveyed to applicable horizontal and vertical datums. For soil borings, only the horizontal coordinates and elevation of the ground surface will be surveyed.

A differential global position system (GPS) will be used for collection of geographic data. The *Trimble Geo 7x* handheld device is capable of collecting data with a margin of error of less than 100 centimeters, however, margin of error may increase if reception is poor due to nearby obstacles such as topography, vegetation and structures.

The North American Datum of 1983 (NAD83) and North American Vertical Datum of 1988 (NAVD88) will be used as horizontal and vertical reference datums respectively. Universal Transverse Mercator (UTM) Zone 18 (meters) will be used as the coordinate system for data reporting.

7.0 Recent Investigations at Bennington Landfill

VTDEC/EPA completed investigations at Bennington Landfill in April and May of 2017. These investigations included drilling of soil borings and installation of two monitoring wells (MW-100S and MW-100D) at the approximate locations shown on Figure 3, and collection of samples from a subset of existing monitoring wells. Results of the investigations obtained by VTDEC/EPA are not yet available and will be provided under separate cover by the EPA.

7.1.1 Monitoring Well Inventory

A complete record of location and condition of existing landfill monitoring wells was not readily available at the time of these investigations. Therefore, one task was to perform a reconnaissance and inventory of the existing well network. This reconnaissance was partially completed by SGPP representatives and VTDEC personnel during the split sampling and subsequent site visits, and included review of existing landfill monitoring wells and discussion of past efforts to identify and recondition existing monitoring wells. As discussed in Section 5.0, additional effort to complete the well inventory will be made as part of this proposed investigation.

7.1.2 Split Sampling

The split sampling described in this section was performed by VTDEC/EPA and SGPP representatives on May 24-25, 2017 while this Work Plan was under VTDEC review and subsequent revision. Laboratory sample containers were filled by the SGPP representatives and shipped to the appropriate laboratory for analysis (ELLE or Test America). Groundwater samples were analyzed for the parameters listed in Section 5.2.5 and were also analyzed for PFC Precursors.

Samples with corresponding rationale were collected from the following shallow (non-bedrock) monitoring wells (see Figure 3):

- B-2-1 – shallow well adjacent to vault
- B-2-2 – intermediate well adjacent to vault
- B-12 – previous sampling with elevated results
- MW-7 – not previously sampled (west of landfill)
- Leachate Vault (VLT-01) – indication of leachate concentrations
- MW-100S – new shallow monitoring well completed by VTDEC/EPA

Attempts to collect a sample from monitoring well B-6-1 were unsuccessful, due to an insufficient volume of water for sample collection.

8.0 Quality Control

8.1 Source Materials Quality Control

As a check on the potential for cross-contamination, quality control samples will be collected from source materials and equipment that are anticipated to be used for the investigation, prior to the mobilization of the equipment and materials. These samples include water used by the drilling contractor for drilling and equipment decontamination; augers, casing, rods, split-spoon sampling barrels, macro core samplers, totes and tanks used by the drilling contractor; downhole equipment used by the geophysical logging contractor; filter sand used as monitoring well sand pack; monitoring well construction materials (PVC riser and screen); and water used as final decontamination rinse water. The samples will be collected and analyzed for PFCs. Analytical results will be reviewed prior to site mobilization. Mobilization to the Site will only be permitted if analytical results indicate PFCs below detection limits or at concentrations that are not expected to cross-contaminate environmental samples. Source equipment including the driller augers, rods, split-spoon sampling barrels, totes and tanks will be segregated and will not be used for any other purpose by the drilling contractor from the time that the quality control samples are collected to the time that the equipment is mobilized to the site for the investigation.

8.2 Field Quality Control

Field Quality Control samples include Equipment Blanks, Duplicates, and Matrix Spike/Matrix Spike Duplicates (MS/MSD). Quality Control samples will be prepared for each media type at a ratio of one (1) set of Quality Control samples per each 20 media samples and one (1) set of Quality Control samples (duplicate and MS/MSD only) per imported source materials. Laboratory-prepared Trip Blanks will be submitted with aqueous samples requiring analysis for TCL VOCs and PFCs. Field Trip Blanks will be submitted with aqueous samples requiring analysis for PFCs. The types of field quality control samples to be collected and the sampling method and rationale are detailed in the QAPP (Appendix A). Quality Control samples for the TOP Assay will be limited to duplicate collection.

8.3 Equipment Decontamination and Investigation-Derived Waste Disposal

Drilling and sampling equipment will be decontaminated between testing locations. Decontamination will be completed within a pre-approved location. A decontamination pad will be constructed to capture the decontamination waste for daily transfer to 55-gallon drums.

All Investigation Derived Waste (IDW) will be managed in accordance with applicable requirements and policy. IDW is anticipated to consist of drilling spoils (soils), decontamination wastes, well development and purge water, and solid wastes (plastic, paper, scrap PVC pipe, etc.).

Water IDW generated at Bennington Landfill will be disposed on the ground in the vicinity of the boring at which it was generated. Soil IDW will be screened for a hazardous waste determination, using the

methods and analyses identified in the FSP (Appendix B), including analyses for VOCs, metals (including mercury), and SVOCs including PCB homologues (Table 3). If the soil IDW is determined to be non-hazardous, the soil cuttings will be thin spread in the vicinity of the boring. Any soil IDW determined to be hazardous will be disposed of accordingly and in consultation with VTDEC. Solid waste will be placed in a 55-gallon drum and disposed of in accordance with applicable requirements and policy.

Soil IDW generated beyond the landfill will be spread on the ground in the vicinity of the boring at which it was generated. Water IDW generated beyond the landfill will containerized in 55-gallon drums and staged at the former Chemfab facility on Water Street pending characterization and disposal. Solid waste generated beyond the landfill will be placed in a 55-gallon drum and disposed of in accordance with applicable requirements and policy.

Upon installation of transducers in residential water wells as discussed in Section 2.2.3, each well will be promptly disinfected in general accordance with American Water Works Association Standard C654-13 Disinfection of Wells and VTDEC/Agency of Natural Resources (ARN) Environmental Protection Rules, Water Supply Rule: Chapter 12, which will include circulation of the chlorinated solution as necessary to ensure adequate disinfection of the entire well.

9.0 Laboratory Reporting and Data Validation

Each laboratory will generate EPA Level IV data deliverable packages of the investigative analytical data. A Data Quality Assessment (DQA) report of the analytical data (excluding the TOP assay) will be prepared to confirm that the data meets the project-specific criteria for data quality and data use. The DQA report will be completed by an independent data validator (Environmental Standards) and will be conducted in accordance with Environmental Standards SOPs based on EPA National Functional Guidelines for evaluating organic and inorganic analyses or following a similar quality assurance plan approved in consultation with VTDEC.

Total oxidized precursor (TOP) analyses provided by Test America will undergo an approved data validation process. The pre-treatment data from the TOP analysis will be compared to the data reported by ELLE to evaluate relative percent differences (RPDs) between laboratory results to ascertain the relative precision between laboratories. None of the data related to inter-laboratory precision will be qualified when RPDs are high, but will be noted as part of the narrative in any reports associated with the data.

10.0 Reporting

Upon completion of field activities and receipt of analytical data from the laboratory, a report of the investigation activities and findings will be prepared. The report will include a summary of the groundwater and soil analytical results and relevant hydrogeologic data including well construction logs, boring logs, and water level measurements. Results of the investigation and available data from the domestic well replacement project, including geophysical logging, will be incorporated into the draft CSM. Interpretations of the distributions of soil and groundwater PFC concentrations around and between Bennington Landfill and the former Chemfab facilities will be presented, with comparisons to the conceptual modeling results described in the Draft CSM Report (Barr, 2017). The draft CSM will be updated as needed to identify data gaps, and to provide recommendations.

11.0 Schedule

Tasks and estimated days to complete each task are summarized in the table below. A comprehensive schedule to implement this Work Plan is outlined in the CSM Site Investigation Implementation Schedule (Appendix C).

The project schedule to implement field activities and subsequent deliverables are largely contingent upon securing access agreement to proposed investigation locations, possible delays to the field investigation (i.e. weather delay, equipment downtime, and unforeseen field complications), the ability of the drilling contractor to provide multiple drilling rigs, and approval of this Work Plan. Once access agreements are established for field investigation locations, an updated schedule with estimated dates for each task will be provided to VTDEC.

The following table outlines the anticipated number of days to complete the proposed scope of work:

Task	Timeline
Complete bedrock study	7 days
Implement field investigation*	37 days
Complete Laboratory Analysis and Review	56 days
Prepare SI report	66 days

* Timeline for the field investigation is dependent on securing successful access agreements.

12.0 References

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Kim, J.J.,, 2017. *DRAFT Preliminary Bedrock Geologic Map of the Bennington Area, Vermont*, Vermont Geological Survey Open File Report VG2017-4, Plate 1, scale 1:12,000.

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Tables

Table 1
Summary of Investigation Tasks
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Investigation Task	Description	Objectives	Sampling Locations	Analyses
Shallow Soil Profiles (Section 3.0)	• Soil sample collection to 8 feet below ground surface • Collection of groundwater sample, if encountered	• Increase spatial coverage of soil data to reveal any patterns in soil PFC concentrations across the study area. • Provide comparison points for assessing modeled air deposition of PFC at the ground surface and at select depths in the unsaturated zone. • Evaluate background levels of PFCs by assessing conditions in the outer portions of the study area (e.g., in Shaftsbury and east of Chapel Road in Bennington).	• Undisturbed, accessible areas across CAA1 and CAA2 • Locations beyond edge of air deposition area (e.g., Shaftsbury)	• **Soil:** PFCs, pH, TOC, moisture content • **Groundwater (if encountered):** PFCs, Metals/Cations (excluding CN- & Hg), Anions, Ammonia, Orthophosphate, TKN
Deep Soil Profiles (Section 4.0)	• Soil sample collection from ground surface to bedrock/water table • Collection of groundwater sample at water table • Completion of permanent monitoring well in unconsolidated aquifer at select locations	• Increase spatial coverage of soil data to reveal any patterns in soil PFC concentrations across the study area. • Provide comparison points for assessing modeled air deposition of PFC at ground surface and deeper soils subject to transport through the unsaturated zone to the water table. • Provide data to assess the concept that the PFC mass in the unsaturated zone, if present, is retained primarily in the shallow, organic-rich soil layers, and that concentrations decrease with depth. • Evaluate background levels of PFCs by assessing conditions in the outer portions of the study area (e.g., in Shaftsbury and east of Chapel Road in Bennington).	• Sampling transects between Bennington Landfill and the former Chemfab facilities • Along transects in cardinal directions away from Water Street facility	• **Soil:** PFCs, pH, TOC, moisture content • **Groundwater (if encountered):** PFCs, Metals/Cations (excluding CN- & Hg), Anions, Ammonia, Orthophosphate, TKN

Table 1
Summary of Investigation Tasks
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Investigation Task	Description	Objectives	Sampling Locations	Analyses
Bennington Landfill – Shallow Soil Profiles (Section 5.0)	• Soil sample collection to 8 feet below ground surface • Collection of groundwater sample, if encountered • Targeted sampling of historic landfill features	• Evaluate the role of the landfill as a PFC source. • Collect soil PFC data at depth in areas where potential sources (landfill, etc.) are present. • Complement shallow well and soil data being collected around the landfill by VTDEC/EPA.	• Accessible areas in vicinity of landfill • Targeted areas, including wastewater sludge storage, leachate vault, drainage areas, and composting operations	• **Soil:** PFCs, pH, TOC, moisture content • **Groundwater (if encountered):** PFCs, VOCs, Metals/Cations, Anions, Ammonia, Orthophosphate, TKN, 1,4-Dioxane
Bennington Landfill - Deep Soil Profiles and Monitoring Wells (Section 5.0)	• Soil sample collection from ground surface to bedrock/water table • Targeted sampling of historic landfill features • Completion of permanent monitoring wells	• Evaluate the role of the landfill as a PFC source. • Collect soil PFC data at depth in areas where potential sources (landfill, etc.) are present. • Complement shallow well and soil data being collected around the landfill by VTDEC/EPA.	• Near leachate collection vault • Near former leachate treatment system infiltration gallery • Near former leachate treatment system building • Near former wastewater sludge storage area	• **Soil:** PFCs, pH, TOC, moisture content • **Groundwater (if encountered):** PFCs, VOCs, Metals/Cations, Anions, Ammonia, Orthophosphate, TKN, 1,4-Dioxane

Table 1
Summary of Investigation Tasks
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Investigation Task	Description	Objectives	Sampling Locations	Analyses
Bennington Landfill – Bedrock Monitoring Wells (Section 5.0)	• Soil sample collection from ground surface to bedrock/saprolite surface • Geophysical logging and discrete interval groundwater sampling • Completion of permanent bedrock monitoring wells	• Evaluate the role of the landfill as a PFC source • Increase spatial coverage of soil data to reveal any patterns in soil PFC concentrations across the study area. • Identify significant intervals for flow and the PFC concentrations in those intervals	• Three wells between the landfill and areas of impacted residential wells west, southwest, and south of the landfill (one will be completed close to existing wells MW-100S/100D to complement this couplet) • One well north of the landfill in the assumed upgradient direction	• **Soil:** PFCs, pH, TOC, moisture content • **Groundwater:** PFCs, VOCs, Metals/Cations, Anions, Ammonia, Orthophosphate, TKN, 1,4-Dioxane
Bennington Landfill – Existing Monitoring Well Split Sampling (Section 7.0)	• Reconnaissance with VTDEC personnel to assess well conditions • Split sampling of subset of existing landfill monitoring wells	• Evaluate the role of the landfill as a PFC source.	• B-2-1 • B-2-2 • B-9 • B-11 • B-12 • B-16 • MW-7 • Leachate Vault (VLT-01)	• **Groundwater:** PFCs, PFC Precursors, VOCs, Metals/Cations, Anions, Ammonia, Orthophosphate, TKN, 1,4-Dioxane

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
Metals - Water	
Aluminum	EPA 6010C/6020A
Antimony	EPA 6010C/6020A
Arsenic	EPA 6010C/6020A
Barium	EPA 6010C/6020A
Beryllium	EPA 6010C/6020A
Boron	EPA 6010C/6020A
Cadmium	EPA 6010C/6020A
Calcium *	EPA 6010C/6020A
Chromium	EPA 6010C/6020A
Cobalt	EPA 6010C/6020A
Copper	EPA 6010C/6020A
Cyanide	EPA 9012A
Iron *	EPA 6010C/6020A
Lead	EPA 6010C/6020A
Magnesium *	EPA 6010C/6020A
Manganese *	EPA 6010C/6020A
Mercury	EPA 7471
Nickel	EPA 6010C/6020A
Potassium *	EPA 6010C/6020A
Selenium	EPA 6010C/6020A
Silver	EPA 6010C/6020A
Sodium *	EPA 6010C/6020A
Thallium	EPA 6010C/6020A
Vanadium	EPA 6010C/6020A
Zinc	EPA 6010C/6020A
General Parameters - Water	
Ammonia	EPA 350.1
Orthophosphate	SM 4500P-E or EPA 300.0
Total Kjeldahl Nitrogen (TKN)	EPA 351.2
Perfluorinated Compounds - Water	
Perfluorobutanoic acid (PFBA)	EPA 537 Rev 1.1 M
Perfluorobutanesulfonate (PFBS)	EPA 537 Rev 1.1 M
Perfluorodecanoic acid (PFDA)	EPA 537 Rev 1.1 M
Perfluorododecanoic acid (PFDoA)	EPA 537 Rev 1.1 M
Perfluoroheptanoic acid (PFHpA)	EPA 537 Rev 1.1 M
Perfluorohexanoic acid (PFHxA)	EPA 537 Rev 1.1 M
Perfluorohexanesulfonate (PFHxS)	EPA 537 Rev 1.1 M
Perfluorononanoic acid (PFNA)	EPA 537 Rev 1.1 M
Perfluorooctanoic acid (PFOA)	EPA 537 Rev 1.1 M
Perfluoro-octanesulfonate (PFOS)	EPA 537 Rev 1.1 M
Perfluoropentanoic acid (PFPA)	EPA 537 Rev 1.1 M

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
Perfluorotetradecanoic acid (PFTA)	EPA 537 Rev 1.1 M
Perfluorotridecanoic acid (PFTriA)	EPA 537 Rev 1.1 M
Perfluoroundecanoic acid (PFUnA)	EPA 537 Rev 1.1 M
Perfluorooctane sulfonamide (FOSA)	EPA 537 Rev 1.1 M
6:2 Fluorotelomer sulfonate	EPA 537 Rev 1.1 M
8:2 Fluorotelomer sulfonate	EPA 537 Rev 1.1 M
MeFOSAA	EPA 537 Rev 1.1 M
EtFOSAA	EPA 537 Rev 1.1 M
PFC Precursors	Total Oxidizable Precursor (TOP) Assay
Anions - Water	
Bromide	EPA 300.0
Chloride	EPA 300.0
Nitrate	EPA 300.0/EPA 353.2
Nitrite	EPA 300.0/EPA 353.2
Sulfate	EPA 300.0
Carbonate	SM 2320B-97
Bicarbonate	SM 2320B-97
TCL VOCs - Water	
1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2,3-Trichlorobenzene	EPA 8260C
1,2,4-Trichlorobenzene	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
2-Butanone	EPA 8260C
2-Hexanone	EPA 8260C
4-Methyl-2-pentanone	EPA 8260C
Acetone	EPA 8260C
Benzene	EPA 8260C
Bromochloromethane	EPA 8260C
Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Bromomethane	EPA 8260C
Carbon Disulfide	EPA 8260C

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
Carbon Tetrachloride	EPA 8260C
Chlorobenzene	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
Cyclohexane	EPA 8260C
Dibromochloromethane	EPA 8260C
Dichlorodifluoromethane	EPA 8260C
Ethylbenzene	EPA 8260C
Freon 113	EPA 8260C
Isopropylbenzene	EPA 8260C
Methyl Acetate	EPA 8260C
Methyl Tertiary Butyl Ether	EPA 8260C
Methylcyclohexane	EPA 8260C
Methylene Chloride	EPA 8260C
Styrene	EPA 8260C
Tetrachloroethene	EPA 8260C
Toluene	EPA 8260C
Trichloroethene	EPA 8260C
Trichlorofluoromethane	EPA 8260C
Vinyl Chloride	EPA 8260C
Xylene (Total)	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
m+p-Xylene	EPA 8260C
o-Xylene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
SVOCs - Water	
1,4-Dioxane	SW-846 8270C SIM with isotope dilution
Metals - Soils	
Aluminum	EPA 6010C/6020A
Antimony	EPA 6010C/6020A
Arsenic	EPA 6010C/6020A
Barium	EPA 6010C/6020A
Beryllium	EPA 6010C/6020A
Cadmium	EPA 6010C/6020A
Calcium	EPA 6010C/6020A
Chromium	EPA 6010C/6020A
Cobalt	EPA 6010C/6020A
Copper	EPA 6010C/6020A
Iron	EPA 6010C/6020A

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
Lead	EPA 6010C/6020A
Magnesium	EPA 6010C/6020A
Manganese	EPA 6010C/6020A
Mercury	EPA 7471
Nickel	EPA 6010C/6020A
Potassium	EPA 6010C/6020A
Selenium	EPA 6010C/6020A
Silver	EPA 6010C/6020A
Sodium	EPA 6010C/6020A
Thallium	EPA 6010C/6020A
Vanadium	EPA 6010C/6020A
Zinc	EPA 6010C/6020A
SVOCs - Soils	
1,2,4,5-Tetrachlorobenzene	EPA 8270D
1,4-Dioxane (P-Dioxane)	EPA 8270D
2,3,4,6-Tetrachlorophenol	EPA 8270D
2,4,5-Trichlorophenol	EPA 8270D
2,4,6-Trichlorophenol	EPA 8270D
2,4-Dichlorophenol	EPA 8270D
2,4-Dimethylphenol	EPA 8270D
2,4-Dinitrophenol	EPA 8270D
2,4-Dinitrotoluene	EPA 8270D
2,6-Dinitrotoluene	EPA 8270D
2-Chloronaphthalene	EPA 8270D
2-Chlorophenol	EPA 8270D
2-Methylnaphthalene	EPA 8270D
2-Methylphenol (O-Cresol)	EPA 8270D
2-Nitroaniline	EPA 8270D
2-Nitrophenol	EPA 8270D
3,3'-Dichlorobenzidine	EPA 8270D
3-Nitroaniline	EPA 8270D
4,6-Dinitro-2-Methylphenol	EPA 8270D
4-Bromophenyl Phenyl Ether	EPA 8270D
4-Chloro-3-Methylphenol	EPA 8270D
4-Chloroaniline	EPA 8270D
4-Chlorophenyl Phenyl Ether	EPA 8270D
4-Methylphenol (P-Cresol)	EPA 8270D
4-Nitroaniline	EPA 8270D
4-Nitrophenol	EPA 8270D
Acenaphthene	EPA 8270D
Acenaphthylene	EPA 8270D
Acetophenone	EPA 8270D

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
Anthracene	EPA 8270D
Atrazine	EPA 8270D
Benzaldehyde	EPA 8270D
Benzo(a)Anthracene	EPA 8270D
Benzo(a)Pyrene	EPA 8270D
Benzo(b)Fluoranthene	EPA 8270D
Benzo(g,h,i)perylene	EPA 8270D
Benzo(k)Fluoranthene	EPA 8270D
Benzyl Butyl Phthalate	EPA 8270D
Biphenyl (Diphenyl)	EPA 8270D
Bis(2-Chloroethoxy) Methane	EPA 8270D
Bis(2-Chloroethyl) Ether (2-Chloroethyl Ether)	EPA 8270D
Bis(2-Chloroisopropyl) Ether	EPA 8270D
Bis(2-Ethylhexyl) Phthalate	EPA 8270D
Caprolactam	EPA 8270D
Carbazole	EPA 8270D
Chrysene	EPA 8270D
Dibenz(a,h)Anthracene	EPA 8270D
Dibenzofuran	EPA 8270D
Diethyl Phthalate	EPA 8270D
Dimethyl Phthalate	EPA 8270D
Di-N-Butyl Phthalate	EPA 8270D
Di-N-Octylphthalate	EPA 8270D
Fluoranthene	EPA 8270D
Fluorene	EPA 8270D
Hexachlorobenzene	EPA 8270D
Hexachlorobutadiene	EPA 8270D
Hexachlorocyclopentadiene	EPA 8270D
Hexachloroethane	EPA 8270D
Indeno(1,2,3-c,d)Pyrene	EPA 8270D
Isophorone	EPA 8270D
Naphthalene	EPA 8270D
Nitrobenzene	EPA 8270D
N-Nitrosodi-N-Propylamine	EPA 8270D
N-Nitrosodiphenylamine	EPA 8270D
Pentachlorophenol	EPA 8270D
Phenanthrene	EPA 8270D
Phenol	EPA 8270D
Pyrene	EPA 8270D
PCB Homologues	EPA 1668

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
VOCs - Soils	
1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloro-1,2,2-Trifluoroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,2,3-Trichlorobenzene	EPA 8260C
1,2,4-Trichlorobenzene	EPA 8260C
1,2-Dibromo-3-Chloropropane	EPA 8260C
1,2-Dibromoethane (Ethylene Dibromide)	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
2-Hexanone	EPA 8260C
Acetone	EPA 8260C
Benzene	EPA 8260C
Bromochloromethane	EPA 8260C
Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Bromomethane	EPA 8260C
Carbon Disulfide	EPA 8260C
Carbon Tetrachloride	EPA 8260C
Chlorobenzene	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
Cis-1,2-Dichloroethylene	EPA 8260C
Cis-1,3-Dichloropropene	EPA 8260C
Cyclohexane	EPA 8260C
Dibromochloromethane	EPA 8260C
Dichlorodifluoromethane	EPA 8260C
Ethylbenzene	EPA 8260C
Isopropylbenzene (Cumene)	EPA 8260C
m,p-Xylene	EPA 8260C
Methyl Acetate	EPA 8260C
Methyl Ethyl Ketone (2-Butanone)	EPA 8260C
Methyl Isobutyl Ketone (4-Methyl-2-Pentanone)	EPA 8260C
Methylcyclohexane	EPA 8260C
Methylene Chloride	EPA 8260C

Table 2
Analytical Parameters and Methods
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Parameter	Method
O-Xylene (1,2-Dimethylbenzene)	EPA 8260C
Styrene	EPA 8260C
Tert-Butyl Methyl Ether	EPA 8260C
Tetrachloroethylene (PCE)	EPA 8260C
Toluene	EPA 8260C
Trans-1,2-Dichloroethene	EPA 8260C
Trans-1,3-Dichloropropene	EPA 8260C
Trichloroethylene (TCE)	EPA 8260C
Trichlorofluoromethane	EPA 8260C
Vinyl Chloride	EPA 8260C
General Parameters - Soils	
Total Organic Carbon (TOC)	SM 5310B-00 (M)
Moisture content	SM 2540G-97
pH	EPA 9045D
Perfluorinated Compounds - Soils	
Perfluorobutanoic acid (PFBA)	EPA 537 Rev 1.1 M
Perfluorobutanesulfonate (PFBS)	EPA 537 Rev 1.1 M
Perfluorodecanoic acid (PFDA)	EPA 537 Rev 1.1 M
Perfluorododecanoic acid (PFDoA)	EPA 537 Rev 1.1 M
Perfluoroheptanoic acid (PFHpA)	EPA 537 Rev 1.1 M
Perfluorohexanoic acid (PFHxA)	EPA 537 Rev 1.1 M
Perfluorohexanesulfonate (PFHxS)	EPA 537 Rev 1.1 M
Perfluorononanoic acid (PFNA)	EPA 537 Rev 1.1 M
Perfluorooctanoic acid (PFOA)	EPA 537 Rev 1.1 M
Perfluoro-octanesulfonate (PFOS)	EPA 537 Rev 1.1 M
Perfluoropentanoic acid (PFPA)	EPA 537 Rev 1.1 M
Perfluorotetradecanoic acid (PFTA)	EPA 537 Rev 1.1 M
Perfluorotridecanoic acid (PFTriA)	EPA 537 Rev 1.1 M
Perfluoroundecanoic acid (PFUnA)	EPA 537 Rev 1.1 M

* Cations

Table 3
Summary of Proposed Investigation Locations
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Investigation Location		Investigation Nomenclature	Approximate Ground Elevation (Feet MSL)[1]	Estimated Total Depth (feet)[3]	Approximate Easting NAD83 UTM18 (meters)	Approximate Northing NAD83 UTM18 (meters)	Figure Reference
Area	**Type**						
Bennington Landfill	Shallow Soil Profile	S13	975	8	647206.0	4754099.8	Figure 4
	Shallow Soil Profile	S15	935	8	647189.9	4753886.1	Figure 4
	Shallow Soil Profile	S16	911	8	647394.3	4753801.2	Figure 4
	Shallow Soil Profile	S18	921	8	647223.2	4753691.4	Figure 4
	Shallow Soil Profile	S19	930	8	647223.2	4753662.0	Figure 4
	Shallow Soil Profile	S20	909	8	647477.0	4753647.2	Figure 4
	Shallow Soil Profile	S21	914	8	647318.6	4753641.3	Figure 4
	Shallow Soil Profile	S22	955	8	646989.9	4753633.5	Figure 4
	Shallow Soil Profile	S23	977	8	646900.6	4753609.3	Figure 4
	Shallow Soil Profile	S24	948	8	647029.4	4753559.2	Figure 4
	Shallow Soil Profile	S25	923	8	647236.3	4753548.6	Figure 4
	Shallow Soil Profile	S26	940	8	647106.6	4753548.1	Figure 4
	Shallow Soil Profile	S27	946	8	647048.9	4753540.5	Figure 4
	Shallow Soil Profile	S28	898	8	647678.4	4753530.4	Figure 4
	Shallow Soil Profile	S29	909	8	647435.7	4753465.8	Figure 4
	Deep Soil Profile	D10	974	BR or GW	646920.9	4753602.3	Figure 4
	Deep Soil Profile and Monitoring Well	D06	922	BR or GW	647236.2	4753670.4	Figure 4
	Deep Soil Profile and Monitoring Well	D08	914	BR or GW	647317.5	4753658.9	Figure 4
	Deep Soil Profile and Monitoring Well	D09	929	BR or GW	647238.0	4753621.4	Figure 4
	Deep Soil Profile and Monitoring Well	D11	950	BR or GW	647012.5	4753598.7	Figure 4
	Monitoring Well in Bedrock	MW-BR1	953	BR and GW	647220.6	4753969.4	Figure 4
	Monitoring Well in Bedrock	MW-BR2	948	BR and GW	647012.1	4753609.4	Figure 4
	Monitoring Well in Bedrock	MW-BR3	908	BR and GW	646548.6	4753207.3	Figure 4
	Monitoring Well in Bedrock	MW-BR4	909	BR and GW	647535.0	4753412.7	Figure 4
Outside of Bennington Landfill	Shallow Soil Profile	S01	719	8	643071.3	4757015.0	Figure 1
	Shallow Soil Profile	S02	707	8	644691.7	4755857.9	Figure 1
	Shallow Soil Profile	S03	733	8	646063.8	4755848.8	Figure 1
	Shallow Soil Profile	S04	1085	8	648818.9	4755658.8	Figure 1
	Shallow Soil Profile	S05	529	8	641021.4	4755468.8	Figure 1
	Shallow Soil Profile	S06	535	8	641690.9	4754727.6	Figure 1
	Shallow Soil Profile	S07	708	8	645104.9	4754554.4	Figure 1
	Shallow Soil Profile	S08	780	8	646138.0	4754540.5	Figure 1
	Shallow Soil Profile	S09	1041	8	648790.8	4754403.1	Figure 1
	Shallow Soil Profile	S10	962	8	647999.1	4754351.6	Figure 1
	Shallow Soil Profile	S11	699	8	644003.1	4754308.6	Figure 1
	Shallow Soil Profile	S12	810	8	646164.7	4754116.1	Figure 1
	Shallow Soil Profile	S14	682	8	642447.3	4753921.7	Figure 1
	Shallow Soil Profile	S30	873	8	647629.1	4752972.3	Figure 1
	Shallow Soil Profile	S31	784	8	646004.3	4752906.0	Figure 1
	Shallow Soil Profile	S32	913	8	648808.2	4752696.8	Figure 1
	Shallow Soil Profile	S33	688	8	645997.8	4752350.0	Figure 1
	Shallow Soil Profile	S34	568	8	645136.6	4752011.3	Figure 1
	Shallow Soil Profile	S35	583	8	644197.7	4751964.8	Figure 1

Table 3
Summary of Proposed Investigation Locations
CSM Site Investigation Work Plan
Bennington, VT
Saint-Gobain Performance Plastics

Investigation Location		Investigation Nomenclature	Approximate Ground Elevation (Feet MSL)[1]	Estimated Total Depth (feet)[3]	Approximate Easting NAD83 UTM18 (meters)	Approximate Northing NAD83 UTM18 (meters)	Figure Reference
Area	Type						
Outside of Bennington Landfill	Shallow Soil Profile	S36	570	8	642591.0	4751908.1	Figure 1
	Shallow Soil Profile	S37	861	8	648412.7	4751889.2	Figure 1
	Shallow Soil Profile	S38	690	8	641619.5	4751055.4	Figure 1
	Shallow Soil Profile	S39	832	8	648949.8	4750927.6	Figure 1
	Shallow Soil Profile	S40	821	8	644065.4	4750868.5	Figure 1
	Shallow Soil Profile	S41	588	8	645483.0	4750811.8	Figure 1
	Shallow Soil Profile	S42	772	8	648337.1	4750585.0	Figure 1
	Shallow Soil Profile	S43	841	8	644235.5	4749791.2	Figure 1
	Shallow Soil Profile	S44	871	8	641682.7	4749523.1	Figure 1
	Shallow Soil Profile	S45	812	8	645294.0	4749450.9	Figure 1
	Shallow Soil Profile	S46	661	8	646749.4	4749375.3	Figure 1
	Shallow Soil Profile	S47	749	8	648431.6	4749299.7	Figure 1
	Shallow Soil Profile	S48	914	8	643165.7	4748755.9	Figure 1
	Shallow Soil Profile	S49	919	8	645224.0	4748608.4	Figure 1
	Deep Soil Profile	D01	764	BR or GW	643164.7	4756059.0	Figure 1
	Deep Soil Profile	D03	646	BR or GW	643102.4	4754772.2	Figure 1
	Deep Soil Profile	D05	634	BR or GW	643055.4	4753953.8	Figure 1
	Deep Soil Profile	D07	1004	BR or GW	648677.3	4753666.0	Figure 1
	Deep Soil Profile	D13	644	BR or GW	645265.5	4753352.1	Figure 1
	Deep Soil Profile	D14	650	BR or GW	644651.9	4753225.6	Figure 1
	Deep Soil Profile	D16	947	BR or GW	647005.1	4753003.1	Figure 1
	Deep Soil Profile	D17	601	BR or GW	640941.3	4752979.9	Figure 1
	Deep Soil Profile	D19	811	BR or GW	646903.4	4752349.4	Figure 1
	Deep Soil Profile	D20	598	BR or GW	643122.7	4752189.7	Figure 1
	Deep Soil Profile	D22	752	BR or GW	643247.2	4751417.5	Figure 1
	Deep Soil Profile	D23	758	BR or GW	643085.6	4750859.9	Figure 1
	Deep Soil Profile	D24	782	BR or GW	643192.1	4749796.1	Figure 1
	Deep Soil Profile and Monitoring Well	D02	960	GW	647065.9	4755018.6	Figure 1
	Deep Soil Profile and Monitoring Well	D12	820	GW	646012.9	4753475.4	Figure 1
	Deep Soil Profile and Monitoring Well	D15	682	GW	643975.3	4753070.3	Figure 1
	Deep Soil Profile and Monitoring Well	D18	552	GW	642167.5	4752892.9	Figure 1
	Deep Soil Profile and Monitoring Well	D21	650	GW	646781.4	4751428.8	Figure 1
	Shallow Soil Profile	BG1	843	8	648491.3	4764755.2	Figure 2
	Shallow Soil Profile	BG2	2333	8	660119.9	4750345.7	Figure 2
	Shallow Soil Profile	BG3	1890[2]	8	678740.4	4747462.1	Figure 2
	Shallow Soil Profile	BG4	1858[2]	8	678562.4	4746888.6	Figure 2

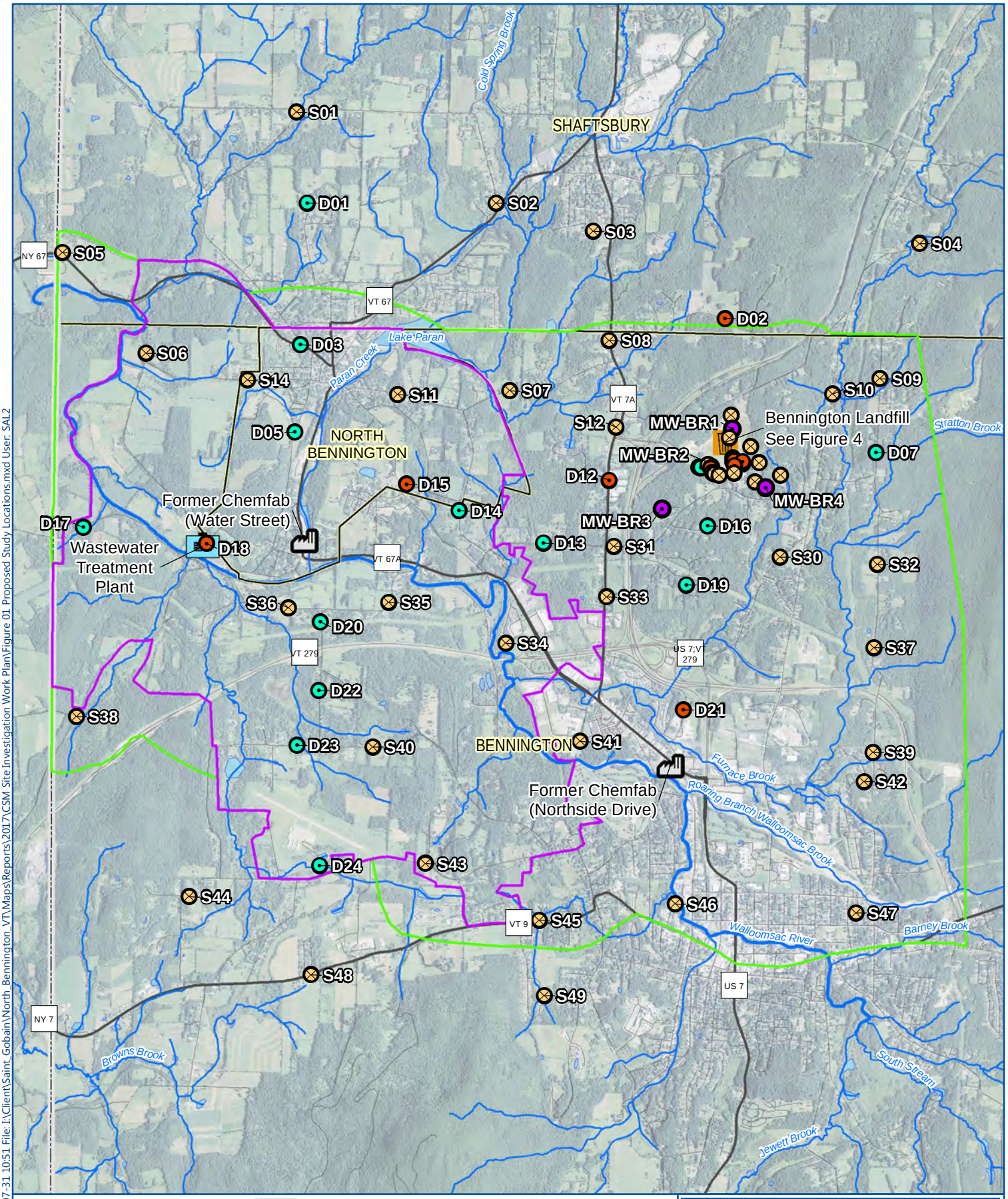
Notes:

[1] - Estimated ground elevation based on Vermont Center for Geographic Information (VCGI) 2.0m 2012 LiDAR data (county dataset).

[2] - Estimated ground elevation based on Vermont Center for Geographic Information (VCGI) 0.7m 2015 LiDAR data (county dataset).

[3] - "GW" = Groundwater, "BR" = Bedrock

Figures



Proposed Investigation Location (Approximate)

- Monitoring Well in Bedrock
- Shallow Soil Profile
- Deep Soil Profile and Monitoring Well
- Deep Soil Profile

- State Boundary
- Village Boundary
- Stream
- Lake/Pond
- Corrective Action Area 1
- Corrective Action Area 2

- Factory
- Wastewater Treatment Plant
- Landfill

N

0 0.5 Miles

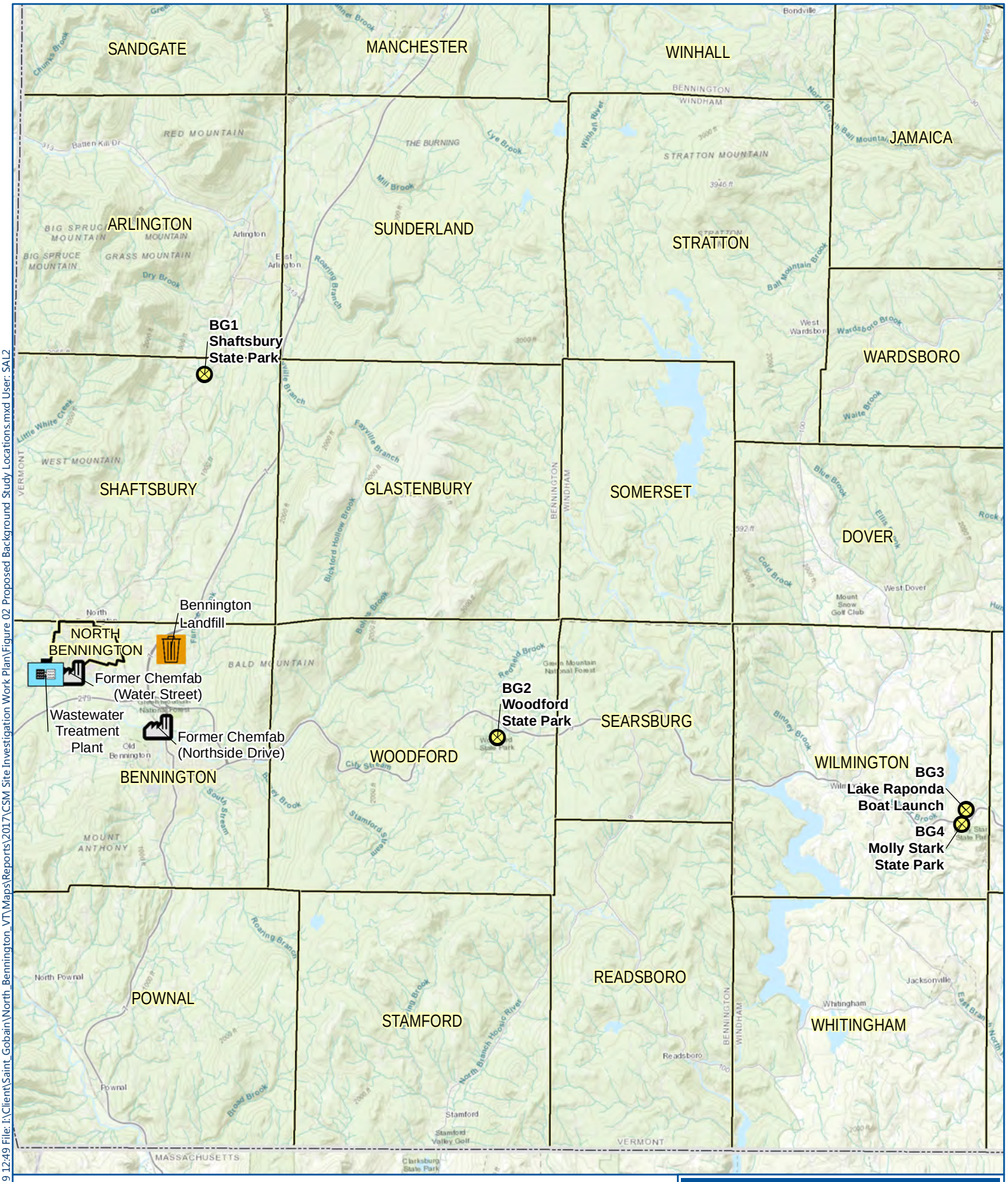
Proposed bedrock monitoring wells will be adjusted based on results of the bedrock study.

BARR

PROPOSED STUDY LOCATIONS
CSM SITE INVESTIGATION
North Bennington, VT
Saint-Gobain

FIGURE 1

Barr Footer: ArcGIS 10.4, 2017-07-31 10:51 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\CSM Site Investigation Work Plan\Figure 01 Proposed Study Locations.mxd User: SAL2



Existing Background Shallow Soil Data (VTDEC, 2017)(Approx.)

State Boundary

Village Boundary

Township Boundary

Factory

Landfill

Wastewater Treatment Plant

N

0 1 2 3

Miles

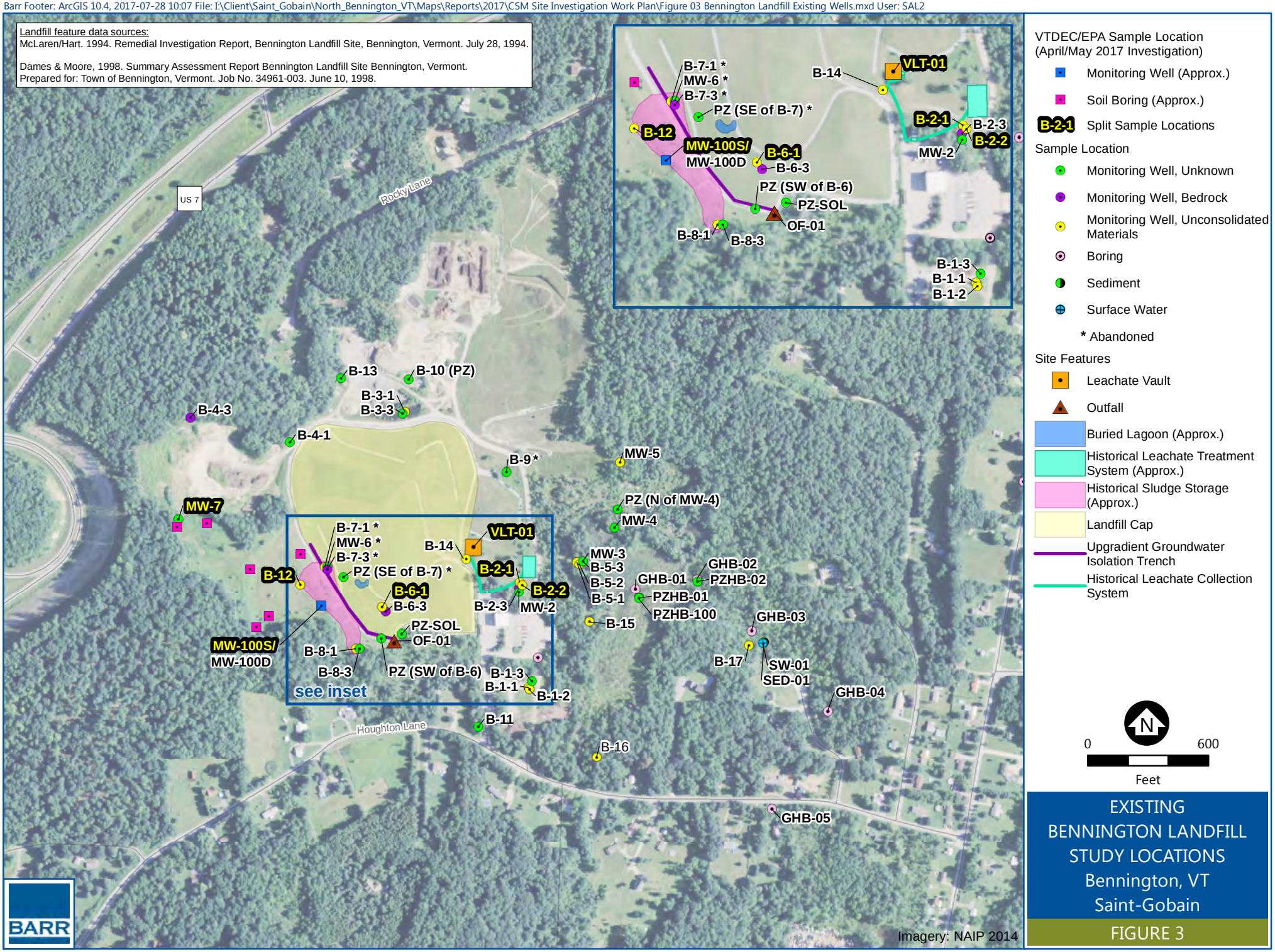
Proposed shallow soil profile locations are consistent with locations evaluated in the statewide study (VTDEC, 2017)

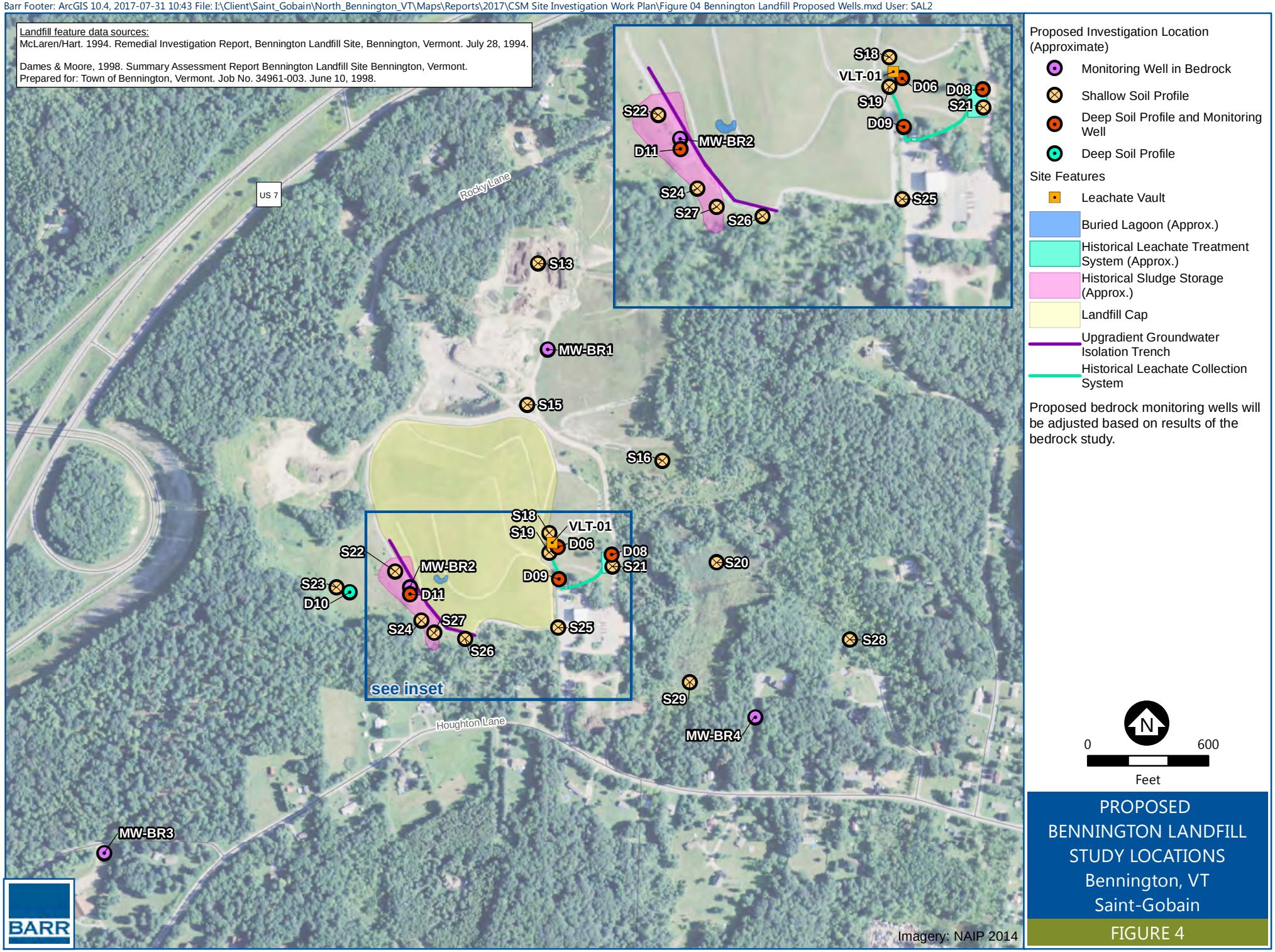
BARR

PROPOSED BACKGROUND STUDY LOCATIONS
CSM SITE INVESTIGATION
North Bennington, VT
Saint-Gobain

FIGURE 2

Barr Footer: ArcGIS 10.4, 2017-07-19 12:49 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\CSM Site Investigation Work Plan\Figure 02 Proposed Background Study Locations.mxd User: SAL2


Landfill feature data sources:
McLaren/Hart. 1994. Remedial Investigation Report, Bennington Landfill Site, Bennington, Vermont. July 28, 1994.
Dames & Moore, 1998. Summary Assessment Report Bennington Landfill Site Bennington, Vermont. Prepared for: Town of Bennington, Vermont. Job No. 34961-003. June 10, 1998.
US 7
Rocky Lane
Houghton Lane
see inset
B-7-1 *
MW-6 *
B-7-3 *
PZ (SE of B-7) *
B-12
MW-100S/
MW-100D
B-6-1
B-6-3
PZ (SW of B-6)
PZ-SOL
OF-01
B-8-1
B-8-3
B-14
VLT-01
B-2-1
B-2-3
B-2-2
MW-2
B-1-3
B-1-1
B-1-2
B-13
B-10 (PZ)
B-3-1
B-3-3
B-4-3
B-4-1
B-9 *
MW-5
PZ (N of MW-4)
MW-4
MW-7
MW-3
B-5-3
B-5-2
B-5-1
GHB-01
GHB-02
PZHB-02
PZHB-01
PZHB-100
B-15
GHB-03
B-17
SW-01
SED-01
GHB-04
B-11
B-16
GHB-05
VTDEC/EPA Sample Location (April/May 2017 Investigation)
Monitoring Well (Approx.)
Soil Boring (Approx.)
Split Sample Locations
Sample Location
Monitoring Well, Unknown
Monitoring Well, Bedrock
Monitoring Well, Unconsolidated Materials
Boring
Sediment
Surface Water
* Abandoned
Site Features
Leachate Vault
Outfall
Buried Lagoon (Approx.)
Historical Leachate Treatment System (Approx.)
Historical Sludge Storage (Approx.)
Landfill Cap
Upgradient Groundwater Isolation Trench
Historical Leachate Collection System
N
0
600
Feet
EXISTING
BENNINGTON LANDFILL
STUDY LOCATIONS
Bennington, VT
Saint-Gobain
FIGURE 3
BARR
Imagery: NAIP 2014



Proposed Investigation Location (Approximate)

- Monitoring Well in Bedrock
- Shallow Soil Profile
- Deep Soil Profile and Monitoring Well
- Deep Soil Profile

Site Features

- Leachate Vault
- Buried Lagoon (Approx.)
- Historical Leachate Treatment System (Approx.)
- Historical Sludge Storage (Approx.)
- Landfill Cap
- Upgradient Groundwater Isolation Trench
- Historical Leachate Collection System

Proposed bedrock monitoring wells will be adjusted based on results of the bedrock study.

N

0 600

Feet

PROPOSED BENNINGTON LANDFILL STUDY LOCATIONS

Bennington, VT

Saint-Gobain

FIGURE 4

Appendices

Appendix A

Quality Assurance Project Plan

A1 - Quality Assurance Project Plan Addendum

resourceful. naturally.
engineering and environmental consultants

BARR

August 2, 2017

John Schmeltzer
State of Vermont
Department of Environmental Conservation
Waste Management and Prevention Division
1 National Life Drive – Davis 1
Montpelier, VT 05620-3704

Re: Quality Assurance Project Plan (QAPP) Addendum – Saint-Gobain Performance Plastics Site

Dear Mr. Schmeltzer:

On behalf of our client Saint-Gobain, this letter provides an addendum to the Saint-Gobain Performance Plastics Site QAPP, dated May 2016.

This QAPP addendum addresses overall corrections and additions to the original QAPP as well as additions necessary for the proposed scope of work described in the following work plans:

- *Domestic Water Well Replacement: Bennington, Vermont* (Barr, August 2017)
- *CSM Site Investigation: Bennington, Vermont* (Barr, August 2017).

The Domestic Water Well Replacement Work Plan calls for collection of groundwater samples to be analyzed for perfluorinated chemicals (PFCs), parameters reflective of the Vermont well construction code, and additional water-quality parameters.

The CSM Site Investigation Work Plan calls for collection of groundwater and soil samples across the study area. Samples will be analyzed for PFCs, PFC Precursors, and water-quality parameters indicative of landfill leachate impacts.

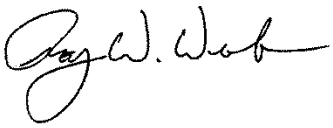
The QAPP requires additional substantive corrections and edits, the most significant will be addressed here. A complete QAPP revision will follow in the coming months to bring the QAPP in alignment with current US EPA guidance.

Updates to the QAPP provided in this addendum include the following:

- General QAPP corrections and clarifications.
- A table of laboratory addresses and phone numbers for samples submitted for the purposes of the planned work.
- A table of additional analytical parameters, analytical methods, hold times and quantitative limits for the collection of additional selected parameters not already included with the initial approved QAPP.
- Copies of Barr, Test America, and Environmental Services Standard Operating Procedures (SOPs)

Please contact me by phone at (952) 832-2696 or email at rwuolo@barr.com if you have any questions or would like to discuss any of the information above.

Sincerely,



Ray Wuolo
Vice President
Senior Hydrogeologist

Attachments:
- Distribution List
- General Corrections List
- Laboratory Addresses and Parameter Responsibility
- QAPP Table 2 - Analytical Methods and Requirements
- Additional SOPs

c: Kirk Moline, C.T. Male
Nancy Bornholm, Eurofins Lancaster Laboratories
Ivana Castaneda, Eurofins Eaton (CA) Laboratories
David Blye, Environmental Standards

Distribution List (omitted)

QUALITY ASSURANCE PROJECT PLAN DISTRIBUTION LIST

The following have received a copy of this Quality Assurance Project Plan:

U.S. EPA Project Manager

John Schmeltzer, Vermont Department of Environmental Conservation Project Manager

Kirk Moline, C.T. Male Associates Project Manager

Elizabeth Rovers, C.T. Male Associates Quality Assurance Officer

Ray Wuolo, Barr Engineering Co. Hydrogeologist

Ivana Castaneda, Laboratory Project Manager, Eurofins Eaton Analytical, Inc.

Nancy Bornholm, Laboratory Project Manager, Eurofins Lancaster Laboratories, LLC.

David Blye, CEAC, Environmental Standards, Inc., Principal Chemist

General Corrections and Edits

Special Training Requirements/Certification (omitted section)

Field Personnel
Field personnel will be under the supervision of a C.T. Male project manager. They will be trained as mandated by the Occupational Safety and Health Administration (OSHA) Act regulations (29 Code of Federal Regulations [CFR] 1910.120) and will be trained to follow the health and safety procedures as outlined in the health and safety plan (HASP). The HASP provides guidelines, requirements, and procedures intended to help protect the health and safety of employees and subcontractors who will participate in the field work. Training will be provided in relation to proper field equipment operation, sampling and preservation techniques, sample handling and custody, and quality control to field personnel.

Laboratories
The laboratories utilized for this project will have the appropriate certifications necessary to perform analysis in the state of Vermont, where applicable. Copies of laboratory accreditation/certification are included as part of this QAPP for all applicable parameters; such documentation is not included where certification is not required. The laboratories' personnel training will be conducted and monitored by the laboratories' QA managers.

Modification to 6.0 Secondary Data

Due to the multiple investigations/sampling that has been performed at the site, secondary data from multiple sources (e.g., EPA, VTDEC) will be incorporated into this evaluation. These data will be compared to the requirements specified in this QAPP to evaluate any potential limitations prior to inclusion to ensure the data meet the goals of the project. The appropriate owners of such data will be contacted if there are inconsistencies or suspected errors and attempts to correct these data will be made, if possible. Data that cannot be resolved or is considered suspect will be omitted from the data used during the investigation.

Added to Section 10

Laboratory Quality Assurance Program Overview

The purpose of the laboratories' quality assurance programs is to ensure that analytical data are scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. QA oversight is performed throughout sample processing from initial order/entry, through the analytical system, to the final report. This is done through various policies, procedures, and quality control checks. The QA managers at each laboratory have the authority and responsibility for implementing, maintaining, and improving the quality system and for ensuring compliance with all regulatory compliance quality standards. The QA managers work with laboratory staff to establish effective quality control and assessment processes and have the authority to stop work in response to quality problems.

Internal Quality Control Procedures

Internal quality control procedures are established, implemented, and maintained. They include, but are not limited to, auditing, data integrity training, document control, control of records, measurement traceability, analysis of proficiency testing (PT) samples, and internal auditing. Detailed information regarding each of these procedures, along with other internal laboratory policies and procedures, are provided in the laboratories' QA manuals. These policies and procedures are established in order to meet requirements of accreditation bodies and applicable programs, as well as client's quality objectives. QC procedures are used to continually assess performance of the laboratory and quality systems. The laboratory maintains control of analytical results by adhering to written standard operating procedures (SOPs), using analytical QC checks with analyses, and by observing sample custody requirements.

Laboratory Quality Control Checks

The laboratories ensure the production of quality analytical data through the use of overall quality assurance systems that are supported by documented quality control checks. The particular types and frequencies of quality control checks analyzed with samples are defined in the laboratories' SOPs and QAMs. Laboratory acceptance criteria is included with each analytical report and in the laboratories' SOPs. An exceedance of these accuracy limits will result in corrective actions by the C.T. Male QA manager or designee.

Laboratory Addresses and Parameter Responsibility

Laboratory	Parameter Responsibility
Laboratory: Eurofins Lancaster Laboratories, LLC. 2425 New Holland Pike Lancaster, Pennsylvania 17605 Phone: (717) 656-2300	All parameters not sub-contracted to Eurofins Eaton or Test America Sacramento.
Laboratory: Eurofins Eaton Laboratories, LLC. Monrovia Laboratory 750 Royal Oaks Drive, Suite 100 Monrovia, CA 91016 Phone: (626) 386-1100	PFCs (Domestic Water Well Replacement only), Uranium, Gross alpha
Laboratory: Test America Sacramento 880 Riverside Parkway West Sacramento, CA 95605-1500 Phone: (916) 374-4383	Total Oxidizable Precursor (TOP) Assay (CSM Site Investigation only)

QAPP Table 2

Notes should be corrected to read:

1) Holding times are relative to the time of sample collection.
2) Method 537. Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). EPA Document #: EPA/600/R-08/092, Version 1.1, September 2009. The laboratory uses a modified version of EPA Method 537 for analysis of PFCs in solids. The laboratory utilizes a proprietary sample preparation method as EPA has not developed a sample preparation method.

QAPP Table 2 - Analytical Methods and Requirements – Domestic Water Well Replacement

Analytical Parameters	EPA Method	Holding Times
Anions (Fluoride, Nitrite)	EPA 300.0	28 days
Anions (Nitrate/Nitrate+nitrite)	EPA 300.0/353.2	48 hours/28 days
Hardness	SM 2340C	180 days
Gross Alpha	EPA 900.0	180 days
Total Coliform	SM 9223B (Colilert)	30 hours
Total Metals ("PFC conformational samples"; Ca, Mg, Na, K)	EPA 200.7/200.8	180 days
Total Metals("VDH samples"; As, Cu, Ca, Fe, Pb, Mg, Mn, Na, U)	EPA 200.7/200.8	180 days

QAPP Table 2 - Analytical Methods and Requirements – Bennington CSM Site Investigation

Analytical Parameters	EPA Method	Holding Times
Ammonia (water)	EPA 350.1	28 days
Orthophosphate (water)	SM 4500P-E or EPA 300.0	15 minutes (filter)/48 hours
Total Kjeldahl Nitrogen (TKN) (water)	EPA 351.2	28 days
1,4-Dioxane (water)	SW-846 8270C SIM with isotope dilution	7 days
Moisture content (soil)	SM 2540G-97	7 days
pH (soil)	EPA 9045D	ASAP
Carbon, Total Organic (TOC) (soil)	SM 5310B-00 (M)	28 days
PCB homologues	EPA 1668	1 year
PFC Precursors (water)	Total Oxidizable Precursor (TOP) Assay	14 days extraction/28 days analyze
Anions (Bromide, Nitrate, Nitrite, Sulfate) (water)	EPA 300.0 and/or 353.2	48 hours (nitrate and nitrite)/28 days

Additional SOPs (Attachments follow)

Collection of Drinking Water Samples from Private Wells or Public Water Supplies, Barr Engineering Co.

Data Validation Standard Operating Procedure SOP: DV-PFC- ELLE, Environmental Standards, Inc.

Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue [Method 537 (Modified)] – TOP Assay Section 11.13, Test America

Attachments

Standard Operating Procedure

Collection of Drinking Water Samples from Private Wells or Public Water Supplies

Revision 0

December 15, 2016

Approved By:

Kevin McGilp		12/15/16
Print Technical Reviewer	Signature	Date

Terri Olson		12/15/16
Print QA Manager	Signature	Date

Review of the SOP has been performed and the SOP still reflects current practice.

Initials: _____ Date: _____

Initials: _____ Date: _____

Initials: _____ Date: _____

Initials: _____ Date: _____

Collection of Drinking Water Samples from Residential Private Wells or Public Water Supplies

Printed Copy is Uncontrolled. Controlled copy is maintained on the internal Barr network. Print a new copy each time a hard copy is required.

1.0 Scope and Applicability

The purpose of this Standard Operating Procedure (SOP) is to describe the methods used for drinking water sample collection from residential private wells or public water supplies.

The recommended procedures in this SOP should be followed unless conditions make it impractical or inappropriate to do so. Modifications should be noted in the applicable documentation and communicated to appropriate personnel. Significant changes may result in a revision or newly created SOP.

2.0 Limitations

- Sample collection methods can vary by project. If not specified in the project scope of work and/or documentation (e.g., Work Plan, Sampling Analysis Plan (SAP), or Quality Assurance Project Plan (QAPP)), consult with the appropriate regulatory agency for guidance.

3.0 Responsibilities

Equipment Technicians are responsible to maintain equipment in working order and aid in troubleshooting equipment issues.

The role of the Project Health and Safety Team Leader is to oversee all aspects of on-site safety activities.

The Project Manager, in conjunction with the client, develops the site specific scope of work (e.g., Work Plan, SAP, etc.).

Experienced Field Technician(s) are responsible for the measurement of field screening procedures, field equipment and calibration, proper sample identification, collection of samples, quality control procedures, and documentation.

Project staff are responsible for ordering sample containers prior to the sampling event.

4.0 Safety

Barr staff is responsible for conducting all aspects of the job safely. When applicable, refer to the appropriate Project Health and Safety Plan (PHASP) to understand the hazards associated with suspected contamination, symptoms of exposure, methods to minimize exposure, personal protection equipment (PPE), and personal air monitoring required when using this SOP. Minimum protection of two pair of chemical resistant gloves (e.g., nitrile) and safety glasses with side shields should be worn to prevent sample contact with the skin and eyes.

Some of the sample containers may require the use of preservatives. Consult the applicable Safety Data Sheet to review hazards and appropriate PPE to minimize exposure.

5.0 Equipment, Reagents, and Supplies

- Water quality meter (e.g., YSI,, or equivalent) (optional)
- Turbidimeter (optional)
- Sample containers (method specific)
- Sample labels
- Coolers
- Chemical resistant gloves (e.g., nitrile)
- Plastic bags
- Waterproof ink pen or pencil
- Custody seal, if applicable
- Ice

6.0 Procedure

This section describes the procedure(s) for calibrating field equipment, and the purging, sampling, handling, and delivery involving drinking water samples.

6.1 Calibration

If field equipment such as a water quality meter or turbidimeter are used, they will be calibrated following the applicable Barr SOP. The meters will undergo calibration checks, at a minimum, before and after sampling. The calibration check will be documented on a calibration form (as appropriate) and/or in the field notebook. Any significant issues found during the calibration check will be noted in the field notebook and the Equipment Technicians will be notified.

6.2 Purging/Sampling

The sampling point should be located ahead of any filtering devices or water conditioners. Select a tap for sampling that is free from exterior contamination and remove anything attached (e.g., aerator, screens, hoses). Check the tap to be sure it is clean. If it is in a state of disrepair, select another sampling location. The tap should be high enough to put a bottle underneath without contacting the mouth of the container with the tap.

6.2.1 Purging

Most public water supplies are generally designed/built with sample taps at various points along treatment or distribution lines and purging (flushing) is not necessary since the systems are constantly running. For the majority of residential drinking water sample collection, purging (flushing) of the in-house lines prior to sampling is performed to remove stagnant water and allow for representative sample collection of the source water; however, this isn't done for all situations. Consult with the Project Manager to determine the protocol for sampling based on the parameters being analyzed and the objectives of the sampling. For example, if analyzing for lead and copper and the sampling objective is to evaluate the 'first flush' or 'first draw' of water, purging of the lines should not be performed.

If the objective is to obtain a representative sample of the water source, open the sampling tap and thoroughly flush. Make certain the water is a steady stream out of the tap and is not leaking by the valve handle. If water is not a steady stream, find a new tap. Generally 3-5 minutes will suffice; however, longer times may be needed. Generally, the water temperature will stabilize which indicates flushing is completed. Other field parameters may be monitored based on project or regulatory agency requirements. The field measurements are taken either by directing the water discharge line through a flow cell or by pouring water into a container holding the water quality meter probe.

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Note: If the intention of the sampling is to remove at least one well and storage tank volume, a longer purging period will be necessary. Twenty minutes is usually sufficient for private residential wells.

6.2.2 Sampling

Samples should be collected from the most volatile towards the least volatile parameter as listed in Barr's 'Water Sampling Guidelines' form. Put on new sampling gloves at each sampling site to reduce the risk of sample cross-contamination and exposure to skin. Never reuse old gloves.

Prepare sampling containers by filling out the label, using an indelible permanent pen, with the following information at a minimum:

- Sample ID
- Date and time of sample collection
- Preservative
- Sample analysis (if required by the lab)

When filling the containers, do not insert any tubing into the containers and do not overfill preserved containers. When all samples are containerized, place the filled sample containers in a sampling cooler with ice, turn off any equipment, disassemble the sampling apparatus, dispose of all one-time use (disposable) equipment, and decontaminate reusable equipment per Barr's SOP 'Decontamination of Sampling Equipment'.

6.2.2.1 Volatile Organic Compounds (VOC)

To prevent the possible loss of some VOCs, samples for volatile parameters should be collected first with as little agitation and disturbance as possible. The 40 mL vials used to collect the VOC samples should be checked for air bubbles. Air bubbles may be caused by insufficient meniscus when sealing the vial, degassing after sample collection or during sample shipment, or reaction between the sample and preservative (HCl). If air bubbles > 6 mm (pea-sized) are observed during sampling, discard the vial and recollect the sample using a new vial. If air bubbles are believed to be due to the sample reacting with the preservative, the sample should be collected in an unpreserved vial if possible.

6.2.2.2 Coliforms

In addition to the items noted under purging, avoid any swiveled faucets if possible when collecting samples for biological testing. Always collect cold water, never sample hot water. Do not touch the inside of the bottle or its cap.

Note: Flaming the end of the tap with a lighter was historically required and can be done but is not necessary if a steady, uninterrupted flow is collected.

6.2.2.3 Lead and Copper

If collecting the sample to comply with the Lead and Copper Rule, the EPA states to not remove any aerators prior to collection as this could mask the added contribution of lead at the tap. Allow the water to sit undisturbed for at least six hours and collect a 'first-flush' or 'first-draw' sample by placing a 1 L bottle under the faucet and opening the tap to collect the first water out. To reduce homeowners' exposure to nitric acid, sample preservation is not required.

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6.2.2.4 Treatment Systems

Parameters to be analyzed may vary based on the treatment system being used. Analyses may be performed on the water before and after the treatment system to ascertain treatment technology effectiveness.

6.2.3 Preservation

Container volume, type, and preservative are important considerations in sample collection. Container volume must be adequate to meet laboratory requirements for quality control, split samples, or repeat analyses. The container type varies with the analysis required. Typically, the analytical laboratory will preserve the container before shipment. Preservation and shelf life vary; contact the laboratory to determine if an on-hand container is still useful. Barr's 'Water Sampling Guidelines' form lists the parameter, container type, container volume, and preservative for many of the most common parameters collected. As noted previously, sample preservation is not required when homeowners are collecting samples for the Lead and Copper Rule.

6.2.4 Handling

The samples will be bubble wrapped or bagged after collection, stored in a sample cooler, and packed on double bagged wet ice. Samples will be kept cold (≤ 6 °C, but not frozen), until receipt at the laboratory (where applicable).

Note: Samples may need to be stored indoors in winter to prevent freezing.

6.2.5 Shipment/Delivery

Once the cooler is packed to prevent breaking of bottles, the proper chain-of-custody (COC) documentation is signed and placed inside a plastic bag then added to the cooler.

All samples will be kept secured to prevent tampering. If sample coolers are left in a vehicle or field office for temporary storage, the area will be locked and secured.

Custody seals may be present, but at a minimum, the coolers must be taped shut to prevent the lid from opening during shipment.

The coolers must be delivered to the laboratory via hand or overnight delivery courier, if possible, in accordance with all Federal, State and Local transportation regulations and Barr's SOP 'Domestic Transport of Samples to the Laboratory'.

6.3 Data Reduction/Calculations

No data reduction or calculations are associated with this procedure.

6.4 Disposal

Waste generated by this process will be disposed of in accordance with Federal, State and Local regulations and Barr's SOP 'Investigative Derived Waste'. Where reasonably feasible, technological changes have been implemented to minimize the potential for environmental pollution.

7.0 Quality Control and Quality Assurance (QA/QC)

The QC activities described below allow the self-verification of the quality and consistency of the work.

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7.1 QA/QC Samples

QA/QC samples are defined in Barr's SOP 'Collection of Quality Control Samples'. The sampling frequency should be performed at the frequency noted in the project scope of work and/or documentation (e.g., Work Plan, SAP, or QAPP).

8.0 Records

The field technician will document any field test measurements on the field log data sheet and/or field notebook. They will also document the type and number of bottles on the chain-of-custody record, as appropriate. The analysis for each container and the laboratory used will be documented on the chain-of-custody record. Refer to Barr's SOP 'Documentation on a Chain-of-Custody (COC)' for further information.

Examples of common field documentation are available in Barr's "Compendium of Field Documentation". Field documentation specific to this SOP are listed below:

- Field Log Data Sheet
- Field Log Cover Sheet
- Field Sampling Report
- Water Sampling Guidelines (includes sampling order, container, preservation, and holding time)

The field documents and COCs are provided to a Barr Data Management Administrator for storage on the internal Barr network.

Additional records information can be found in Barr's "Records Management System Manual".

Other Barr SOP subjects referenced within this SOP: water quality meter, turbidimeter, collection of QC samples, decontamination of sampling equipment, investigative derived waste, domestic transport of samples, and documentation on a COC.

9.0 References

Environmental Protection Agency. *Title 40 of the Code of Federal Regulations, Part 141*.

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1.0 OBJECTIVES

This standard operating procedure (SOP) describes procedures that the Environmental Standards data reviewers will use to validate Perfluorinated Compound (PFC) data for solid samples generated by Eurofins SOP "Perfluorinated Compounds (PFCs) in Solids by Method 537 Modified Using LC/MS/MS" (Eurofins Document Reference 1-P-QM-WI-9035864), "Polyfluorinated Alkyl Substances (PFASs) in Solids by Method 537.1 Modified Using LC/MS/MS" (Eurofins Document Reference 1-P-QM-WI-9039643) or a draft version of "Polyfluorinated Alkyl Substances (PFASs) in Solids by Method 537 Version 1.1 Modified Using LC/MS/MS" (Eurofins Document Reference T-PFAS-WI12031) and aqueous samples generated by Eurofins SOP "Determination of Selected Perfluorinated Alkyl Acids (PFAAs) in Aqueous Samples by LC/MS/MS by Method 537" (Eurofins Document Reference 1-P-QM-WI -9012802), "Polyfluorinated Alkyl Substances (PFASs) in Aqueous Samples by Method 537.1 Modified Using LC/MS/MS" (Eurofins Document Reference 1-P-QM-WI -9039651), or a draft version of "Polyfluorinated Alkyl Substances (PFASs) in Aqueous Samples by Method 537 Revision 1.1 Using LC/MS/MS" (Eurofins Document Reference T-PFAS-WI14355) for various Saint-Gobain Performance Plastics Corporation (Saint-Gobain) sites. Validation will be performed to assess compliance of the sample data to these Eurofins SOPs and any applicable Work Plans and/or Quality Assurance Project Plans (QAPPs). In addition, the usability of the PFC data provided by the analytical laboratory will be determined based on the general guidance provided in the "National Functional Guidelines for Organic Superfund Data Review" (US EPA, September 2016) and "National Functional Guidelines for High Resolution Superfund Methods Data Review (USEPA, April 2016). It should be noted that the National Functional Guidelines apply strictly to data generated by the Contract Laboratory Program (CLP) protocol and are not directly applicable to validation of data generated by Modified EPA Method 537; therefore, this SOP presents the specific data qualification actions that will be used for validation.

The validation findings will be presented in a quality assurance review (QAR) that will be prepared for one or more sample delivery groups (SDGs). Copies of annotated analytical results summaries (Form I's), including any changes to the analytical results and data qualifier codes, or a data summary spreadsheet of the qualified analytical results, will be included in the support documentation of the QAR.

2.0 EVALUATION TOOLS

- field duplicate form (DVF_DUP_SG_ELLE.xlsm)

Chemistry Applications:

- Curve fitting software (DVF_CAL.xlsm)
- Methods Database

3.0 REFERENCE DOCUMENTS

- "National Functional Guidelines for Organic Superfund Data Review" (US EPA, September 2016)

- "National Functional Guidelines for High Resolution Superfund Methods Data Review (USEPA, April 2016).

- Eurofins Document Reference 1-P-QM-WI -9035864.

- Eurofins Document Reference 1-P-QM-WI -9012802.

- Eurofins Document Reference 1-P-QM-WI -9039643.
- Eurofins Document Reference 1-P-QM-WI -9039651.
- Eurofins Document Reference T-PFAS-WI12031.
- Eurofins Document Reference T-PFAS-WI14355.
- US EPA Method 537, Version 1.1 (September 2009).
- Guidance for Labelling Externally Validated Laboratory Analytical Data for Superfund Use (EPA 540-R-08-005, 2009).

4.0 PROCEDURE

4.1 EVALUATION OF METHOD COMPLIANCE

The data reviewer will assess the method compliance of the PFC data based on an evaluation of information presented in the data package deliverables. Compliance to the aforementioned SOPs (and Work Plan and/or QAPP when applicable) will be evaluated as part of the assessment. In addition, the deliverables will be evaluated for reporting errors and inconsistencies. The findings of the compliance assessment will be described in terms of comments/deficiencies about the data/deliverables and presented in two subdivisions (*i.e.*, Reporting Issues and Procedural Issues) of the Organic Data Evaluation Section of the QAR. Each issue discussed in the QAR will indicate any subsequent impact on the usability of the data or will identify aspect(s) of the data that could not be evaluated due to the deficiency.

The data reviewer may contact the project laboratory to request the correction of deficiencies prior to submittal of the QAR (if feasible and sanctioned by Saint Gobain). At a minimum, corrections required to allow for a full evaluation of the usability of the data should be requested. Such correctable deficiencies may include sample result errors, missing data deliverables, or calculation errors that would require a significant amount of the data reviewer's time to correct. Any laboratory resubmittals as a result of such requests will be discussed in the Reporting Issue subdivision of the QAR and included as an attachment to the QAR.

4.2 DETERMINATION OF DATA USABILITY

The data reviewer will determine the usability of the PFC data based on an evaluation of the information presented in the data package deliverables. The findings of the PFC data usability assessment will be presented in terms of data qualifications that the project team should consider in order to best utilize the data; these qualifications will be presented in the Organic Data Qualifier subsection of the QAR. Each qualification discussed in the QAR will indicate that the affected sample result(s) has been flagged with a representative qualifier code(s) in the data tables to provide, at a glance, an indication of the quantitative and qualitative reliability of each analytical result. In general, the qualifier statements will be presented in the QAR in the following order: blank contamination (UB), unusable results (R/UR), estimated results (J/UJ), tentative identifications of target compound results (N), and a general qualifier for all results reported below the limit of quantitation (if applicable). In addition, a Validation Reason Code will be presented on the data tables to indicate the reason that a qualifier code has been applied.

The data reviewer's criteria for evaluating the usability of the PFC data and the resultant qualifications and reason codes will be as stipulated on the attached Table for the Validation of PFC Data Generated. Additional qualifications and reason codes will be assigned based on professional judgement. It should be noted that the project manager should be consulted when "professional judgement" use is indicated on the attached table.

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Temperature Upon Receipt	≤6°C	If temperature is <2°C, no action is required unless samples were frozen/broken and then professional judgment should be used. If temperature is >6°C but ≤20°C, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "SPL") If temperature is > 20°C, qualify positive results as estimated ("J") and qualify "not-detected" results as unusable ("R"). (Validation Reason Code "SPL") Note time of collection relative to receipt at laboratory. Professional judgement should be used if < 8 hours has elapsed from collection to receipt at the laboratory to determine if qualification due to elevated temperature applies.
Technical Holding Time	Solid samples should be extracted within 28 days of sample collection and aqueous samples should be extracted within 14 days of collection. All extracts should be analyzed within 28 days after extraction.	If a holding time is exceeded, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "HPL" or "HAL" for extraction or analysis holding time exceedance, respectively) If a holding time is grossly exceeded (*i.e.*, > twice the holding time), qualify positive results as estimated ("J") and qualify "not-detected" results as unusable ("R"). (Validation Reason Code "HPL" or "HAL" for extraction or analysis holding time exceedance, respectively)

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Initial Calibration (See Note #1 for additional information.)	Back calculated concentration of each calibration point should be within 70-130% of true value. The level 1 (lowest) calibration standard back calculated concentrations should be within 50-150% of true value. Analytes without a labeled internal standard back calculated concentrations should be within 60-140% of true value (except for Eurofins Document References T-PFAS-WI12031 and T-PFAS-WI14355, where the criteria for analytes without a labeled internal standard is 50-150% of true value for the lowest level standard and 70-130% of true value for the remaining standards).	**When evaluating initial calibration, use professional judgment to first assess impact of any out-of-criteria labeled PFC on the corresponding target PFC(s).** If the low point or consecutive points at the low end of the curve are below the lower recovery criteria, qualify positive results < lowest compliant point as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "ICL") If the low point or consecutive points at the low end of the curve are above the upper recovery criteria, qualify positive results < lowest compliant point as estimated ("J"). (Validation Reason Code "ICH") If a point in the middle of the curve or non-consecutive points (beside the low point) quantitate outside of criteria, qualify positive results as estimated ("J"). If the high point or consecutive points at the upper end of the curve quantitates outside of criteria, qualify positive results > highest compliant point as estimated ("J"). (Validation Reason Code "ICL," "ICH," or "IC," are to be used based on whether direction of bias can be determined in these situations) Professional judgement should be used to qualify "not-detected" results as estimated ("UJ") if low recoveries are observed for standards other than the lowest calibration point. (Validation Reason Code "ICL")

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Second Source Initial Calibration Verification (ICV)	1. Calculated amount for each compound should be within 70-130% (±30%) of the true value. Analytes without a labeled extraction standard should have calculated amounts within 60-140% (±40%) of the true value. 2. The isotopically labeled injection and/or extraction standards should be within criteria.	**Qualification is for all samples associated with initial calibration being verified.** **When evaluating ICV, use professional judgment to first assess impact of any out-of-criteria labeled PFC on the corresponding target PFC.** If target PFC has %D>30% (or >40% for compounds without labeled extraction standards) with the response indicating a sensitivity increase, qualify positive results as estimated ("J") and do not qualify "not-detected" results. (Validation Reason Code "SSH") If target PFC has %D>30% (or >40% for compounds without labeled extraction standards) but ≤90%, with the response indicating a sensitivity decrease, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "SSL") If target PFC has %D>90% with the response indicating a sensitivity decrease , qualify positive results as estimated ("J") and qualify "not-detected" results as unusable ("R"). (Validation Reason Code "SSL")
Daily Calibration Verification (See Note #2 for additional information.)	Calculated amount should be within ±30% of the true value. Compounds without labeled extraction standards should have calculated amounts within ±40% of the true value. The isotopically labeled injection and/or extraction standards should be within criteria.	**Qualification is for all samples on both sides of the out-of-criteria calibration verification standards**. **When evaluating calibration verification, use professional judgment to first assess impact of any out-of-criteria labeled PFC on the corresponding target PFC.** If target PFC has %D>30% (or >40% for compounds without labeled extraction standards) with the response indicating a sensitivity increase, qualify positive results as estimated ("J") and do not qualify "not-detected" results. (Validation Reason Code "CVH") If target PFC has %D>30% (or >40% for compounds without labeled extraction standards) but ≤90%, with the response indicating a sensitivity decrease, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "CVL") If target PFC has %D>90% with the response indicating a sensitivity decrease , qualify positive results as estimated ("J") and qualify "not-detected" results as unusable ("R"). (Validation Reason Code "CVL")

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Blanks (See Note #3 for additional information.)	Summarize all results greater than the method detection limit (MDL) present in the blanks. The highest positive result associated with a sample should be utilized for evaluation of contamination.	If a target PFC is found in the blank but not in the associated sample(s), no action is required. If a sample result is ≤5× the blank result, qualify the positive result as "not detected" ("UB") and raise the method detection limit (MDL) and/or limit of quantitation (LOQ) (if lower than original reported positive result) to the value of the original result. (Validation Reason Code(s) "EB," FB," "IB," "MB," and or "TB," as appropriate). If a sample result is >5× blank result, qualification is not required. Professional judgement should be used to evaluate whether an aqueous blank should be used to qualify a solid sample.
Injection/Internal Standards (Labelled Analytes, spiked prior to injection and used as internal standards for extraction standards) (Eurofins Document References T-PFAS-WI12031 and T-PFAS-WI14355 only)	The response for each internal standard in the original sample must be within ±%50 of the average initial calibration response (Eurofins Document References T-PFAS-WI12031 and T-PFAS-WI14355 only).	If an internal response is outside of criteria, use professional judgment to determine the potential impact on the quantitation of the extraction standard recoveries and whether qualification due to out-of-criteria extraction standard recoveries (see directly below) should be modified.
Extraction Standards (Labelled Analytes, spiked prior to extraction and used as internal standards for target compounds)	The response for each ES in the original sample (prior to dilutions) must be within ±%50 of the average initial calibration response (except for Eurofins Document References T-PFAS-WI12031 and T-PFAS-WI14355, where the criteria is 70-130% recovery).	If an ES response or recovery is outside of criteria but ≥10%, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ") for PFCs quantitated using that ES. (Validation Reason Code "IS") If an ES response is < 10%, qualify positive results for the associated PFCs as estimated ("J") and qualify "not-detected" results for the associated PFCs as estimated ("UJ") or unusable ("R") using professional judgment (based on the approximate signal-to-noise ratio for the ES and the expected response for the target PFC at the LOQ). (Validation Reason Code "IS")

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Laboratory Control Samples (LCS)/ Laboratory Control Sample Duplicates (LCSD)	%R within 70-130%, RPD ≤ 30%.	**The LCS qualification will be applied to all samples in the preparation batch.** If the recovery is > 130%, qualify positive results in all associated samples as estimated ("J") and do not qualify "not-detected" results. (Validation Reason Code "LAH") If the recovery is < 70%, qualify positive results in all associated samples as estimated ("J") and qualify "not-detected" results in all associated samples as estimated ("UJ"). (Validation Reason Code "LAL") If the recovery is < 30%, qualify positive results in all associated samples as estimated ("J") and qualify "not-detected" results in all associated samples as unusable ("R"). (Validation Reason Code "LAL") If the precision between recoveries exceeds the RPD criterion, qualify positive results as estimated ("J") and do not qualify "not-detected" results. (Validation Reason Code "LP")
Matrix Spike/Matrix Spike Duplicate (MS/MSD) (If performed)	%R within 70-130%, RPD ≤ 30%.	**The MS/MSD qualification will be applied to all samples in the preparation batch.** Data should not be qualified due to %Rs (or RPDs calculated on %Rs) that are outside of criteria if the original concentration of a PFC is >4× the spiking level for that compound. In such cases, RPDs calculated using MS/MSD results can be used to evaluate precision. If the recovery is > 130%, qualify positive results in all associated samples as estimated ("J") and do not qualify "not-detected" results. (Validation Reason Code "MAH") If the recovery is < 70%, qualify positive results in all associated samples as estimated ("J") and qualify "not-detected" results in all associated samples as estimated ("UJ"). If the recovery is < 30%, qualify positive results in all associated samples as estimated ("J") and qualify "not-detected" results in all associated samples as unusable ("R"). (Validation Reason Code "MAL") If the precision between recoveries exceeds the RPD criterion, qualify the positive result in the native sample as estimated ("J") and do not qualify the "not-detected" result. (Validation Reason Code "MP")

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Field/Laboratory Duplicate (See Note #4 for additional information)	The RPD should be ≤30% when both results are >5× the sample-specific LOQ (RL). The difference between results should be ≤ 1.5×LOQ when at least one result is ≤5× the LOQ.	**If both results are <LOQ, a quantitative assessment of duplicate precision is not performed.** If the criteria are not met, qualify positive results for the out-of-criteria PFCs in the original sample and its duplicate as estimated ("J"). (Validation Reason Code "LD" for laboratory duplicate or "FD" for field duplicate) Use the MDL as a numerical value for any "not-detected" result in the difference calculation. Qualify "not-detected" results as estimated ("UJ") if the difference between the results is outside of criteria. (Validation Reason Code "LD" for laboratory duplicate or "FD" for field duplicate)
Percent Solids	Solid samples with less than 30% solid content require qualification.	If a solid sample has a percent solid content <30%, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code of "PS") Use professional judgment to qualified "not-detected" results as unusable ("R") if a solid sample has a percent solids content <10%. (Validation Reason Code of "PS")
Compound Quantitation and Qualitative Identification (See Notes #5 for additional information.)	Samples with results that exceed the instrument calibration range should be reanalyzed at a dilution or re-extracted with a lower volume.	If a target PFC result exceeds the instrument calibration range, qualify positive result as estimated ("J"). (Validation Reason Code "EC") Use professional judgment to determine whether sample reanalyses and dilutions should be compared to the original analyses. If criteria (see field duplicate usability) between the original sample results and the reanalysis sample results are not met, qualify positive results as estimated ("J") and qualify "not-detected" results as estimated ("UJ"). (Validation Reason Code "LD") If a target PFC is <LOQ but ≥MDL, qualify positive results as estimated ("J"). (Validation Reason Code "RL") Use professional judgment to determine whether quantitation and qualitative identifications are accurate and whether data qualification is necessary.
System Performance	Professional judgement should be used when assessing the degradation of system performance during analyses.	Use professional judgment to qualify the data if it is determined that system performance degraded during sample analyses.

Table for the Validation of PFC Data

Quality Control Item	Usability Criteria	Action
Overall Assessment of Data	Assess overall quality of the data. Review available materials to assess the quality, keeping in mind the additive nature of the analytical problems.	Use professional judgment to determine the need to qualify data not qualified based on the QC previously discussed. Write a brief narrative to give the user an indication of the analytical limitations of the data. If sufficient information on the intended use and required quality of the data is available, include the assessment of the usability of the data within the given context.

Validation Notes

1. Use professional judgment when evaluating the response intercept of a calibration curve. If the response intercept is positive, the samples should be evaluated for false positives. If the response intercept is negative, the sample should be evaluated for false negatives.

2. If instrument instability (*i.e.*, several calibration verification standards with PFCs exhibiting both increasing and decreasing sensitivity throughout an analytical sequence) is observed in the analysis of sequential calibration verification standards, "not-detected" results may be qualified as estimated ("UJ") due to instrument sensitivity of a continuing calibration standard response that is greater than the initial calibration standard response (increase in instrument sensitivity).

3. The frequency of equipment/rinse blanks is determined during the sampling event. The results of an equipment/rinse blank should be applied to all collected in the same day by the same techniques, unless only one blank was collected for a several-day sampling event. In instances where more than one blank is associated with a given sample, qualification should be based upon a comparison with the associated blank having the highest concentration of a contaminant. Professional judgement should be used to evaluate whether an aqueous blank should be used to directly qualify a solid sample.

   Method blank contamination should be applied to samples in the preparation batch.

   Instrument blank contamination should be applied to samples bracketing the contaminated instrument blank.

   Blanks should also be evaluated using professional judgment for non-target interference.

Validation Notes

4. Duplicate samples may be collected and analyzed as an indication of overall precision. Field duplicate analyses measure both field and laboratory precision; therefore, the results may have more variability than laboratory duplicates that measure only laboratory performance. Laboratory duplicate results and field duplicate results apply only to the original sample and the laboratory/field duplicate. Solid duplicate results are expected to have greater variance than aqueous duplicate results.

5. If a sample result exceeds the instrument calibration range (lower dilution analysis) or is less than the LOQ (secondary dilution), do not utilize this result when comparing an original analysis and a diluted reanalysis.

   Poor chromatographic performance may affect qualitative identification and/or quantitation. Indications of substandard performance include:

   - High background levels
   - Extraneous peaks
   - Loss of resolution

- Peak tailing or peak splitting that may result in inaccurate quantitation
- The laboratory analyzes a Cal3 level standard that contains linear and branch chained isomers of PFOA, PFOS, and PFHxS for analyses by Eurofins Document References 1-P-QM-WI-9039643, 1-P-QM-WI -9039651, T-PFAS-WI12031 and T-PFAS-WI14355. The analysis of this standard is used to demonstrate where the branch chained isomers elute and is not included in the calibration curve. This will assist the chemist in the integration of branched isomers of these compounds in samples.

Title: Per- and Polyfluorinated Substances (PFAS) in Water, Soils, Sediments and Tissue

[Method 537 (Modified)]

Approvals (Signature/Date):

Robert Hrabak 4/21/17 Technical Manager Date	Joe Schairer 4/24/17 Health & Safety Manager / Coordinator Date
Lisa Stafford 4/21/17 Quality Assurance Manager Date	Crystal Pollock 4.24.17 Laboratory Manager Date

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1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water, soil, sediment and tissue samples for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS).

Compound Name	Abbreviation	CAS #
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-butanoic acid	PFBA	375-22-4
Perfluoro-n-pentanoic acid	PFPeA	2706-90-3
Perfluoro-n-hexanoic acid	PFHxA	307-24-4
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluoro-n-decanoic acid	PFDA	335-76-2
Perfluoro-n-undecanoic acid	PFUdA (PFUnA)	2058-94-8
Perfluoro-n-dodecanoic acid	PFDoA	307-55-1
Perfluoro-n-tridecanoic acid	PFTrDA	72629-94-8
Perfluoro-n-tetradecanoic acid	PFTeDA (PFTA)	376-06-7
Perfluoro-n-hexadecanoic acid	PFHxDA	67905-19-5
Perfluoro-n-octadecanoic acid	PFODA	16517-11-6
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-heptanesulfonic acid	PFHpS	375-92-8
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1
Perfluoro-1-decanesulfonic acid	PFDS	335-77-3
Perfluorinated sulfonamides (FOSA)		
Perfluoro-1-octanesulfonamide	FOSA	754-91-6
N-ethylperfluoro-1-octanesulfonamide	EtFOSA	4151-50-2
N-methylperfluoro-1-octanesulfonamide	MeFOSA	31506-32-8
Perfluorinated sulfonamidoacetic acids (FOSAA)		
N-ethylperfluoro-1-octanesulfonamidoacetic acid	EtFOSAA	2991-50-6
N-methylperfluoro-1-octanesulfonamidoacetic acid	MeFOSAA	2355-31-9
Fluorotelomer sulfonates (FTS)		
1H,1H,2H,2H-perfluorooctane sulfonate *(6:2)*	6:2 FTS	27619-97-2
1H,1H,2H,2H-perfluorodecane sulfonate *(8:2)*	8:2 FTS	39108-34-4

Abbreviations in parenthesis are the abbreviations listed in Method 537, where they differ from the abbreviation used by the laboratory's LIMS.

Sample results for PFOA may also be reported as APFO, at the request of the client. (See Section 12.7)

1.2. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	Nominal Sample Size	Reporting Limit	Working Range
Water	250 mL	2.0 ng/L – 100 ug/L	2.0 ng/L to 400 ug/L
Soil/Sediment/Tissue	5 g	0.2 ug/kg – 20 ug/kg	0.2 to 100 ug/kg

1.3. The procedure for the analysis of water samples via in line solid phase extraction (SPE) for a subset of the list in Section 1.1 using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500 is described in the Appendix to this SOP.

1.4. This procedure also includes direction for preparing and analyzing samples to determine "Total Oxidizable Precursors", which may assist in improving understanding of potential PFAS environmental risk.

1.5. When undertaking projects for the Department of Defense (DoD) and/or the Department of Energy (DOE) the relevant criteria in QA Policy WS-PQA-021, "Federal Program Requirements" must be checked and incorporated.

2. SUMMARY OF METHOD

2.1. Water samples are extracted using a solid phase extraction (SPE) cartridge, unless EtFOSA and MeFOSA are requested. PFAS are eluted from the cartridge with an ammonium hydroxide/methanol solution.

2.2. Soil samples are extracted with a KOH/methanol solution using an orbital shaker for 3 hours followed by sonication for 12 hours. The mixture is centrifuged and the solvent filtered.

2.2.1. Optional cleanups may include sample freezing and/or cleanup by SPE cartridge, unless EtFOSA and MeFOSA are requested.

2.3. The final 80:20 methanol:water extracts are analyzed by LC/MS/MS. PFAS are separated from other components on a C18 column with a solvent gradient program using 20 mM ammonium acetate/water and methanol. The mass spectrometer detector is operated in the electrospray (ESI) negative ion mode for the analysis of PFAS.

2.4. An isotope dilution technique is employed with this method for most compounds of interest. The isotope dilution analytes (IDA) consist of carbon-13 labeled analogs, oxygen-18 labeled analogs or deuterated analogs of the compounds of interest, and

they are spiked into the samples at the time of extraction. This technique allows for the correction for analytical bias encountered when analyzing more chemically complex environmental samples. The isotopically labeled compounds are chemically similar to the compounds of concern and are therefore affected by sample-related interferences to the same extent as the compounds of concern. Compounds that do not have a labeled analog are quantitated by the IDA method using a closely related labeled analog.

2.5. Quantitation by the external standard method is employed for the IDA analytes and assumes a proportional relationship between the initial calibration and the analyte in the extract. The ratio of the peak response to mass or concentration injected is used to prepare a calibration curve. Peak response is measured as the area of the peak.

2.6. Samples for the "Total Oxidizable Precursor" assay (TOP) are analyzed in two phases – an aliquot is prepared and analyzed as a normal sample, and a second aliquot is subjected to oxidation with potassium persulfate and sodium hydroxide prior to solid phase extraction and analysis. The total perfluorocarboxylic acid value is determined for each aliquot, and the difference calculated.

3. DEFINITIONS

3.1. PFCAs: Perfluorocarboxylic acids

3.2. PFSAs: Perfluorinated sulfonates

3.3. FOSA: Perfluorinated sulfonamides

3.4. PFOA: Perfluorooctanoic acid (may also be written PHOA).

3.5. APFO: Ammonium perfluorooctanoate

3.6. PFOS: Perfluorooctane sulfonate (may also be written PHOS)

3.7. MPFOA: Perfluoro-n-[1,2,3,4-13C4]octanoic acid. Carbon-13 labeled PFOA

3.8. MPFOS: Perfluoro-1-[1,2,3,4-13C4]octanesulfonate. Carbon-13 labeled PFOS

3.9. PTFE: Polytetrafluoroethylene (e.g., Teflon®)

3.10. SPE: Solid phase extraction.

3.11. PP: Polypropylene

3.12. PE: Polyethylene

3.13. HDPE: High density polyethylene

3.14. IDA: Isotope dilution analytes

3.15. Further definitions of terms used in this SOP may be found in the glossary of the Laboratory Quality Assurance Manual (QAM).

4. INTERFERENCES

4.1. PFAS have been used in a wide variety of manufacturing processes, and laboratory supplies should be considered potentially contaminated until they have been tested and shown to be otherwise. The materials and supplies used during the method validation process have been tested and shown to be clean. These items are listed below in Section 6.

4.2. To avoid contamination of samples, standards are prepared in a ventilation hood in an area separate from where samples are extracted.

4.3. PTFE products can be a source of PFOA contamination. The use of PTFE in the procedure should be avoided or at least thoroughly tested before use. Polypropylene (PP) or polyethylene (PE, HDPE) products may be used in place of PTFE products to minimize PFOA contamination.

4.3.1. Standards and samples are injected from polypropylene autosampler vials with polypropylene screw caps once. Multiple injections may be performed on Primers when conditioning the instrument for analysis.

4.3.2. Random evaporation losses have been observed with the polypropylene caps causing high IDA recovery after the vial was punctured and sample re-injected. For this reason, it is best to inject standards and samples once in the analytical sequence.

4.3.3. Teflon-lined screw caps have detected PFAS at low concentrations. Repeated injection from the same teflon-lined screw cap have detected PFNA at increasing concentration as each repeated injection was performed, therefore, it is best to use polypropylene screw caps.

4.4. Volumetric glassware and syringes are difficult to clean after being used for solutions containing high levels of PFOA. These items should be labeled for use only with similarly concentrated solutions or verified clean prior to re-use. To the extent possible, disposable labware is used.

4.5. Commercial sources of PFOS, PFHxS, PFOA, and other PFAS may produce several peaks in the chromatogram. These adjacent peaks are either completely resolved or not resolved but with a profound deflection that can be resolved during peak integration. The later of the peaks matches the retention time of the single labeled PFAS peak. In general, earlier peaks are branched isomers and are not a result of peak splitting. When

reference standards of technical mixtures of specific PFAS area available, they should be used to ensure that all appropriate peaks are included during peak integration. Refer to Section 7, Reagents, for the available technical mixtures utilized by this SOP.

4.6. The phenomenon of the linear and branched isomers of PFOS exists for other PFAS, such as PFHxS and PFBS. Thus, in an attempt to reduce PFOS bias, it is required that *m/z* 449>80 transition be used as the quantitation transition.

4.7. Both branched and linear PFAS can potentially be found in the environment. For the compounds that give rise to more than one peak, all the chromatographic peaks observed in the standard and/or sample must be integrated and the areas included.

4.8. Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.15 pg/L or 0.01 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

5. SAFETY

Employees must abide by the policies and procedures in the Corporate Safety Manual, Sacramento Supplement to the CSM, and this document. All work must be stopped in the event of a known or potential compromise to the health or safety of an associate. The situation must be reported **immediately** to a supervisor, the EH&S Staff, or a senior manager.

5.1. Specific Safety Concerns

5.1.1. Preliminary toxicity studies indicate that PFAS could have significant toxic effects. In the interest of keeping exposure levels as low as reasonably achievable, PFAS must be handled in the laboratory as hazardous and toxic chemicals.

5.1.2. Exercise caution when using syringes with attached filter disc assemblies. Application of excessive force has, upon occasion, caused a filter disc to burst during the process.

5.1.3. Laboratory procedures such as repetitive use of pipets, repetitive transferring of extracts and manipulation of filled separatory funnels and other glassware represent a significant potential for repetitive motion or other ergonomic injuries. Laboratory associates performing these procedures are in the best position to realize when they are at risk for these types of injuries. Whenever a situation is found in which an employee is performing the same repetitive motion, the employee shall immediately bring this to the attention of their supervisor, manager, or the EH&S staff. The task will be analyzed to determine a better means of accomplishing it.

5.1.4. Eye protection that satisfies ANSI Z87.1 (as per the TestAmerica Corporate

Safety Manual), laboratory coat, and nitrile gloves must be worn while handling samples, standards, solvents, and reagents. Disposable gloves that have been contaminated will be removed and discarded; other gloves will be cleaned immediately.

5.1.5. Perfluorocarboxylic acids are acids and are not compatible with strong bases.

5.1.6. The use of vacuum systems presents the risk of imploding glassware. All glassware used during vacuum operations must be thoroughly inspected prior to each use. Glass that is chipped, scratched, cracked, rubbed or marred in any manner must not be used under vacuum. It must be removed from service and replaced.

5.1.7. Glass containers are not to be used for "tumbling" soil samples.

5.2. Primary Materials Used

The following is a list of the materials used in this method, which have a serious or significant hazard rating. NOTE: This list does not include all materials used in the method. The table contains a summary of the primary hazards listed in the SDS for each of the materials listed in the table. A complete list of materials used in the method can be found in the reagents and materials section. Employees must review the information in the SDS for each material before using it for the first time or when there are major changes to the SDS.

Material[(1)]	**Hazards**	**Exposure Limit[(2)]**	**Signs and Symptoms of Exposure**
Acetic Acid (3-2-1)	Corrosive Poison Flammable	10 ppm-TWA 15 ppm-STEL	Contact with concentrated solution may cause serious damage to the skin and eyes. Inhalation of concentrated vapors may cause serious damage to the lining of the nose, throat, and lungs. Breathing difficulties may occur.
Ammonium Hydroxide (3-0-0)	Corrosive Poison	50 ppm-TWA	Severe irritant. Effects from inhalation of dust or mist vary from mild irritation to serious damage to the upper respiratory tract. Symptoms may include sneezing, sore throat or runny nose. Contact with skin can cause irritation or severe burns and scarring with greater exposures. Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent damage, including blindness. Brief exposure to 5000 PPM can be fatal.

Material[1]	Hazards	Exposure Limit[2]	Signs and Symptoms of Exposure
Hexane (2-3-0)	Flammable Irritant	500 ppm-TWA	Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Vapors may cause irritation to the skin and eyes.
Hydrochloric Acid (3-0-1)	Corrosive Poison	5 ppm (Ceiling)	Can cause pain and severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause deep ulcerations to skin, permanent eye damage, circulatory failure and swallowing may be fatal.
Methanol (2-3-0)	Flammable Poison Irritant	200 ppm (TWA)	A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Symptoms of overexposure may include headache, drowsiness and dizziness. Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure. Irritant to the eyes.
Potassium Hydroxide (3-0-1)	Corrosive Poison		Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.
Potassium Persulfate (2-0-1-OX)	Oxidizer	None	Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath. Causes irritation to skin and eyes. Symptoms include redness, itching, and pain. May cause dermatitis, burns, and moderate skin necrosis.
Sodium Hydroxide (3-0-1)	Corrosive Poison	2 mg/cm^3 (Ceiling)	Severe irritant. Can cause severe burns upon inhalation, ingestion, eye or skin contact. Exposure to concentrated solutions may cause severe scarring of tissue, blindness, and may be fatal if swallowed.

(1) Always add acid to water to prevent violent reactions.
(2) Exposure limit refers to the OSHA regulatory exposure limit.

6. EQUIPMENT AND SUPPLIES

6.1. 15 mL polypropylene test tubes with polypropylene screw caps.

6.2. 50 mL graduated plastic centrifuge tubes.

6.3. 125 mL HDPE wide-mouth bottles.

6.4. 125 mL HDPE containers with screw caps.

6.5. 16 oz or 500 mL HDPE bottles with HDPE screw caps.

6.6. Analytical balance capable of accurately weighing to the nearest 0.0001g, and checked for accuracy each day it is used in accordance with WS-QA-0041.

6.7. Syringe filter, Millipore Millex-HV 0.45 um, or equivalent. Do not use PTFE type filters.

6.8. 300 µL autosampler vials, polypropylene, with polypropylene screw caps, Waters PN 1860004112, or equivalent.

6.9. SPE columns

6.9.1. Phenomenex Strata SPE C18, 6 mL, 500 mg, part number 8B-S002-HCH, Waters SepPak C18, 1 to 10g, or equivalent.

6.9.2. Waters Oasis WAX 150 mg/6 cc (PN 186002493) for the cleanup of solids.

6.9.3. Waters Oasis WAX 500 mg/6 cc (PN 186004647) for extraction of PFAS from aqueous sample.

6.9.4. Phenomonex Gemini 3 µm C18 110Å, 50 X 2 mm, Part No. 00B-4439-B0.

6.9.5. Phenomonex Luna 5 µm C18(2) 100Å, 30 X 3 mm, Part No. 00A-4252-Y0.

6.10. Granulated carbon.

6.11. Vacuum manifold for Solid Phase Extraction (SPE).

6.12. Miscellaneous laboratory apparatus (beakers, test tubes, volumetric flasks, pipettes, etc.). These should be disposable where possible, or marked and segregated for high-level versus low-level use.

6.13. Water bath: Heated with concentric ring cover capable of temperature control (±5°C) up to 95°C. The bath must be used in a fume hood.

6.14. Plastic tub for an ice bath, AKRO-N.S.T. part No. 35-180 or equivalent.

6.15. pH indicator paper, wide range.

6.16. Bottle rotating apparatus for soil extractions.

6.17. Glass fiber filter, Whatman GF/F, catalog number 1825 090 or equivalent.

6.18. Liquid Chromatography/Tandem Mass Spectrometer (LC/MS/MS) – Either of the instruments described below, or equivalent, may be used for this method. Both HPLC are equipped with a refrigerated autosampler, an injection valve, and a pump capable of variable flow rate. The use of a column heater is required to maintain a stable temperature throughout the analytical run. Data is processed using Chrom Peak Review, version 2.1 or equivalent.

6.18.1. Waters LC/MS/MS

This consists of a Waters Acquity UPLC system interfaced with a Waters Quattro Premiere tandem mass spectrometer. The instrument control and data acquisition software is MassLynx version 4.1, or equivalent.

6.18.1.1. Analytical column: Waters Acquity UPLC BEH C18 1.7 um, 3.0 mm x 150 mm, Part No. 186004690,

6.18.1.2. PFAS Isolator column, Waters Acquity UPLC BEH Shield RP-18, 1.7 um, 2.1 mm x 50 mm, PN 186004476, or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters.

6.18.2. SCIEX LC/MS/MS

This system consists of a Shimadzu HPLC interfaced with a SCIEX 5500 Triple Quad MS. The instrument control and data acquisition software is SCIEX Analyst, version 1.6.3 or equivalent.

6.18.2.1. Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent.

6.18.2.2. Phenomenex Gemini C_{18} 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent.

6.18.2.3. PFAS Isolator column, Phenomenex Luna C_{18} 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E0 or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters.

6.19. Preventive and routine maintenance is described in the table below

HPLC/MS/MS Preventative Maintenance
As Needed:
Change pump seals.
Change in-line filters in autosampler (HPLC).
Check/replace in-line frit if excessive pressure or poor performance.
Replace column if no change following in-line frit change.
Clean corona needle.
Replace sample inlet tube in APCI (10.1 cm).
Replace fused silica tube in ESI interface.
Clean lenses.
Clean skimmer.
Ballast rough pump 30 minutes.
Daily (When in use)
Check solvent reservoirs for sufficient level of solvent.
Verify that pump is primed, operating pulse free.
Check needle wash reservoir for sufficient solvent.
Verify capillary heater temperature functioning.
Verify vaporizer heater temperature.
Verify rough pump oil levels.
Verify turbo-pump functioning.
Verify nitrogen pressure for auxiliary and sheath gasses.
Verify that corona and multiplier are functioning.
Semi-Annually
Replace rough-pump oil (4-6 months).
Replace oil mist and odor elements.
Replace activated alumina filter if applicable.
Annually
Vacuum system components including fans and fan covers.
Clean/replace fan filters, if applicable.

7. REAGENTS AND STANDARDS

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Acetic acid, glacial

7.1.2. Ammonium acetate (20 mM in water)

7.1.3. Ammonium hydroxide (NH4OH), 0.3% in methanol

7.1.4. Hexane

7.1.5. Hydrochloric acid (HCl), 2.0 M solution in water

7.1.6. Hydrochloric acid (HCl), concentrated, reagent grade

7.1.7. Methanol

7.1.8. Potassium hydroxide (KOH), 0.4% in methanol

7.1.9. Potassium persulfate, reagent grade

7.1.10. Ottawa Sand

7.1.11. Sodium hydroxide (NaOH), 0.1N, in water

7.1.12. Sodium hydroxide (NaOH), 10N, reagent grade

7.1.13. Water, Nanopure or Millipore, must be free of interference and target analytes

7.2. Standards

7.2.1. PFAS are purchased as high purity solids (96% or greater) or as certified solutions. Standard materials are verified compared to a second source material at the time of initial calibration. The solid stock material is stored at room temperature or as specified by the manufacturer or vendor.

7.2.1.1. Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.15 pg/L or 0.01 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

7.2.2. If solid material is used for preparing a standard, stock standard solutions are prepared from the solids and are stored at 4 ± 2°C. Stock standard solutions should be brought to room temperature before using. Standards are monitored for signs of degradation or evaporation. Standard solutions must be replaced at least annually from the date of preparation.

7.2.3. PFBS, PFHxS, PFHpS, PFOS, PFDS, MPFOS, and many other PFAS are not available in the acid form, but rather as their corresponding salts, such as sodium or potassium. The standards are prepared and corrected for their salt content according to the equation below.

$Mass_{acid}$ = Measured $Mass_{salt} \times MW_{acid} / MW_{salt}$

Where: MW_{acid} is the molecular weight of PFAA
MW_{salt} is the molecular weight of the purchased salt.

7.2.4. For example, the molecular weight of PFOS is 500.1295 and the molecular weight of NaPFOS is 523.1193. Therefore, the amount of NaPFOS used must be adjusted by a factor of 1.046

7.3. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of PFOA and PFOS stock solutions in 80% methanol/water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.4. Initial Calibration (ICAL) Levels (ng/mL)

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Perfluoroalkylcarboxylic acids (PFCAs)							
PFBA	0.5	1.0	5.0	20	50	200	400
PFPeA	0.5	1.0	5.0	20	50	200	400
PFHxA	0.5	1.0	5.0	20	50	200	400
PFHpA	0.5	1.0	5.0	20	50	200	400
PFOA	0.5	1.0	5.0	20	50	200	400
PFNA	0.5	1.0	5.0	20	50	200	400
PFDA	0.5	1.0	5.0	20	50	200	400
PFUdA	0.5	1.0	5.0	20	50	200	400
PFDoA	0.5	1.0	5.0	20	50	200	400
PFTrDA	0.5	1.0	5.0	20	50	200	400
PFTeDA	0.5	1.0	5.0	20	50	200	400
PFHxDA	0.5	1.0	5.0	20	50	200	400
PFODA	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonic acids (PFSAs)							
PFBS	0.5	1.0	5.0	20	50	200	400
PFHxS *	0.5	1.0	5.0	20	50	200	400
PFHpS	0.5	1.0	5.0	20	50	200	400
PFOS *	0.5	1.0	5.0	20	50	200	400
PFDS	0.5	1.0	5.0	20	50	200	400
Perfluorinated sulfonamides (FOSA)							
FOSA	0.5	1.0	5.0	20	50	200	400
EtFOSA	0.5	1.0	5.0	20	50	200	400
MeFOSA	0.5	1.0	5.0	20	50	200	400

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7
Perfluorinated sulfonamidoacetic acids (FOSAA)							
EtFOSAA	0.5	1.0	5.0	20	50	200	400
MeFOSAA	0.5	1.0	5.0	20	50	200	400
Fluorotelomer sulfonates (FTS)							
6:2 FTS	0.5	1.0	5.0	20	50	200	400
8:2 FTS	0.5	1.0	5.0	20	50	200	400
Labeled Isotope Dilution Analytes (IDA)							
MPFBA	50	50	50	50	50	50	50
M5PFPeA	50	50	50	50	50	50	50
MPFHxA	50	50	50	50	50	50	50
MPFHpA	50	50	50	50	50	50	50
M4PFOA	50	50	50	50	50	50	50
MPFNA	50	50	50	50	50	50	50
MPFDA	50	50	50	50	50	50	50
MPFUdA	50	50	50	50	50	50	50
MPFDoA	50	50	50	50	50	50	50
MPFHxS	50	50	50	50	50	50	50
MPFOS	50	50	50	50	50	50	50
M8FOSA	50	50	50	50	50	50	50
D5-EtFOSA	50	50	50	50	50	50	50
D3-MeFOSA	50	50	50	50	50	50	50
D5-EtFOSAA	50	50	50	50	50	50	50
D3-MeFOSAA	50	50	50	50	50	50	50
M2-4:2FTS	50	50	50	50	50	50	50
M2-6:2FTS	50	50	50	50	50	50	50
M2-8:2FTS	50	50	50	50	50	50	50

* both branched and linear isomers are used.

Note: Sample extracts are in 80% MeOH/H_2O.

FOSAA may be added to the mix and are added at the same concentration as FOSA.

Note- The above calibration limits are provided o nly as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program.

7.4.1. A technical (qualitative) grade PFOA standard is analyzed initially, then after initial calibration when a new column is installed or when significant changes are made to the HPLC parameters. This solution is used as a reference for the PFOA isomers (branched and linear) retention times.

7.5. Initial Calibration Verification Standard (ICV).

A second source solution for PFAS is purchased from the same vendor; the PFC-MXB contains most of the target analytes in this mixture and is used as an ICV. A few

compounds are not available in this mixture, may not be available as another lot, and are not available from another vendor. For these analytes only, a second analyst may prepare a second source standard from the same source as the ICAL to produce an ICV. The recommended concentration of the ICV standard should be in the mid-range of the calibration curve. The concentration may be adjusted if the initial calibration levels are changed or altered. The IS is added at a fixed concentration of 50 ng/mL.

7.6. LCS/Matrix PFC Spike Solution, 20 ng/mL.

The PFC spike solution is prepared by diluting all PFAS to produce a solution containing each PFAS at a concentration of 20 ng/mL in methanol.

7.7. PFC Isotope Dilution Analyte Solution, 50 ng/mL.

The PFC-IS solution is prepared by diluting all labeled PFAS to produce a solution containing each compound at a concentration of 50 ng/mL in methanol.

7.8. Reverse Surrogate Solution, 1000 ng/mL

The reverse surrogate solution is prepared by diluting M2-4:2 FTS to produce a solution containing this compound at a concentration of 1000 ng/mL in methanol. This is added to all samples for the TOP assay to monitor the efficiency of the oxidation process.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Soil samples are collected in pre-cleaned 250 mL HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6°C for shipment to the laboratory.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6°C. Water samples must be extracted within 14 days of collection. Soil samples must also be extracted within 14 days of collection. Tissue samples must be extracted within 1 year of collection if stored at -20°C. Extracts must be refrigerated at 0 - 6°C, and analyzed within 40 days from extraction.

NOTE: As of this writing, Method 537 provides for a 14 day holding time for water samples preserved with Trizma buffer. The scientific literature indicates that perfluorinated substances are highly persistent in the environment. TestAmerica Sacramento has conducted holding time studies that support a 14 day holding time for aqueous samples with and without Trizma preservation. TestAmerica Denver has conducted stability studies indicating that medium- and low-level solutions of PFOA are stable for at least three months in polystyrene and polypropylene plastics at 0-6°C. The 14 /40 day holding times given above are based on the holding time study and general EPA convention for the holding time of extractable organic compounds in water and soil.

9. QUALITY CONTROL

9.1. Initial Demonstration of Capability (IDOC)

The initial demonstration and method detection limit (MDL) studies described in Section 13 must be acceptable before analysis of samples may begin.

9.2. Batches are defined at the sample preparation step. Batches should be kept together through the whole analytical process as far as possible, but it is not mandatory to analyze prepared extracts on the same instrument or in the same sequence. Refer to the QC program document (WS-PQA-003) for further details of the batch definition.

9.2.1. The quality control batch is a set of up to 20 samples of the same matrix processed using the same procedure and reagents within the same time period. The quality control batch must contain a matrix spike/matrix spike duplicate (MS/MSD), a laboratory control sample (LCS) and a method blank. Laboratory generated QC samples (Blank, LCS, MS/MSD) do not count toward the maximum 20 samples in a batch. Field QC samples are included in the batch count. In some cases, at client request, the MS/MSD may be replaced with a matrix spike and sample duplicate. If insufficient sample is available for an MS/MSD, an LCSD may be substituted if batch precision is required by the program or client. In the event that multiple MS/MSDs are run with a batch due to client requirements, the additional MS/MSDs do not count toward the maximum 20 samples in a batch.

9.3. One method blank (MB, laboratory reagent blank) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. For aqueous samples, the method blank is an aliquot of laboratory reagent water. For solid samples, the method blank is an aliquot of Ottawa sand. The method blank is processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, then implemented when target analytes are detected in the method blank above the reporting limit or when surrogate recoveries are outside of the control limits. Re-extraction of the blank, other batch QC, and the affected samples are required when the method blank is deemed unacceptable. See policy WS-PQA-003 for specific acceptance criteria.

9.3.1. If the MB produces a peak within the retention time window of any of the analytes, determine the source of the contamination and eliminate the interference before processing samples.

9.3.2. The method blank must not contain any analyte at or above the reporting limit, or at or above 10% of the measured concentration of that analyte in the associated samples, whichever is higher.

9.3.3. If there is no target analyte greater than the RL in the samples associated with an unacceptable method blank, the data may be reported with qualifiers.

Such action should be taken in consultation with the client.

9.3.4. Re-extraction and reanalysis of samples associated with an unacceptable method blank is required when reportable concentrations are determined in the samples.

9.3.5. Refer to WS-PQA-003 for further details of the corrective actions.

9.3.6. Projects performed under the auspices of the DOD/DOE must meet QSM specific criteria for method blanks. Results are acceptable if the blank contamination is less than ½ of the reporting limit for each analyte, or less than 1/10 of the regulatory limit, or less than 1/10 of the sample result for the same analyte, whichever is greater. If the method blank does not meet the acceptance criteria, the source of contamination must be investigated and measures taken to correct, minimize or eliminate the problem. If contamination remains, the contaminated samples should be re-prepared and reanalyzed with a new MB and batch-specific QC samples.

9.4. A laboratory control sample (LCS) must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. The LCS is an aliquot of laboratory matrix (e.g. water for aqueous samples and Ottawa sand for solids) spiked with analytes of known identity and concentration. The LCS must be processed in the same manner and at the same time as the associated samples. Corrective actions must be documented on a Non-Conformance memo, then implemented when recoveries of any spiked analyte is outside of the control limits. Re-extraction of the blank, other batch QC and all associated samples are required if the LCS is deemed unacceptable. See WS-PQA-0003 for specific acceptance criteria. The control limits for the LCS are stored in TALS.

9.5. A matrix spike/matrix spike duplicate (MS/MSD or MS/SD) pair must be extracted with every process batch of similar matrix, not to exceed twenty (20) samples. An MS/MSD pair is aliquots of a selected field sample spiked with analytes of known identity and concentration. The MS/MSD pair must be processed in the same manner and at the same time as the associated samples. Spiked analytes with recoveries or precision outside of the control limits must be within the control limits in the LCS. Corrective actions must be documented on a nonconformance memo, then implemented when recoveries of any spiked analyte are outside of the control limits provided by TALS or by the client.

9.6. A duplicate control sample (LCSD or DCS) may be added when insufficient sample volume is provided to process an MS/MSD pair, or is requested by the client. The LCSD is evaluated in the same manner as the LCS. See WS-PQA-003 for specific acceptance criteria.

9.7. Initial calibration verification (ICV) – When available, a second source standard is analyzed with the initial calibration curve. The concentration should be at the mid range of the curve.

Corrective actions for the ICV include:

- Rerun the ICV.
- Remake or acquire a new ICV.
- Evaluate the instrument conditions.
- Evaluate the initial calibration standards.

9.8. Isotope Dilution Analytes

9.8.1. The IDA solution is added to each field and QC sample at the time of extraction, as described in Section 11. As described in Section 7, this solution consists of isotopically labeled analogs of the analytes of interest.

9.8.2. IDA recoveries are flagged if they are outside of the acceptance limits (25–150%). Quantitation by isotope dilution generally precludes any adverse effect on data quality due to IDA recoveries being outside of the acceptance limits as long as the signal-to-nose ratio is greater than 10:1.

9.8.2.1. Evaluate data quality for usability, flag and submit a non-conformance memo for any analytes outside of the recovery criteria, and report if data is deemed not adversely effected.

9.8.2.2. Re-extraction of samples should be performed if the signal-to-noise for any IDA is less than 10:1 or if the IDA recoveries fall below 10%.

9.8.2.2.1. Re-extraction may be necessary under other circumstances when data quality has been determined to be adversely affected.

10. CALIBRATION

10.1. For details of the calculations used to generate the regression equations, and how to use the factors generated by these equations, refer to SOP CA-Q-P-003 “Calibration Curves and Selection of Calibration Points”.

10.2. Routine instrument operating conditions are listed in the table in Section 11.15.

10.3. Instrument Tuning

Instrument tuning is done initially when the method is first developed and thereafter as needed to maintain the sensitivity and selectivity of the method. Tuning is done by infusing each individual compound (native and IDA) into the mobile phase using a tee

fitting at a point just before the entrance to the electrospray probe. The responses for the parent and daughter ions for each compound are observed and optimized for sensitivity and resolution. Mass assignments are reviewed and calibrated if necessary. The mass assignments must be within ± 0.5 amu of the values shown in the table in Section 11.15.

10.4. A new calibration curve must be generated after major changes to the system or when the continuing calibration criteria cannot be met. Major changes include, but are not limited to, new columns or pump seals. A new calibration is not required after minor maintenance.

10.5. With the exception of the circumstances delineated in policy CA-Q-P-003, it is not acceptable to remove points from a calibration curve. In any event, at least five points must be included in the calibration curve. Average Response Factor and linear fit calibrations require five points, whereas Quadratic (second order) calibrations require six points.

10.6. A fixed injection volume is used for quantitation purposes and is to be the same for both the sample and standards.

10.7. All units used in the calculations must be consistently uniform, such as concentration in ng/mL.

10.8. Initial Calibration

10.8.1. A number of analytical standards of different analyte concentrations are used to generate the curve. Each standard is injected once to obtain the peak response for each analyte at each concentration. These standards define the working range of the analysis.

10.8.1.1. A minimum of five analytical standards is used when using average response factor and/or linear calibration fits.

10.8.1.2. A minimum of six analytical standards is used when a quadratic fit is used to generate the curve.

10.8.2. Calibration is by average response factor, linear fit, or by quadratic fit. Quadratic fit is used for the analyte if the response is non-linear.

10.8.2.1. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated by isotope dilution must be < 35% for the curve to be valid.

10.8.2.2. For average response factor (RFa), the relative standard deviation (RSD) for all compounds quantitated by IDA must be < 50% for the curve to be valid.

10.8.2.3. For linear fit, the intercept of the line must be less than ½ the reporting limit, and the coefficient of determination (r2) must be greater than or equal to 0.990 for the curve to be considered valid (or the correlation coefficient (r) > 0.995).

10.9. Calibration Curve Fits

10.9.1. Linear regression or quadratic curves may be used to fit the data to a calibration function. Detailed descriptions and formulas for each fitting type can be found in SOP CA-Q-P-003, "Calibration Curves and Selection of Calibration Points".

10.9.2. The linear curve uses the following function:

Equation 1

$$y = bx + c$$

Where:

$$y = \frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$$

x = concentration
b = slope
c = intercept

10.9.3. The quadratic curve uses the following function:

Equation 2

$$y = ax^2 + bx + c$$

Where y, x, b, and c are the same as above, and a = curvature.

10.9.4. The external standard method uses the following equation:

Equation 3

$$Response\ Factor = \frac{Peak\ \ Area}{Concentration\ of\ \ Solution\ (ng/mL)}$$

10.9.5. Evaluation of Calibration Curves

The following requirements must be met for any calibration to be used:

- Response must increase with increasing concentration.
- The absolute value of the intercept of a regression line (linear or non-linear) at zero response must be less than the reporting limit.
- There should be no carryover at or above 1/2 MRL after a high CAL standard.

If these criteria are not met, instrument conditions and standards will be checked, and the ICAL successfully repeated before continuing.

10.9.6. Weighting of Calibration Points

In linear and quadratic calibration fits, the points at the lower end of the calibration curve have less absolute variance than points at the high

concentration end of the curve. This can cause severe errors in quantitation at the low end of the calibration. Because accuracy at the low end of the curve is very important for this analysis, it is preferable to increase the weighting of the lower concentration points. 1/concentration or 1/x weighting is encouraged. Visual inspection of the line fitted to the data is important in selecting the best fit.

10.10. Initial Calibration Blank (ICB)

10.10.1. Immediately following the ICAL, a calibration blank is analyzed that consists of an injection of 80:20 methanol:water blank.

10.10.2. The result for the calibration blank must be less than the reporting limit.

10.10.3. If the ICB is greater than the reporting limit then the source of contamination must be identified and any necessary cleaning completed, and then the instrument should be recalibrated.

10.11. Initial Calibration Verification (ICV)

10.11.1. Following the ICAL and the ICB, an ICV standard obtained from a different source or vendor than the ICAL standards is analyzed. This ICV standard is a mid-range standard.

10.11.2. The recovery for the ICV must meet the appropriate following criteria:

10.11.2.1. The native analyte must be within or equal to 60-140% for all native analytes quantitated by isotope dilution.

10.11.2.2. The native analyte must be within or equal to 50-150% for all native analytes quantitated by internal standard (i.e. those compounds that do not have corresponding isotopically labelled analogs).

10.11.2.3. The IDA must be within or equal to 50-150%.

10.11.3. See Section 9.8 for corrective actions in the event that the ICV does not meet the criteria above.

10.12. Continuing Calibration Verification (CCV)

Analyze a CCV at the beginning of a run, the end of a run, and after every 10 samples to determine if the calibration is still valid. The exception is after an acceptable curve and ICV are run 10 samples can be analyzed before a CCV is required. The CCVs are usually at the mid-level range of the curve and should vary throughout the run. The curve and ICV do not need to be run every day. To start an analytical run a CCV can be analyzed and if it meets acceptance criteria a run can be started. In addition, the low

standard in the curve must be analyzed and must be within ± 50% of the expected value.

10.12.1. The recovery for the CCV standards must be equal to or within 60-140% for all natives quantitated by isotope dilution and equal to or within 50% to 150% for all natives quantitated by internal standard. The recovery for the IDA must be within or equal to 50-150%.

10.12.2. If this is not achieved, the instrument has drifted outside the calibration limits. The instrument must be recalibrated.

11. PROCEDURE

11.1. One-time procedural variations are allowed only if deemed necessary in the professional judgment of a supervisor to accommodate variation in sample matrix, chemistry, sample size, or other parameters. Any variation in procedure shall be completely documented using an Non-Conformance Memo (NCM). The NCM process is described in more detail in SOP WS-QA-0023. The NCM shall be filed in the project file and addressed in the case narrative.

Any deviations from this procedure identified after the work has been completed must be documented in an NCM, with a cause and corrective action described.

11.2. Water Sample Preparation

11.2.1. Visually inspect samples for the presence of settled and/or suspended sediment. If sediment is apparent, filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity or vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration. File an NCM noting the need for filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.2.2. Measure 250 mL of each sample using a graduated cylinder and pour into a labeled 16 oz. polyethylene (HDPE) bottle. *Prepare separate aliquots of 1.0 mL if EtFOSA and/or MeFOSA are requested.)*

11.2.3. Prepare additional aliquots of a field sample for the MS/MSD, if requested.

11.2.4. Prepare two 250 mL aliquots of HPLC-grade water for the method blank and LCS (or 1.0 mL if EtFOSA and/or MeFOSA are requested.)

11.2.5. Spike the LCS and MS/MSD (if requested) with 0.5 mL of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration

of 40 ng/L. If EtFOSA and/or MeFOSA are required, increase the amount of LCS Matrix PFC spike solution added to 2.5 uL.

11.2.6. Add 0.5 mL of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial. If EtFOSA and/or MeFOSA are requested increase the amount of IDA added to 2.5 uL.

11.2.7. If EtFOSA and/or MeFOSA are requested, adjust the final volume (FV) of these aliquots to 5.0 mL with MeOH. QC samples, LCS, MS, and MSD will require concentration via nitrogen to adjust the FV to 5.0 mL. Vortex each sample. Then, transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.3. Solid Phase Extraction (SPE) of Aqueous Samples

(Do not perform SPE clean up if EtFOSA and/or MeFOSA are requested.)

The automated Zymark Auto-Trace Workstation can be used as long as the program follows these conditions and passes the background check.

11.3.1. Condition the SPE cartridges (Waters WAX, 500 mg/6 cc) by passing the following without drying the column.

NOTE: *The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.3.2. Wash with 5.0 mL of 0.3% NH_4OH/methanol.

11.3.3. Wash with 5.0 mL of 0.1N NaOH/water. Close valve when ~ 200 uL remains on top to keep column wet. After this step, the columns cannot go dry until the completion of loading and rinsing samples.

11.3.4. Appropriately label the columns and add the reservoir to the column.

11.3.5. Add samples to the columns and with vacuum, pull the entire 250 mL aliquot of the sample through the cartridge at rate of approximately 2 to 5 drops per second.

11.3.6. After the final loading of the sample but before completely passed through the column, rinse the SPE column with 1 mL of water.

11.3.7. After the sample and water rinse has completely passed through the cartridge, allow the column to dry well with vacuum for 15 minutes.

11.4. SPE Column Wash of Aqueous Samples with Hexane

11.4.1. Load the first 5 mL of hexane to soak for five minutes, then elute to waste.

11.4.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.4.3. Allow the column to dry with vacuum for 5 to 10 minutes. Columns must be dried before continuing.

11.5. SPE Elution of Aqueous Samples – using 15 mL polypropylene test tubes as receiving tubes in the SPE manifold.

11.5.1. Rinse sample bottles with 5 mL of 0.3% NH_4OH/methanol and transfer to the column reservoir onto the cartridge. Allow the solution to soak for 5 minutes and then elute into the 15 mL collection tube.

11.5.2. Repeat sample bottle to column reservoir rinse and cartridge elution with a second 5 mL aliquot of 0.3% NH_4OH/methanol. The total collection should be approximately 10 mL.

11.6. Extract Concentration for Aqueous Samples

11.6.1. Concentrate each sample under a gentle stream of nitrogen to near dryness.

11.6.2. Add 400 uL of methanol to each extract, soak and vortex to mix well to reconstitute extract.

11.6.3. Add 100 uL of water to each sample for a final solvent composition of 80:20 methanol:water and vortex to mix the mixture well.

11.6.4. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.6.5. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.

11.7. Soil, Sediment and Tissue Sample Preparation and Extraction

11.7.1. Visually inspect soil samples for homogeneity.

11.7.2. Weigh a representative 5 g aliquot of soil, sediment or tissue sample into a

50 mL HDPE wide-mouth bottle. Weigh additional sample amounts for the matrix spike and matrix spike duplicate analyses if they are requested. *(Prepare separate aliquots if EtFOSA and/or MeFOSA are requested.)*

11.7.3. For the method blank and LCS matrix, use 5 g each of Ottawa sand.

11.7.4. Spike the LCS and MS/MSD (if requested) with 1.0 mL of the LCS/Matrix PFC Spike solution (Section 7.6). This will result in a sample concentration of 4.0 ng/g.

11.7.5. Add 1.0 mL of the IDA PFC solution (Section 7.7) into each sample and QC sample, for a fixed concentration of 50 ng/mL in the final sample vial.

11.7.6. Cap the bottles and allow the spike to settle into the sample matrix. Gently shake the bottles to mix the spike into the matrix.

11.7.7. Add 20 mL of 0.4% KOH/methanol to each sample.

11.7.8. Shake each sample on an orbital shaker at room temperature for 3 hours.

11.7.9. Following the shaking, extract the samples in an ultrasonic water bath for an additional 12 hours.

11.7.10. After the completion of extraction, centrifuge each sample at 3500 rpm for 15 minutes.

11.7.11. Collect and decant the KOH/methanol extract to a new 50 mL centrifuge tube.

11.7.12. Add another 2 mL of 0.4% KOH/methanol solution to the residue, briefly shake to mix and centrifuge at 3500 rpm for 15 minutes.

11.7.13. Combine the rinsate to the first corresponding tubes.

11.7.14. To the final KOH/methanol extract, add 2 mL of water to each. *(Omit this step if EtFOSA and/or MeFOSA are requested.)*

11.7.15. Concentrate the KOH/methanol/water extract under nitrogen to less than 2 mL, and dilute with water to 15 mL final volume. *(Omit this step if EtFOSA and/or MeFOSA are requested.)*

11.7.16. Acidify with 80 uL of glacial acetic acid, and mix the contents well with vortex mixer. Check the pH to ensure pH is between 6 to 8.

11.7.17. Centrifuge at 3500 rpm for 15 minutes.

11.8. Solid Cleanup by SPE

(Do not perform SPE clean up if EtFOSA and/or MeFOSA are requested. Proceed directly to Section 11.11)

11.8.1. Set up WAX 150 mg/6 cc SPE columns for sample cleanup using vacuum manifold.

11.8.2. Condition the SPE cartridges by passing the following without drying the column.

NOTE: *The cartridges should not be allowed to go dry until the final elution step with methanol. At all of the other transition steps, the solvent/sample level should be stopped at the top of the column before the next liquid is added.*

WARNING: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.8.3. Wash with 5.0 mL of 0.3% NH_4OH/methanol.

11.8.4. Wash with 10 mL of 0.1N NaOH/water. Close valve when ~ 500uL remains on top of column to keep column wet. *After this step, the columns cannot go dry until the completion of loading and rinsing samples.*

11.8.5. Add extracts to the columns and with vacuum, pull the entire extracts through the cartridge at rate of approximately 3 to 5 drops per second.

11.8.6. Rinse the sample tube with 5 mL of water and add to the SPE column.

11.8.7. Dry the columns with vacuum for 15 minutes.

11.9. SPE Column Wash of Solid Samples with Hexane

11.9.1. Load the first 5 mL of hexane to soak for five minutes, and elute to waste.

11.9.2. Load the second 5 mL of hexane and elute to waste (without a soaking period).

11.9.3. Allow the column to dry with vacuum for 10 minutes. Columns must be dried before continuing.

11.10. SPE Elution of Solid Samples – using 15 mL polypropylene test tube as receiving tube in the SPE manifold.

11.10.1. Elute the analytes from the cartridge with 5.0 mL of 0.3% NH_4OH/methanol, first allow the solution to soak for 5 minutes, and then elute into the 15 mL collection tube.

11.10.2. Add a second 5 mL of 0.3% NH_4OH/methanol and collect the eluant into the collection tube. The total collection should be approximately 10 mL.

11.11. Extract Concentration for Solid Samples

11.11.1. Concentrate each sample under a gentle stream of nitrogen to near dryness.

11.11.2. Add 800 uL of methanol to each extract, soak and vortex to mix well to reconstitute extract.

11.11.3. Add 200 uL of water to each sample for a final solvent composition of 80:20 methanol:water and vortex to mix the mixture well.

11.11.4. Transfer a portion of the extract to a 300 uL polypropylene autosampler vial (7 drop-wise or approximately ½ filled is sufficient). Archive the rest of the extracts for re-injection and dilution.

11.11.5. Seal the vial with a polypropylene screw cap. *Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.*

11.12. Product/Dispersion Samples

11.12.1. Check the solubility of the material in both methanol and water

11.12.1.1. If the material is soluble in water, dilute 0.5 mL of sample into 250 mL of DI water and proceed to Section 11.3 (follow water extraction procedures). Fortify sample appropriately with IDA or PFC spike solution, see Section 11.2.

11.12.1.2. If the material is soluble in methanol, dilute 1 g (if solid) or 1 mL (if liquid) of material into 10 mL of methanol (MeOH).

11.12.1.2.1. If the material does not completely dissolve, contact your immediate supervisor.

11.12.2. Take 100 uL of the 10 mL solution and dilute it to 10 mL in MeOH.

11.12.3. Take a 1 mL aliquot of this solution (effective dilution of 1000x (1 mg for solid or 0.001 mL for liquid)) and fortify with 25 uL of labeled IDA or surrogate solution (Section 7.7).

11.12.4. DO NOT PASS EXTRACT THROUGH SPE CARTIRIDGE (omit steps 11.9 – 11.11).

11.12.5. Proceed to Section 11.6 of this SOP for extract concentration.

11.13. TOP (Total Oxidizable Precursor) Assay

11.13.1. Prepare 3-250 mL HDPE containers with HPLC grade water to create the needed QC Samples (MB, LCS/LCSD).

11.13.2. Prepare enough 125 mL HDPE containers as needed for all “Pre” and “Post” samples, including QC. Label each appropriately.

11.13.3. Spike the “Pre” and “Post” MB 125 mL containers with 25 uL of the reverse surrogate solution of M2-4:2 FTS (Section 7.8).

11.13.4. Spike the “Pre” and “Post” LCS/LCSD 125 mL containers with 20 uL of the LCS Spike solution (Section 7.6), both regular and “add-on”, and 25 uL of the reverse surrogate solution (Section 7.8).

11.13.5. Remove the methanol solvent from all Post QC sample 125 mL containers (MB and LCS/LCSD) by using N2 evaporation.

11.13.6. Subsample 100 mL aliquots of water from each field sample and QC from the 250 mL containers into each of the corresponding 125 mL containers for both the “Pre” and “Post” samples.

11.13.7. Set aside all “Pre” sample containers.

11.13.8. Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each “Post” sample container.

11.13.9. Heat each “Post” sample container in a water bath (KD) at 85°C for 6 hours.

11.13.10. After digestion for 6 hours, place the “Post” sample containers in an ice bath for 30 minutes.

11.13.11. Adjust the pH of “Post” samples and associated QC aliquots to 7 with concentrated HCl. Use pH paper to determine the pH.

11.13.12. Spike both “Pre” and “Post” samples and their associated QC samples with 25 uL of PFC IDA solution (Section 7.7), both regular and add-on.

11.13.13. Use the following SPE procedure for both “Pre” and “Post” samples:

11.13.13.1. Set up WAX 150 mg/6 cc SPE columns for sample extraction using a vacuum manifold.

11.13.13.2. Establish a sample loading flow rate of 1 mL/minute for each port of the vacuum manifold, for as many ports as will be used simultaneously during sample loading.

11.13.13.3. Wash/condition the SPE column with 5 mL of 0.3% NH_4OH/Methanol, then 5 mL water.

11.13.13.4. Load 100 mL of sample onto the SPE cartridge at a flow rate of 1 mL/minute.

11.13.13.5. Add 5 mL rinse water

11.13.13.6. After the sample and water rinse have completely passed through the column, allow it to dry well using vacuum with a flow rate of 1 mL/minute for 15 minutes.

11.13.13.7. Wash the SPE column with 10 mL hexane rinse eluting all to waste.

11.13.13.8. Allow the column to dry well using vacuum with a flow rate of 1 mL/minute for 5 minutes. Columns must be dry before continuing.

11.13.13.9. Elute the samples into 15 mL polypropylene test tubes in the SPE manifold by rinsing each 125 mL sample container with 5 mL of 0.3% NH_4OH/methanol, and add to the SPE cartridge as eluent.

11.13.13.10. Repeat with another 5 mL of 0.3% NH_4OH/methanol.

11.13.13.11. Collect the 10 mL of eluent and concentrate per Section 11.6.

11.14. Other types of Sample Cleanup

11.14.1. Freezing technique to remove lipids.

If samples contain lipids then freeze the methanolic extract and QC extracts at -20^{o}C for at least 1 hour. Collect the solvent layer.

11.14.2. Cleanup with graphitized carbon which may also be used to remove organic interferences.

11.14.2.1. Add 100 mg of graphitized carbon to each sample extract and QC extracts.

11.14.2.2. Shake vigorously and then let sit for 10 minutes.

11.14.2.3. Centrifuge each sample for 2 minutes at 1000 rpm.

11.14.2.4. Decant the solvent layer

11.14.3. Concentrate each sample under a gentle stream of nitrogen to approximately 0.5 mL.

11.14.4. Add 200 uL of Millipore water to each sample.

11.14.5. Bring the final volume to 1.0 mL with methanol (80% methanol/20% water).

11.14.6. Filter through a 0.45 µm syringe filter as necessary or centrifuge the extracts to obtain a clear supernant. *Note: Syringe filter should be checked for PFAS background before using.*

WARNING: Application of excessive pressure has caused disc filters to rupture and burst. Exercise discretion when filtering.

11.15. Instrument Analysis

Suggested operating conditions are listed below for the Waters LCMS system:

Recommended Instrument Operating Conditions					
HPLC Conditions (Waters Acquity UPLC)					
Column (Column temp = 50°C)	Waters Acquity BEH 1.7µm C18, 3.0 x 150 mm				
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol				
Gradient Program	**Time**	**%A**	**%B**	**Curve**	**Flow Rate mL/min.**
	0	98	2	6	0.30
	1	98	2	6	0.30
	2	50	50	6	0.30
	12	10	90	6	0.30
	12.5	0	100	6	0.30
	16	0	100	6	0.30
	16.2	98	2	6	0.30
	Maximum pressure limit = 15,000 psi				
Injection Size	10 µL (fixed amount throughout the sequence)				
Run Time	~20 minutes				

Mass Spectrometer Interface Settings (Quattro Premier XE)	
MS Interface Mode	ESI Negative Ion
Capillary (kV)	2.8
Cone (V)	Varies from 8.0 to 65
Extractor (V)	3
Source Temp	135ºC
Desolvation Temp	350ºC
Cone Gas (nitrogen) Flow	25 L/hour
Desolvation Gas (nitrogen) Flow	1100 L/hour

Recommended Instrument Operating Conditions						
Mass Spectrometer Scan Settings (Quattro Premier XE)						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
PFBA	Native analyte	213 > 169	0.02	8	10	1
13C4-PFBA	IDA	217 > 172	0.02	12	10	1
PFPeA	Native analyte	263 > 219	0.02	10	10	2
13C5PFPeA	IDA	268 > 223	0.02	11	9	2
PFBS	Native analyte	299 > 80	0.02	45	35	2
PFHxA	Native analyte	313 > 269	0.02	10	10	3
13C2-PFHxA	IDA	315 > 270	0.02	12	9	3
PFHpA	Native analyte	363 > 319	0.02	10	10	4
13C4-PFHpA	IDA	367 > 322	0.02	12	10	4
PFHxS	Native analyte	399 > 80	0.02	55	35	4
18O2-PFHxS	IDA	403 > 84	0.02	50	40	4
PFOA	Native analyte	413 > 369	0.02	12	10	5
13C4PFOA	IDA	417 > 372	0.02	12	12	5
PFHpS	Native analyte	449 > 80	0.02	60	38	5
PFNA	Native analyte	463 > 419	0.02	16	10	7
13C5-PFNA	IDA	468 > 423	0.02	12	12	7
PFOS	Native analyte	499 > 80	0.02	60	40	6
13C4-PFOS	IDA	503 > 80	0.02	35	48	6
PFDA	Native analyte	513 > 469	0.02	16	12	8
813C2-PFDA	IDA	515 > 470	0.02	14	12	8
PFUdA	Native analyte	563 > 519	0.02	15	12	10
13C2-PFUdA	IDA	565 > 520	0.02	14	12	10
PFDS	Native analyte	599 > 80	0.02	74	48	10
FOSA	Native analyte	498 > 78	0.02	40	32	9
13C8-FOSA	IDA	506 > 78	0.02	48	32	9
PFDoA	Native analyte	613 > 569	0.02	15	14	11
13C2-PFDoA	IDA	615 > 570	0.02	16	12	11
PFTrDA	Native analyte	663 > 619	0.02	12	12	11
PFTeDA	Native analyte	713 > 669	0.02	12	18	11
PFHxDA	Native analyte	813 > 769	0.02	18	15	12
PFODA	Native analyte	913 > 869	0.02	20	16	12
13C2-PFTeDA	IDA	715 > 670	0.02	15	15	11
13C2-PFHxDA	IDA	815 > 770	0.02	18	15	12
EtFOSA	Native analyte	526 > 169	0.02	45	36	11
d5EtFOSA	IDA	531 >169	0.02	40	30	11
MeFOSA	Native analyte	512 > 169	0.02	45	25	11
d5MeFOSA	IDA	515 > 169	0.02	40	30	11
EtFOSAA	Native analyte	584 > 419	0.02	35	20	9
d5-EtFOSAA	IDA	589 > 419	0.02	30	25	9
MeFOSAA	Native analyte	570 > 419	0.02	30	28	9

Recommended Instrument Operating Conditions						
Mass Spectrometer Scan Settings (Quattro Premier XE)						
Compound	Comments	Reaction (MRM)	Dwell (sec)	Cone Volt.	Col. Energy	Function Number
d5-MeFOSAA	IDA	573 > 419	0.02	30	25	9
6:2FTS	Native analyte	427 > 407	0.02	40	30	5
M2-6:2FTS	IDA	429 > 409	0.02	40	28	5
8:2FTS	Native analyte	527 > 507	0.02	40	28	8
M2-8:2FTS	IDA	529 > 509	0.02	40	28	8

Recommended Instrument Operating Conditions				
Retention Times & Quantitation (Quattro Premier XE)				
Native Compounds	**Native RT (minutes)**	**IS analog**	**IS RT (minutes)**	**Quantitation Method**
PFBA	4.77	13C4-PFBA	4.79	Isotope Dilution
PFPeA	5.90	13C5-PFPeA	5.92	Isotope Dilution
PFBS	6.01	18O2-PFHxS	8.64	IS calculation
PFHxA	7.22	13C2-PFHxA	7.25	Isotope Dilution
PFHpA	8.57	13C4-PFHpA	8.59	Isotope Dilution
PFHxS	8.60	18O2-PFHxS	8.64	Isotope Dilution
PFOA	9.80	13C4-PFOA	9.83	Isotope Dilution
PFHpS	9.80	13C4-PFOS	10.90	IS calculation
PFNA	10.88	13C5-PFNA	10.92	Isotope Dilution
PFOS	10.87	13C4-PFOS	10.90	Isotope Dilution
PFDA	11.82	13C2-PFDA	11.86	Isotope Dilution
FOSA	12.41	13C8-FOSA	12.46	Isotope Dilution
PFDS	12.57	13C4-PFOS	10.90	IS calculation
PFUdA	12.62	13C2-PFUdA	12.66	Isotope Dilution
PFDoA	13.32	13C2-PFDoA	13.34	Isotope Dilution
PFTrDA	13.91	13C2-PFDoA	13.34	IS calculation
PFTeDA	14.39	13C2-PFDoA	13.34	IS calculation
PFHxDA	15.16	13C2-PFDoA	13.34	IS calculation
PFODA	15.57	13C2-PFDoA	13.34	IS calculation
EtFOSA	14.13	d-EtFOSA	14.11	Isotope Dilution
MeFOSA	13.73	d-MeFOSA	13.73	Isotope Dilution
EtFOSAA	12.63	D5-EtFOSAA	12.62	Isotope Dilution
MeFOSAA	12.3	D3-MeFOSAA	12.28	Isotope Dilution
6:2FTS	10.08	M2-6:FTS	10.08	Isotope Dilution
8:2FTS	11.95	M2-8:FTS	11.95	Isotope Dilution

Recommended Instrument Operating Conditions				
HPLC Conditions (Shimadzu HPLC)				
Column (Column temp = 45°C)	Phenomenex Gemini 3 µm C18 110Å, 50 X 2 mm			
Mobile Phase Composition	A = 20 mM Ammonium Acetate in Water B = Methanol			
Gradient Program	**Time**	**%A**	**%B**	**Flow Rate mL/min.**
	0	90	10	0.60
	0.1	45	55	0.60
	4.5	1	99	0.60
	4.95	1	99	0.60
	5	90	10	0.60
	Maximum pressure limit = 5,000 psi			
Injection Size	2 µL (fixed amount throughout the sequence)			
Run Time	~6.6 minutes			

Mass Spectrometer Interface Settings (SCIEX 5500)	
MS Interface Mode	ESI Negative Ion
Ion Spray Voltage (kV)	4.5
Entrance Potential (V)	5
Declustering Potential (V)	25
Desolvation Temp	600ºC
Curtain Gas	35 psi
Collision Gas	8 psi

Recommended Instrument Operating Conditions								
Mass Spectrometer Scan Settings (SCIEX 5500)								
Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	RT (Min)
PFBA	Native analyte	212.9 > 169	0.011	-5	-12	-25	-31	1.74
13C4_PFBA	IDA	217 > 172	0.011	-5	-12	-25	-31	1.74
PFBS	Native analyte	298.9 > 80	0.011	-6	-58	-55	-37	1.76
PFBS_2	Native analyte	298.9 > 99	0.011	-5	-40	-55	-12	1.76
PFPeA	Native analyte	262.9 > 219	0.011	-7	-12	-20	-34	1.99
13C5_PFPeA	IDA	267.9 > 223	0.011	-7	-12	-20	-35	1.99
M2-4:2FTS	IDA	329 > 309	0.011	-7	-32	-50	-10	2.10
PFHxA	Native analyte	313 > 269	0.011	-5	-12	-25	-37	2.25
13C2_PFHxA	IDA	315 > 270	0.011	-5	-12	-25	-38	2.25
PFHpA	Native analyte	363 > 319	0.011	-6	-12	-25	-41	2.57
13C4_PFHpA	IDA	367 > 322	0.011	-6	-12	-25	-41	2.57
PFHxS	Native analyte	399 > 80	0.011	-12	-74	-60	-43	2.59
18O2_PFHxS	IDA	403 > 84	0.011	-12	-74	-60	-43	2.59
6:2 FTS	Native analyte	427 > 407	0.011	-7	-32	-50	-10	2.91
M2-6:2FTS	IDA	429 > 409	0.011	-7	-32	-50	-10	2.91
PFOA	Native analyte	413 > 369	0.011	-6	-14	-25	-44	2.93

Recommended Instrument Operating Conditions								
Mass Spectrometer Scan Settings (SCIEX 5500)								
Compound	Comments	Reaction (MRM)	Dwell (sec)	Ent. Pot. (V)	Col. Energy (V)	Declu. Pot. (V)	Cell Exit Pot. (V)	RT (Min)
PFOA_2	Native analyte	413 > 169	0.011	-5	-22	-25	-12	2.93
13C4_PFOA	IDA	417 > 372	0.011	-6	-14	-25	-44	2.93
PFHpS	Native analyte	449 > 80	0.011	-11	-88	-65	-46	2.94
PFNA	Native analyte	463 > 419	0.011	-6	-14	-25	-47	3.29
13C5_PFNA	IDA	468 > 423	0.011	-6	-14	-25	-48	3.29
PFOS	Native analyte	499 > 80	0.011	-9	-108	-65	-50	3.29
PFOS_2	Native analyte	499 > 99	0.011	-5	-58	-65	-12	3.29
13C4_PFOS	IDA	503 > 80	0.011	-9	-108	-65	-50	3.29
PFDA	Native analyte	513 > 469	0.011	-6	-16	-25	-51	3.65
13C2_PFDA	IDA	515 > 470	0.011	-6	-16	-25	-51	3.65
8:2 FTS	Native analyte	527 > 507	0.011	-7	-40	-50	-15	3.65
M2-8:2FTS	IDA	529 > 509	0.011	-7	-40	-50	-15	3.65
PFOSA	Native analyte	498 > 78	0.011	-8	-85	-60	-50	3.7
13C8_PFOSA	IDA	506 > 78	0.011	-8	-85	-60	-50	3.7
N-MeFOSAA	Native analyte	570 > 419	0.011	-7	-36	-40	-15	3.82
d3-MeFOSAA	IDA	573 > 419	0.011	-7	-36	-40	-15	3.82
PFDS	Native analyte	599 > 80	0.011	-11	-118	-85	-54	3.96
PFUdA	Native analyte	563 > 519	0.011	-7	-18	-25	-54	3.97
13C2_PFUdA	IDA	565 > 520	0.011	-7	-18	-25	-54	3.97
N-EtFOSAA	Native analyte	584 > 419	0.011	-7	-36	-50	-15	3.99
d5-EtFOSAA	IDA	589 > 419	0.011	-7	-36	-50	-15	3.99
MeFOSA	Native analyte	512 > 169	0.011	-7	-37	-75	-15	4.21
d3MeFOSA	IDA	515 > 169	0.011	-7	-37	-75	-15	4.21
PFDoA	Native analyte	613 > 569	0.011	-5	-18	-25	-54	4.3
13C2_PFDoA	IDA	615 > 570	0.011	-5	-18	-25	-54	4.3
EtFOSA	Native analyte	526 > 169	0.011	-7	-37	-75	-15	4.39
d5EtFOSA	IDA	531 > 169	0.011	-7	-37	-75	-15	4.39
PFTrDA	Native analyte	663 > 619	0.011	-7	-20	-25	-54	4.56
PFTeDA	Native analyte	713 > 669	0.011	-2	-22	-25	-10	4.79
PFTeDA_2	Native analyte	713 > 169	0.011	-7	-36	-25	-30	4.79
13C2_PFTeDA	IDA	715 > 670	0.011	-2	-22	-25	-10	4.79
PFHxDA	Native analyte	813 > 769	0.011	-7	-24	-25	-54	5.25
13C2_PFHxDA	IDA	815 > 770	0.011	-7	-24	-25	-54	5.25
PFODA	Native analyte	913 > 869	0.011	-7	-26	-25	-54	5.55

11.15.1. Tune and calibrate the instrument as described in Section 10.

11.15.2. A typical run sequence is as follows:

- Primer (A number of primers are injected for conditioning of the instrument before analysis, especially when the instrument was idled or changed from a different analysis).
- Blank
- Calibration Curve

- ICB
- ICV
- MB
- LCS
- LCSD (if applicable)
- Sample 1
- Sample 1 MS (if applicable)
- Sample 1 MSD (if applicable)
- Sample 2 (up to sample 10 before next CCV)
- CCV
- Up to 10 samples.
- End sequence with CCV

12. CALCULATIONS

12.1. If the concentration of the analyte ions exceeds the working range as defined by the calibration standards, then the sample must be diluted and reanalyzed. It may be necessary to dilute samples due to matrix.

12.2. Qualitative Identification

12.2.1. The retention times of PFAS with labeled standards must be the same as that of the labeled IDA's to within 0.05 min. For PFAS with no labeled standards, the RT must be within ± 0.3 minutes of the ICV and CCV standards. *Note: The IS RT and native RT may be offset by 0.02 to 0.04 minutes.*

12.3. The ICAL established in Section 10 is used to calculate concentrations for the extracts.

12.4. Extract concentrations are calculated as below. The first equation applies to the linear fit, the second to the quadratic line fit.

Equation 4

$$\text{Concentration, ng/mL} = \frac{y - c}{b}$$

Equation 5

$$\text{Concentration, ng/mL} = \frac{-b + \sqrt{b^2 - 4a(c - y)}}{2a}$$

Where:

$$y = \frac{\text{Area (analyte)}}{\text{Area (IS)}} \times \text{Concentration (IS)}$$

x = concentration
a = curvature
b = slope
c = intercept

12.5. Water Sample Result Calculation:

Equation 6

$$\text{Concentration, ng/L} = \frac{C_{ex} V_t}{V_o}$$

Where:

C_{ex} = Concentration measured in sample extract (ng/mL)
V_t = Volume of total extract (mL)
V_o = Volume of water extracted (L)

12.6. Soil Sample Result Calculation:

Equation 7

$$\text{Concentration, } ng/g = \frac{C_{ex} V_t}{W_s D}$$

Where ng/g = µg/kg and:

C_{ex} = Concentration measured in sample extract (ng/mL)
V_t = Volume of total extract (mL)
W_s = Weight of sample extracted (g)
D = Fraction of dry solids, which is calculated as follows:

$$\frac{100 - \%\text{ moisture in sample}}{100}$$ (for dry weight result)

12.7. IDA Recovery Calculation:

Equation 8

$$\%\,\text{Recovery} = \frac{RF_{ex} A_t}{Amt}$$

Where ng/g = µg/kg and:

RF_{ex} = Response Factor for IDA compound
A_t = Area response for IDA compound
Amt = Amount spike of IDA

12.8. If results are to be reported as ammonium perfluorooctanoate (APFO), instead of PFOA, apply a multiplier of 1.0406 to the sample results to correct for the molecular weight differences between PFOA and APFO or this adjustment can be made during the preparation of the standards used for calibration. (Use one, not both.)

12.9. Raw data, calibration summaries, QC data, and sample results are reviewed by the analyst. These must also be reviewed thoroughly by a second qualified person. See the Data Review Policy (WS-PQA-0012). These reviews are documented on the Data Review Checklist.

13. METHOD PERFORMANCE

13.1. The group/team leader has the responsibility to ensure that this procedure is performed by an associate who has been properly trained in its use and has the required expertise.

13.2. Method Detection Limit

The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in SOP WS-QA-0006. MDLs are available in the Quality Assurance Department.

13.3. Initial Demonstration of Capability (IDOC)

Each analyst performing this procedure must successfully analyze four LCS QC samples using current laboratory LCS control limits. IDOCs are approved by the Quality Assurance Manager and the Technical Director. IDOC records are maintained by the QA staff in the central training files.

13.4. The laboratory must generate a valid method detection limit for each analyte of interest. The MDL must be below the reporting limit for each analyte. The procedure for determination of the method detection limit is given in 40 CFR Part 136, Appendix B, and further defined in WS-QA-0006 and policy WS-PQA-003.

14. POLLUTION PREVENTION

14.1. All waste will be disposed of in accordance with Federal, State and Local regulations.

14.2. Solid phase extraction used for water samples greatly reduces the amount of solvent used compared to liquid-liquid extraction.

14.3. Standards and reagents are purchased and prepared in volumes consistent with laboratory use to minimize the volume of expired standards and reagents requiring disposal.

14.4. Where reasonably feasible, technological changes have been implemented to minimize the potential for pollution of the environment. Employees will abide by this method and the policies in Section 13 of the Corporate Safety Manual for “Waste Management and Pollution Prevention.”

14.5. Do not allow waste solvent to vent into the hoods. All solvent waste is stored in capped containers unless waste is being transferred.

14.6. Transfer waste solvent from collection cups (tri-pour and similar containers) to jugs and/or carboys as quickly as possible to minimize evaporation.

15. WASTE MANAGEMENT

The following waste streams are produced when this method is carried out:

15.1. Assorted test tubes, autovials, syringes, filter discs and cartridges. Dump the solid waste into a yellow contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the hazardous waste – landfill steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.2. Extracted soil samples, used sodium sulfate, paper funnel filters, glass wool, thimbles, and extracted solids contaminated with solvents. Dump these materials into an orange contaminated lab trash bucket. When the bucket is full or after no more than one year, tie the plastic bag liner shut and put the lab trash into the incineration steel collection drum in the H3 closet. When the drum is full or after no more than 75 days, move it to the waste collection area for shipment.

15.3. Waste Methanol. Collect the waste solvents in tripours during use. Empty the tripours into a 1-liter to 4-liter carboy at the fume hood. When the carboy is full, or at the end of your shift, whichever comes first, empty the carboy into the steel solvent drum in the H3 closet. When full to no less than six inches of the top, or after no more than 75 days, move the steel drum to the waste collection area for shipment.

15.4. Mixed water/methanol waste from soil extraction. Collect the waste in the HPLC waste carboy. When full, or after no more than one year, dump into the blue plastic HPLC collection drum in the H3 closet. When the drum is full, to no less than six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.5. Aqueous acidic waste from the LCMS instrument contaminated with methanol. This is collected in a 1-gallon carboy at the instrument. When the carboy is full, or after no more than one year, it is emptied into the blue plastic HPLC collection drum in the H3 closet. When the drum is full to between two and six inches of the top, or after no more than 75 days, move it to the waste collection area for shipment.

15.6. Autovials contaminated with methanol. As the autovials are removed from the instrument after analysis, they are collected in open containers at the instrument. After all autovials are removed, the open container must be dumped into a closed satellite collection container in a fume hood, as the punctured septa in the autovial can allow

methanol and other contaminants to evaporate into the atmosphere. The satellite collection containers are transferred to the waste disposal area when full or after no more than one year, where they are disposed through the vial eater.

16. REFERENCES

16.1. Cheryl Moody, Wai Chi Kwan, Johnathan W. Martin, Derek C. G. Muir, Scott A. Mabury, "Determination of Perfluorinated Surfactants in Surface Water Samples by Two Independent Analytical Techniques: Liquid Chromatography/Tandem Mass Spectrometry and 19FNMR," Analytical Chemistry 2001, 73, 2200-2206.

16.2. John Giesy et al., "Accumulation of Perfluorooctane Sulfonate in Marine Mammals", Environmental Science & Technology, 2001 Vol. 35, No. 8, pages 1593-1598.

16.3. U.S. EPA, "Residue Chemistry Test Guidelines, OPPTS 860.1340, Residue Analytical Method", EPA 712-C-95-174, August 1995.

16.4. STL Denver White Paper DEN-W-LC-002, "Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, September 5, 2003.

16.5. STL Denver White Paper DEN-W-LC-003, "Addendum A to Method Validation Study for Analysis of Ammonium Perfluorooctanate in Soil Matrices by High Performance Liquid Chromatography/Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, August 6, 2003.

16.6. STL Denver White Paper DEN-W-LC-004, "Method Validation Study for Analysis of Perfluorooctanoic Acid in Waters by High Performance Liquid Chromatography/Tandem Mass Spectrometry (HPLC/MS/MS)", Mark Dymerski, January 26, 2005.

16.7. Waters application note; "Acquity UPLC System for Quantifying Trace Levels of Perfluorinated Compounds with an Acquity PFC Analysis Kit", Peter J. Lee, Evan T. Bernier, Gordon T. Fujimoto, Jeremy Shia, Michael S. Young, and Alice J. Di Gloia, Waters Corporation, Milford, MA. USA.

16.8. US EPA, "Method 537 - Determination of Selected Perfluorinated alkyl acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometery (LC/MS/MS)", Version 1.1, September 2009, J.A. Shoemaker, P.E. Grimmett, B.K. Boutin, EPA Document #: EPA/600/R-08/092

16.9. Erika F. Houtz and David L. Sedlak, "Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff," Environmental Science and Technology 46, no. 17 (2012): 9342-49.

17. METHOD MODIFICATIONS

17.1. Modifications from Method 537 are detailed below:

17.1.1. Water sample containers are not preserved with Trizma.

17.1.2. The method has been modified to address soil/solid matrices. The extraction holding time is set at 14 days.

17.1.3. The analyte list has been expanded. The number of labeled analytes has been expanded as well to improve quantitation.

17.1.4. The reporting limits differ as they are all set at one consistent value.

17.1.5. Calibration levels differ from the referenced method.

17.1.6. More labeled analytes are fortified into the samples prior to the extraction process. Most target analytes are quantitated against a labeled analyte.

17.1.7. There is no symmetry requirement.

17.1.8. Calibration, both initial and continuing, has different acceptance criteria due to the longer list of analytes, and the use of IDA/external standard quantitation.

17.1.9. The eluents and HPLC configuration differs. As a result the final extract is in 80:20 methanol:water.

17.1.10. The LCS and MS/MSD are spiked at one concentration and do not rotate between a low to high levels.

17.1.11. Samples are not checked for residual chlorine or pH.

17.1.12. A different SPE cartridge (Waters OASIS WAX) is used for the extraction process. As a result solvents and elution procedures are different.

18. ATTACHMENTS

18.1. Attachment 1 - Analysis of Perfluorinated Compounds (PFAS) in Water via In Line Solid Phase Extraction (SPE).

19. REVISION HISTORY

Revisions to Attachment 1 are documented in the attachment.

19.1. WS-LC-0025, Revision 2.4, Effective 04/25/2017

19.1.1. Removed all references to Method ISO 25101from this SOP due to the creation of WS-DW-0005 which covers Method ISO 25101.

19.1.2. Section 7.6, changed the concentration from 500 ng/mL to 20 ng/mL to increase spike amounts by diluting the solution in order to reduce the percent error when spiking.

19.1.3. Section 7.7, changed the concentration from 1000 ng/mL to 50 ng/mL to increase spike amounts by diluting the solution in order to reduce the percent error when spiking.

19.1.4. Section 11.2.5, changed 0.020mL (20uL) to 0.5 mL and changed 200 uL to 2.5 mL to aid in spiking efficiency.

19.1.5. Section 11.2.6, changed 0.025 mL (25 uL) to 0.5 mL and changed 125 uL to 2.5 mL to aid in spiking efficiency.

19.1.6. Ection 11.2.7, added “QC samples, LCS, MS, and MSD will require concentration via nitrogen to adjust the FC to 5.0 mL” to adjust for the increased spike volumes.

19.1.7. Section 11.7.4, changed 0.040 (40 uL) to 1.0 mL to aid in spiking efficiency.

19.1.8. Section 11.7.5, changed 0.05 mL (50 uL) to 1.0 mL to aid in spiking efficiency.

19.1.9. Editorial changes.

19.2. WS-LC-0025, Revision 2.3, Effective 04/10/2017

19.2.1. Updated the title to include Method ISO 25101:2009.

19.2.2. Removed Section 1.3,” Due to poor chromatographic peak shape which degraded with repeated injections for Perfluoro-1-octanesulfonamidoamide (FOSSA), this analyte is no longer included in the method.”, as this no longer applies. Renumbered subsections in Section 1.

19.2.3. Inserted Section 1.4, “This procedure also includes direction for preparing and analyzing samples to determine “Total Oxidizable Precursors”, which may assist in improving understanding of potential PFAS environmental

risk."

19.2.4. Added Section 2.6 to read, "Samples for the "Total Oxidizable Precursor" assay (TOP) are analyzed in two phases – an aliquot is prepared and analyzed as a normal sample, and a second aliquot is subjected to oxidation with potassium persulfate and sodium hydroxide prior to solid phase extraction and analysis. The total perfluorocarboxylic acid value is determined for each aliquot, and the difference calculated."

19.2.5. Changed all mentions of "direct aqueous injection (DAI)" to "in line solid phase extraction (SPE)."

19.2.6. Added Section 4.8 to read, "Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.15 pg/L or 0.01 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

19.2.7. Section 5.2, added "Potassium Persulfate (2-0-1-OX)" to the table.

19.2.8. Section 6, added the following:

- 125 mL HDPE containers with screw caps
- Water bath: Heated with concentric ring cover capable of temperature control (±5°C) up to 95°C. The bath must be used in a fume hood.
- Plastic tub for an ice bath, AKRO-N.S.T. part No. 35-180 or equivalent
- pH indicator paper, wide range

19.2.9. Section 7.1, added the following:

- Potassium persulfate, reagent grade
- Sodium hydroxide (NaOH), 10N, reagent grade
- Hydrochloric acid (HCl), concentrated, reagent grade

19.2.10. Added Section 7.2.1.1 to read, "Per the Certificate of Analysis for labeled perfluorohexadecanoic acid ($13C_2$-PFHxDA) produced by Wellington Laboratories, the stock standard contains roughly 0.3% of native perfluorohexadecanoic acid. This equates to roughly 0.15 pg/L or 0.01 ug/kg of perfluorohexadecanoic acid expected in all samples and blanks.

19.2.11. Section 7.4, added M2-4:2FTS to the "Initial Calibration Levels" table.

19.2.12. Added section 7.8 title, "Reverse Surrogate Solution, 1000 ng/mL" to read, "The reverse surrogate solution is prepared by diluting M2-4:2 FTS to produce a solution containing this compound at a concentration of 1000

ng/mL in methanol. This is added to all samples for the TOP assay to monitor the efficiency of the oxidation process."

19.2.13. Added Section 11.12 titled, "Product Dispersion Samples" to read:

"11.12.1. Check the solubility of the material in both methanol and water

11.12.1.1 If the material is soluble in water, dilute 0.5 mL of sample into 250 mL of DI water and proceed to Section 11.3 (follow water extraction procedures). Fortify sample appropriately with IDA or PFC spike solution, see Section 11.2.

11.12.1.2 If the material is soluble in methanol, dilute 1 g (if solid) or 1 mL (if liquid) of material into 10 mL of methanol (MeOH).

11.12.1.2.1 If the material does not completely dissolve, contact your immediate supervisor.

11.12.2 Take 100 uL of the 10 mL solution and dilute it to 10 mL in MeOH.

11.12.3 Take a 1 mL aliquot of this solution (effective dilution of 1000x (1 mg for solid or 0.001 mL for liquid)) and fortify with 25 uL of labeled IDA or surrogate solution (Section 7.7).

11.12.4 DO NOT PASS EXTRACT THROUGH SPE CARTIRIDGE (omit steps 11.9 – 11.11).

11.12.5 Proceed to Section 11.6 of this SOP for extract concentration."

19.2.14. Added Section 11.13 titled, " TOP (Total Oxidizable Precursor) Assay" to read:

11.13.1 Prepare 3-250 mL HDPE containers with HPLC grade water to create the needed QC Samples (MB, LCS/LCSD).

11.13.2 Prepare enough 125 mL HDPE containers as needed for all "Pre" and "Post" samples, including QC. Label each appropriately.

11.13.3 Spike the "Pre" and "Post" MB 125 mL containers with 25 uL of the reverse surrogate solution of M2-4:2 FTS (Section 7.8).

11.13.4 Spike the "Pre" and "Post" LCS/LCSD 125 mL containers with 20 uL of the LCS Spike solution (Section 7.6), both regular and "add-

on", and 25 uL of the reverse surrogate solution (Section 7.8).

11.13.5 Remove the methanol solvent from all Post QC sample 125 mL containers (MB and LCS/LCSD) by using N2 evaporation.

11.13.6 Subsample 100 mL aliquots of water from each field sample and QC from the 250 mL containers into each of the corresponding 125 mL containers for both the "Pre" and "Post" samples.

11.13.7 Set aside all "Pre" sample containers.

11.13.8 Add 2g of potassium persulfate and 1.9 mL of 10N NaOH to each "Post" sample container.

11.13.9 Heat each "Post" sample container in a water bath (KD) at 85°C for 6 hours.

11.13.10 After digestion for 6 hours, place the "Post" sample containers in an ice bath for 30 minutes.

11.13.11 Adjust the pH of "Post" samples and associated QC aliquots to 7 with concentrated HCl. Use pH paper to determine the pH.

11.13.12 Spike both "Pre" and "Post" samples and their associated QC samples with 25 uL of PFC IDA solution (Section 7.7), both regular and add-on.

11.13.13 Use the following SPE procedure for both "Pre" and "Post" samples:

11.13.13.1 Set up WAX 150 mg/6 cc SPE columns for sample extraction using a vacuum manifold.

11.13.13.2 Establish a sample loading flow rate of 1 mL/minute for each port of the vacuum manifold, for as many ports as will be used simultaneously during sample loading.

11.13.13.3 Wash/condition the SPE column with 5 mL of 0.3% NH_4OH/Methanol, then 5 mL water.

11.13.13.4 Load 100 mL of sample onto the SPE cartridge at a flow rate of 1 mL/minute.

11.13.13.5 Add 5 mL rinse water

11.13.13.6 After the sample and water rinse have completely passed through the column, allow it to dry well using vacuum with a flow rate of 1 mL/minute for 15 minutes.

11.13.13.7 Wash the SPE column with 10 mL hexane rinse eluting all to waste.

11.13.13.8 Allow the column to dry well using vacuum with a flow rate of 1 mL/minute for 5 minutes. Columns must be dry before continuing.

11.13.13.9 Elute the samples into 15 mL polypropylene test tubes in the SPE manifold by rinsing each 125 mL sample container with 5 mL of 0.3% NH_4OH/methanol, and add to the SPE cartridge as eluent.

11.13.13.10 Repeat with another 5 mL of 0.3% NH_4OH/methanol.

11.13.13.11 Collect the 10 mL of eluent and concentrate per Section 11.6.

19.2.15. Section 11.15, added M2-4:2FTS to the "Mass Spectrometer Scan Settings (SCIEX 5500)" table.

19.2.16. Inserted Section 16.8 to read, "Method ISO 25101, "Water quality – Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) – Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry", First Edition, 2009-03-01, International Organization for Standardization, Technical Committee ISO/TC 147, *Water Quality*, Subcommittee SC 2, *Physical, chemical and biochemical methods*."

19.2.17. Added Section 16.10 to read, "Erika F. Houtz and David L. Sedlak, "Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff," Environmental Science and Technology 46, no. 17 (2012): 9342-49."

19.2.18. Section 17, inserted Section 17.1, and placed all modifications to Method 537 under Section 17.2 and subheadings.

19.2.19. Editorial changes.

19.3. WS-LC-0025, Revision 2.2, Effective 02/02/2017

19.3.1. Title, revised to read, "Per- and Polyfluorinated Subtances (PFAS) in Water, Soils, Sediments and Tissue"

19.3.2. Many occurrences of the acronym “PFC” have been replaced with “PFAS”. If the acronym “PFC” is used within the laboratory as an identifier, it has been kept in the SOP in that context.

19.3.3. References to polypropylene (PP) containers for use within the laboratory have been changed to polyethylene (HDPE), as these are the containers in use.

19.3.4. Section 2.5, deleted the following (redundant): “Isotope dilution technique is employed with this method for most compounds of interest. The IDA’s consist of carbon-13 labeled analogs or oxygen-18 labeled analogs of the compounds of interest, and they are spiked to the samples at the time of extraction. This technique allows correction for analytical bias encountered when analyzing more chemically complex environmental samples, because the isotopically labeled compounds are chemically similar to the compounds of concern and are therefore affected by sample-related interferences to the same extent as the compounds of concern. Compounds that do not have a labeled analog are quantitated by IDA method using a closely related labeled analog.”

19.3.5. Section 4.5, revised to read, “Commercial sources of PFOS, PFHxS, PFOA, and other PFAS may produce several peaks in the chromatogram. These adjacent peaks are either completely resolved or not resolved but with a profound deflection that can be resolved during peak integration. The later of the peaks matches the retention time of the single labeled PFAS peak. In general, earlier peaks are branched isomers and are not a result of peak splitting. When reference standards of technical mixtures of specific PFAS area available, they should be used to ensure that all appropriate peaks are included during peak integration. Refer to Section 7, Reagents, for the available technical mixtures utilized by this SOP.”

19.3.6. Section 6.1, removed: “8 mL test tubes, screw thread, with caps.”

19.3.7. Sections 6.10 (Isolator Column), 6.13 (Waters UPLC system), 6.14 (Columns + Shimadzu HPLC) reorganized as Section 6.14 and subsections.

19.3.8. Section 6.14 (after reorganization) changed to read, “Liquid Chromatography/Tandem Mass Spectrometer (LC/MS/MS) – Either of the instruments described below, or equivalent, may be used for this method. Both HPLC are equipped with a refrigerated autosampler, an injection valve, and a pump capable of variable flow rate. The use of a column heater is required to maintain a stable temperature throughout the analytical run. Data is processed using Chrom Peak Review, version 2.1 or equivalent.

19.3.9. Section 6.14.1, inserted to read, “Waters LC/MS/MS

This consists of a Waters Acquity UPLC system interfaced with a Waters Quattro Premiere tandem mass spectrometer. The instrument control and data acquisition software is MassLynx version 4.1, or equivalent."

19.3.10. Section 6.14.1.1, inserted to read, "Analytical column: Waters Acquity UPLC BEH C18 1.7 um, 3.0 mm x 150 mm, Part No. 186004690"

19.3.11. Section 6.14.1.1, inserted to read, "PFAS Isolator column, Waters Acquity UPLC BEH Shield RP-18, 1.7 um, 2.1 mm x 50 mm, PN 186004476, or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters."

19.3.12. Section 6.14.2, inserted to read, "SCIEX LC/MS/MS

This system consists of a Shimadzu HPLC interfaced with a SCIEX 5500 Triple Quad MS. The instrument control and data acquisition software is SCIEX Analyst, version 1.6.3 or equivalent."

19.3.13. Section 6.14.2.1, inserted to read, "Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent."

19.3.14. Section 6.14.2.2, inserted to read, "Phenomenex Gemini C_{18} 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent."

19.3.15. Section 6.14.2.3, inserted to read, "PFAS Isolator column, Phenomenex Luna C_{18} 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E0 or equivalent. This is plumbed between the UPLC pumps and autosampler valve to minimize PFAS background from the UPLC solvent lines and filters."

19.3.16. Section 10.11.2.2, changed to read, "The native must be within or equal to 50-150% for all native analytes quantitated by internal standard (ie, those compounds that do not have corresponding isotopically labelled analogs)."

19.3.17. Section 11.2, moved as paragraph under Section 11.1. Renumbered Section 11.

19.3.18. Section 11.2.1, appended the following, "File an NCM noting the need for filtration."

19.3.19. Section 11.13, MS Scan Settings Tables – under the comments section, replaced compound names with "native analyte". Correlation between compound names and abbreviations is at the beginning of the SOP.

19.3.20. Editorial changes.

19.4. WS-LC-0025, Revision 2.1, Effective 12/09/2016

19.4.1. Section 8.2, second sentence, changed 7 days to 14 days.

19.4.2. Note following Section 8.2, changed to read: "NOTE: As of this writing, Method 537 provides for a 14 day holding time for water samples preserved with Trizma buffer. The scientific literature indicates that perfluorinated substances are highly persistent in the environment. TestAmerica Sacramento has conducted holding time studies that support a 14 day holding time for aqueous samples with and without Trizma preservation. TestAmerica Denver has conducted stability studies indicating that medium- and low-level solutions of PFOA are stable for at least three months in polystyrene and polypropylene plastics at 0-6C. The 14 day/40 day holding times given above are based on the holding time study and general EPA convention for the holding time of extractable organic compounds in water and soil."

19.4.3. Section 17.1, removed the second sentence "Holding time has been changed to 7 days for extraction."

19.4.4. Editorial Changes

19.5. WS-LC-0025, Revision 2.0, Effective 11/18/2016

19.5.1. Replace "internal standard" with "IDA" throughout SOP.

19.5.2. Section 4.7, changed last sentence of paragraph to include "…in the standard **and/or sample** must…".

19.5.3. Section 6.9.4, added - "Phenomenex Gemini 3 µm C18 110Å, 50 X 2 mm, Part No. 00B-4439-B0."

19.5.4. Section 6.9.5, added – "Phenomonex Luna 5 µm C18(2) 100Å, 30 X 3 mm, Part No. 00A-4252-Y0."

19.5.5. Section 6.14, added – "SCIEX 5500 Triple Quad MS. The system utilizes Chrom Peak Review, version 2.1 or equivalent."

19.5.6. Section 7.4.1, added - "A technical (qualitative) grade PFOA standard is analyzed after an initial calibration initially, when a new column is installed or when significant changes are made to the HPLC parameters. This solution is used as a reference for the PFOA isomers (branched and linear) retention times."

19.5.7. Section 11.14.1, HPLC settings, gradient time 1, corrected flow rate from

0330 mL/min to 0.30 mL/min.

19.5.8. Section 11.14.1, MS Settings, removed the following lines for Waters instrument and added additional Table for Shimadzu HPLC.

PFPeS	Perfluoropentanesulfonate	3749 > 80	0.02	55	32	3
PFNS	Perfluorononanesulfonate	549 > 80	0.02	65	54	8
PFDoS	Perfluorododecanesulfonate	699 > 80	0.02	80	55	11

19.5.9. Section 15, added – "Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent."

19.5.10. Editorial chamges.

19.6. WS-LC-0025, Revision 1.9, Effective 05/27/2016

19.6.1. Editorial Changes.

19.6.2. Added Attachment 1.

19.7. WS-LC-0025, Rev 1.8, Effective 05/19/2016

19.7.1. Section 1.2, changed water sample volume from 500 to 250 mL.

19.7.2. Section 7.6, change the LCS solution from 1000 ng/mL to 500 ng/mL

19.7.3. Section 8.1, changed the sample container from 500 mL volume to 250 mL volume for water samples.

19.7.4. Section 11.3.2, 11.3.4, and 11.4.5, changed water sample volume from 500 to 250 mL.

19.7.5. Section 11.3.5, change the volume of spike added for EtFOSA/MeFOSA from 100 uL to 200 uL.

19.7.6. Section 11.3.6, change the volume of solution added from 0.050mL (50 uL) to 0.025 ml (25 ul), and from 250 to 125 uL if EtFOSA/MeFOSA is requested.

19.7.7. Section 11.7.2, change the volume of methanol from 800 uL to 400 uL.

19.7.8. Section 11.7.3, change the volume of water added from 200 uL to 100 uL.

19.7.9. Section 11.8.4, changed the volume of spike added from 20 uL to 40 uL.

19.7.10. Editorial Changes

19.8. WS-LC-0025 Rev. 1.7, Effective 03/18/2016

19.8.1. Section 4.5 – Deleted the last sentence in this section: “Until more information is available” and changed “excluded” to “included”.

19.8.2. Section 4.7 - Deleted the last sentence. “Chromatographic peaks in a sample must be integrated in the same way as the CAL standard.”

19.8.3. Section 7.4 – Changed upper calibration limit (CS-7) for all analytes from 500 ng/mL to 400 ng/mL

19.8.4. Section 9.8.2 – Revised 1st sentence to “IDA recoveries are flagged if they are outside of the acceptance limits (25–150%)”

19.8.5. Section 11.3.5 – Added to end of Section, “If EtFOSA and/or MeFOSA are required, increase the amount of LCS Matrix PFC spike solution added to 100 uL.”

19.8.6. Editorial changes.

19.9. WS-LC-0025 Rev. 1.6, Effective January 22, 2016

19.9.1. Section 11.6.1 – Revised to include rinse of sample container

19.9.2. Section 11.6.2 – Revised to include rinse of sample container.

19.9.3. Editorial changes

1. SCOPE AND APPLICATION

1.1. This procedure describes the analysis of water samples via in line solid phase extraction (SPE) for the following compounds using liquid chromatography / tandem mass spectrometry (LC/MS/MS) on a SCIEX 5500.

Compound Name	Abbreviation	CAS #
Perfluoroalkylcarboxylic acids (PFCAs)		
Perfluoro-n-heptanoic acid	PFHpA	375-85-9
Perfluoro-n-octanoic acid	PFOA	335-67-1
Perfluoro-n-nonanoic acid	PFNA	375-95-1
Perfluorinated sulfonic acids (PFSAs)		
Perfluoro-1-butanesulfonic acid	PFBS	375-73-5
Perfluoro-1-hexanesulfonic acid	PFHxS	355-46-4
Perfluoro-1-octanesulfonic acid	PFOS	1763-23-1

1.2. The working range of the method is listed below. The linear range can be extended by diluting the extracts.

Matrix	Nominal Sample Size	Reporting Limit	Working Range
Water	1.0 mL	2.0 ng/L	2 to 200 ng/L

2. SUMMARY OF METHOD

2.1. A 1 mL aliquot of sample is diluted to a 40:60 methanol:water extract and analyzed by LC/MS/MS. PFAS are separated from other components on a C18 column with a solvent gradient program using 20mM ammonium acetate/water and methanol.

3. DEFINITIONS

Refer to Section 3 of the main body of this SOP for a summary of definitions.

4. INTERFERENCES

Refer to Section 4 of the main body of this SOP for interferences.

5. SAFETY

Refer to Section 5 of the main body of this SOP for safety information.

6. EQUIPMENT AND SUPPLIES

Refer to Section 6 of the main body of this SOP for supplies, other than those listed below specific to the in line SPE analysis.

6.1. 2 mL auto sampler vials, clear glass, Thermo Scientific Nation surestop vial, part no. C5000-1, or equivalent**.**

6.2. Vial caps, Thermo Scientific National AVCS blue cap, pre slit TEF/STL septa, part no. C5000-55B or equivalent.

6.3. Eppendorf 1000 uL epTIPS, part no. 022491954 or equivalent.

6.4. Eppendorf 200 uL epTIPS, part no. 022491938 or equivalent.

6.5. 50 mL graduated plastic centrifuge tubes, SCP Science DigiTUBES part no. 010-500-263 or equivalent

The 5 items above are to be maintained in the drawer labeled "Segregated Supplies for in line SPE Analysis" in the LC/MS instrument room

6.6. 1000 uL Pipette: Eppendorf Research Plus

6.7. 100 uL Pipette: Rainin EDP3-Plus

6.8. 250 mL HDPE bottles with PPE screw caps, ESS part no. 0250-1902-QC or equivalent.

6.9. Analytical columns

6.9.1. Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm, Part No. 00D-4439-Y0, or equivalent.

6.9.2. PFAS Isolator column, Phenomenex Luna C18 5 um, 50 mm x 4.6 mm, part no. 00B-4252-E 0 or equivalent.

6.10. SCIEX 5500 Triple Quad MS. The system utilizes Chrom Peak Review, version 2.1 or equivalent.

6.11. Shimadzu CTO-20AC HPLC equipped with 3 LC-20AD pumps and one DGU-20 degassing unit or equivalent.

7. REAGENTS AND STANDARDS

Refer to Section 7 of the main body of this SOP for reagents and standards, other than those listed below specific to the in line SPE analysis.

7.1. Reagent grade chemicals shall be used in all tests whenever available. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on the Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.1.1. Ammonium acetate, Fisher Optima LCMS grade (20 mM in water), part no. A114-50, or equivalent.

7.1.2. Methanol, Baker HPLC grade, part no. 9093-03.

7.1.3. Water, Nanopure or Millipore or Fisher Optima LCMS grade, part no. W6-4, must be free of interference and target analytes.

7.2. Calibration Standards

The calibration stock solution is prepared by diluting the appropriate amounts of the stock solutions (Section 7.2 of the main body of this SOP) in 40:60 methanol:water. The calibration stock solution is diluted with methanol to produce initial calibration standards. These are the normal calibration levels used. A different range can be used if needed to achieve lower reporting limits or a higher linear range.

7.3. Initial Calibration (ICAL) Levels (ng/L)

Compound	CS-1	CS-2	CS-3	CS-4	CS-5	CS-6	CS-7	CS-8
Perfluoroalkylcarboxylic acids (PFCAs)								
PFHpA	1.0	2.0	5.0	10	20	50	100	200
PFOA	1.0	2.0	5.0	10	20	50	100	200
PFNA	1.0	2.0	5.0	10	20	50	100	200
Perfluorinated sulfonic acids (PFSAs)								
PFBS	1.0	2.0	5.0	10	20	50	100	200
PFHxS	1.0	2.0	5.0	10	20	50	100	200
PFOS	1.0	2.0	5.0	10	20	50	100	200
Labeled Isotope Dilution Analytes (IDA)								
13C4-PFHpA	50	50	50	50	50	50	50	50
13C4-PFOA	50	50	50	50	50	50	50	50
13C5-PFNA	50	50	50	50	50	50	50	50
18O2-PFHxS	50	50	50	50	50	50	50	50
13C4-PFOS	50	50	50	50	50	50	50	50

Note- The above calibration levels are provided only as an example. The actual ICAL level used for each analytical batch will depend upon the LOQ requirements of the program.

7.4. LCS/Matrix PFC Spike Solution, 100 ng/mL.

The PFC spike solution is prepared by diluting all PFAS to produce a solution containing each PFAS at 100 ng/mL in methanol.

7.5. PFC Isotope Dilution Analyte (IDA) Spike Solution, 1 ng/mL.

The PFC-IDA solution is prepared by diluting all labeled PFAS to produce a solution containing each at 1 ng/mL in methanol.

8. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1. Water samples are collected in pre-cleaned 250 mL HDPE containers. Other containers may also be suitable. Samples are chilled to 0 - 6 °C for shipment to the laboratory.

8.2. Samples are logged in following normal laboratory procedures and are stored under refrigeration at 0 - 6 °C. Water samples must be analyzed within 28 days of collection.

9. QUALITY CONTROL

Refer to Section 9 of the main body of this SOP for Quality Control information.

10. CALIBRATION

Refer to Section 10 of the main body of the SOP for calibration information.

11. PROCEDURE

Refer to Section 11 of the main body of this SOP for procedures, other than those listed below specific to the in line SPE analysis.

11.1. Water Sample Preparation

11.1.1. Visually inspect samples for the presence of settled and or suspended sediment. If sediment is apparent, remove the aliquot for testing from the aqueous layer. If the sediment concentration is too high centrifuge the sample first or filter the water sample through a glass fiber filter (Whatman GF/F Cat No 1825 090 or equivalent). Gravity or vacuum can be used to pass the sample through the filter. Prepare a filtration blank with any samples requiring filtration. File an NCM noting the need for filtration.

Warning: The use of a vacuum system creates the risk of glassware implosion. Inspect all glassware prior to use. Glassware with chips, scratches, rub marks or cracks must not be used.

11.1.2. Prepare an LCS and method blank by adding 250 mL of HPLC grade water into a 250 mL HDPE bottle.

11.1.3. If requested, find the client assigned sample for MS/MSD.

11.1.4. Spike directly into the sample bottles for the LCS and MS/MSD (if requested) with 0.050 mL (50 uL) of the LCS/Matrix PFC Spike solution (Section 7.4). This will result in a sample concentration of 20 ng/L. Shake well to disperse spike.

11.1.5. Measure 1 mL of each sample using an Eppendorf pipette and pour into a

labeled 2.0 mL injection vial. This includes the LCS and method blank samples as well.

11.1.6. Be sure to "prepare" the pipette by collecting two 1 mL aliquots and disposing of them, and then collect the aliquot for testing.

11.1.7. Add 83 uL of surrogate solution (PFC IDA Spike Solution, Section 7.5) into each vial for each sample and QC sample. This will result in an extract concentration of 50 ng/L for the surrogate.

11.1.8. Add 577 uL of methanol to each sample for a final solvent composition of 40:60 methanol:water.

11.1.9. Seal the vial with a polypropylene screw cap. Note: Teflon lined caps can not be used due to detection of low level concentration of PFAS.

11.1.10. Vortex to mix the mixture well.

11.2. Instrument Analysis

11.2.1. Suggested operation conditions are listed below:

<table>
<tr><th colspan="6">Routine Instrument Operating Conditions</th></tr>
<tr><td colspan="6">HPLC Conditions (Shimadzu HPLC)</td></tr>
<tr><td>Column (Column temp = 35°C)</td><td colspan="5">Phenomenex Gemini C18 3 um, 3.0 mm x 100 mm</td></tr>
<tr><td>Mobile Phase Composition</td><td colspan="5">A = 20 mM Ammonium Acetate in Water B = Methanol</td></tr>
<tr><td rowspan="9">Gradient Program</td><td>Time (min)</td><td>%A</td><td>%B</td><td>Curve</td><td>Flow Rate (mL/min)</td></tr>
<tr><td>0</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td>1</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td>1.5</td><td>35</td><td>65</td><td>6</td><td>0.60</td></tr>
<tr><td>8</td><td>5</td><td>95</td><td>6</td><td>0.60</td></tr>
<tr><td>8.1</td><td>1</td><td>99</td><td>6</td><td>0.60</td></tr>
<tr><td>12</td><td>1</td><td>99</td><td>6</td><td>0.60</td></tr>
<tr><td>12.5</td><td>90</td><td>10</td><td>6</td><td>0.60</td></tr>
<tr><td colspan="5">Maximum Pressure limit = 5,000 psi</td></tr>
<tr><td>Injection Size</td><td colspan="5">950 uL (fixed amount throughout the sequence)</td></tr>
<tr><td>Run Time</td><td colspan="5">17.1 minutes</td></tr>
</table>

Routine Instrument Operating Conditions	
Mass Spectrometer Interface Settings (SCIEX 5500)	
MS Interface Mode	ESI Negative Ion
Ion Spray Voltage (kV)	4.5
Entrance Potential (V)	5
Declustering Potential (V)	25
Desolvation Temp	550 ºC
Curtain Gas (nitrogen) Flow	35 psi
Collision Gas (nitrogen) Flow	8 psi

Routine Instrument Operating Conditions						
Mass Spectrometer Scan Settings (SCIEX 5500)						
Compound	**Comments**	**Reaction (MRM)**	**Dwell (sec)**	**Ent. Pot. (V)**	**Col. Energy (V)**	**Declu. Pot. (V)**
PFBS	Perfluorobutanesulfonate	299 > 80	0.02	6	58	55
18O2-PFHxS	IS	403 > 84	0.02	12	74	60
PFHpA	Perfluoroheptanoic acid	363 > 319	0.02	6	12	25
13C4-PFHpA	IS	367 > 322	0.02	6	12	25
PFHxS	Perfluorohexanesulfonate	399 > 80	0.02	12	74	60
18O2-PFHxS	IS	403 > 84	0.02	12	74	60
PFOA	Perfluorooctanoic acid	413 > 369	0.02	6	14	25
13C4PFOA	IS	417 > 372	0.02	6	14	25
PFNA	Perfluorononanoic acid	463 > 419	0.02	6	14	25
13C5-PFNA	IS	468 > 423	0.02	6	14	25
PFOS	Perfluorooctanesulfonate	499 > 80	0.02	9	108	65
13C4-PFOS	IS	503 > 80	0.02	9	108	65

Native Compounds	Native RT (minutes)	IS analog	IS RT (minutes)	Quantitation Method
PFBS	6.68	18O2-PFHxS	7.76	IS calculation
PFHpA	7.77	13C4-PFHpA	7.77	Isotope Dilution
PFHxS	7.76	18O2-PFHxS	7.76	Isotope Dilution
PFOA	8.44	13C4-PFOA	8.44	Isotope Dilution
PFNA	9.10	13C5-PFNA	9.10	Isotope Dilution
PFOS	9.06	13C4-PFOS	9.06	Isotope Dilution

11.2.2. Tune and calibrate the instrument as described in Section 10.

12. CALCULATIONS

Refer to Section 12 of the main body of this SOP for calculation information.

13. METHOD PERFORMANCE

Refer to Section 13 of the main body of this SOP for method performance information.

14. POLLUTION PREVENTION

Refer to Section 14 of the main body of this SOP for pollution prevention information.

15. WASTE MANAGEMENT

Refer to Section 15 of the main body of this SOP for waste management information.

16. REFERENCES

Refer to Section 16 of the main body of this SOP for reference information.

17. METHOD MODIFICATIONS

17.1. Refer to Section 17 of the main body of this SOP for modifications from Method 537, except as detailed below:

17.1.1. Water samples are prepared at 1.0 mL, not 250 mL.

17.1.2. Water sample containers are not preserved with Trizma. Holding time has been changed to 28 days for analysis.

17.1.3. The eluents and HPLC configuration differs. As a result the final extract is in 40:60 methanol:water.

18. ATTACHMENTS

There are no attachments to this Appendix.

19. REVISION HISTORY

19.1. WS-LC-0025 Attachment 1, Revision 2.4, Effective 04/25/2017

19.1.1. No revisions to this attachment.

19.2. WS-LC-0025 Attachment 1, Revision 2.3, Effective 04/10/2017

19.2.1. Changed all mentions of “direct aqueous injection (DAI)” to “in line solid phase extraction (SPE).”

19.2.2. Inserted Section 17.1, and changed formatting of the modifications to Method 537 to Section 17.2 and subheadings.

19.3. WS-LC-0025 Attachment 1, Revision 2.2, Effective 01/31/2017

19.3.1. Title, changed to read, “Analysis of Per- and Polyfluorinated Compounds (PFAS) in Water via Direct Aqueous Injection (DAI)”

19.3.2. Many occurrences of the acronym “PFC” have been replaced with “PFAS”. If the acronym “PFC” is used within the laboratory as an identifier, it has been kept in the SOP in that context.

19.3.3. Section 11.1, appended the following, “File an NCM noting the need for filtration.”

19.3.4. Section 18 – Changed SOP to Appendix.

19.1.2 Editorial revisions including revision history (19.2 below) and header.

19.4. WS-LC-0025 Attachment 1, Revision 2.1, Effective 12/09/2016

19.4.1. No revisions to this Appendix.

19.5. WS-LC-0025 Attachment 1, Revision 1.9, Effective 05/27/2016

19.5.1. This is the first version of this Appendix.

A2 - Quality Assurance Project Plan

QUALITY ASSURANCE PROJECT PLAN
SAINT-GOBAIN PERFORMANCE PLASTICS SITE
1030 WATER STREET
VILLAGE OF NORTH BENNINGTON
BENNINGTON COUNTY, VERMONT

QUALITY ASSURANCE PROJECT PLAN
SAINT GOBAIN PERFORMANCE PLASTICS SITE
1030 WATER STREET
VILLAGE OF NORTH BENNINGTON
BENNINGTON COUNTY, VERMONT

KEY PERSONNEL AND SIGNATURES

Approved: _____ Date: _____
Project Principal
Daniel Reilly, P.E.
Environmental Services Manager
C.T. Male Associates

Approved: _____ Date: _____
Project Manager & Health and Safety Coordinator
Kirk Moline
Managing Geologist
C.T. Male Associates

Approved: _____ Date: _____
Quality Assurance Officer
Elizabeth Rovers, P.E.
Managing Engineer
C.T. Male Associates

FIGURES

TABLES

APPENDICES

1.0 PROJECT DESCRIPTION

1.1 Introduction

This Quality Assurance Project Plan (QAPP) has been prepared for the implementation of the a Site Characterization investigation at the Saint-Gobain Performance Plastics Corporation (Saint-Gobain) Site ("the Site") located at 1030 Water Street in the Village of North Bennington, Bennington County, Vermont. It has been developed in conjunction with the SCIWP as prepared by C.T. Male Associates. A description of the Site, background information, objectives and the Site Characterization scope of work are presented in detail in the referenced SCIWP.

This QAPP presents the organizational structure and data quality objectives (DQOs) for the site characterization, and the quality assurance (management system) and quality control methods of checks and audits to be implemented to ensure that the quantity and quality of the data required for its intended use is obtained and documented (i.e., that DQOs are met). The measurement parameters used to determine the quality of the data are precision, accuracy, completeness, representativeness and comparability, and are discussed further in this QAPP.

A Field Sampling Plan (FSP) has been prepared by C.T. Male Associates as a separate exhibit and forms an integral part of this QAPP. The field sampling and data gathering procedures are presented in the FSP and incorporated into the QAPP by reference. The QAPP and FSP document the laboratory quality assurance/quality control (QA/QC) procedures and field sampling and data gathering procedures that will be followed during implementation of the site characterization scope of work so that valid data of a known quality is generated.

The project specific field QA/QC procedures and the project specific laboratory QA/QC procedures are presented in the text of this QAPP. The general internal laboratory QA/QC procedures are presented in the subcontractor laboratory's Quality Manual which is retained at the laboratory's place of business. Vermont certified subcontract laboratories for this project are Eurofins Eaton Analytical, Inc. of South Bend, Indiana for aqueous analyses, and Eurofins Lancaster Laboratories, LLC of Lancaster, Pennsylvania for solids analyses. The laboratory certifications and statement of qualifications are included in Attachment A.

The QAPP has been prepared in a manner consistent with the following guidance documents:

- Investigation and Remediation of Contaminated Properties Procedure, State of Vermont Agency of Natural Resources, Effective April 2012.
- Data Quality Objectives for Remedial Response Activities: Development Process, EPA/540/G-87/003, USEPA, March 1987.

1.2 Objectives and Scope of Work

It is the objective of the SC and this QAPP to obtain and present representative data of a known quality and sufficient quantity. The primary goal is to perform soil/fill and groundwater sampling through a variety of investigative tasks to preliminarily evaluate the Site's environmental quality and to refine the Site's conceptual model. Depending on the conclusions drawn from the SC, additional investigation of the Site may be required.

To achieve these objectives, the scope of work will include the following items as presented in the SCIWP, in this QAPP and in the FSP. The investigative tasks will include the advancement of soil test borings, collection and analysis of soil/fill samples, installation of monitoring wells, and collection and analysis of groundwater samples.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

C.T. Male Associates is responsible for providing professional services associated with the quality control/quality assurance of the Site Characterization. These will include project management, coordination, and scheduling of activities in-house and with qualified subcontractors. The work tasks that will be performed by a subcontractor to C.T. Male Associates include: conventional hollow stem auger (HAS) or Rotosonic drilling of borings/monitoring wells, analytical laboratory testing and third party validation of analytical data for preparation of a Data Usability Summary Report (DUSR).

A project organizational chart listing key individuals of the project and their associated title is presented as Figure 1 at the end of this document. Personnel from C.T. Male Associates, the subcontract drilling contractor, laboratory and data validator can be reached at the following addresses:

- C.T. Male Associates
  Contact: Kirk Moline
  50 Century Hill Drive
  Latham, New York 12110
  Phone: (518) 786-7400
  Fax No.: (518) 786-7299
  Email: k.moline@ctmale.com

- Drilling Contractor: Cascade Drilling, L.P.
  430 Hudson River Road
  Waterford, New York 12188
  Phone: (518) 326-1441

- Laboratory: Eurofins Eaton Analytical, Inc.
  110 S. Hill Street
  South Bend, Indiana 46617
  Phone: (800) 332-4345

- Laboratory: Eurofins Lancaster Laboratories, LLC.
  2425 New Holland Pike
  Lancaster, Pennsylvania 17605
  Phone: (717) 656-2300

- Data Validation: To Be Determined

A description of the responsibilities by title of the key individuals is presented as follows:

Project Principal is responsible for the review of the SC activities and reports for their technical adequacy and conformance to the scope of work.

Quality Assurance Officer is responsible for the independent review of the SC documents and reports to check that the appropriate project documentation, of the quality control activities performed, exist and are maintained; and for conducting field and sampling audits.

Project Manager is responsible for the overall coordination and implementation of the project, the management of staff and resources, the implementation of schedules, the conformance by the technical staff and subcontractors to the scope of work, assessing the adequacy of the work being performed, implementing corrective action as necessary, interaction with the client and regulatory agencies, maintaining complete project documentation, and report preparation.

Health and Safety Coordinator is responsible for implementation of the project specific Health and Safety Plan, and resolution of safety issues which arise during the completion of the work. The Health and Safety Coordinator or designee will be present during the completion of the field work.

Laboratory Quality Assurance Officer is responsible for review of the laboratory data quality control procedures and documentation to determine if the QA objectives are being met; and to report non-conforming events to the laboratory technical staff and Project Manager and implement corrective action as necessary.

Laboratory Director is responsible for all activities within the laboratory, and for the performance of the laboratory work tasks in accordance with the project work plans, interactions with the Project Manager, and the adherence to project schedule.

Project Geologist/Engineer/Scientist is responsible for coordinating and conducting the field hydrogeologic activities and subcontractors, the adherence of activities to

the QAPP and the FSP, evaluation of the collected data, soil classifications, report preparation and interaction with Project Manager and Project Team.

Project Team is responsible for adequately performing the work tasks in accordance with the project work plans so that the objectives of investigations and the project are achieved, notifying the Project Manager of any non-conformance to the work plan so that corrective actions can be taken as necessary, and notifying the Project Manager of unforeseen conditions so that modifications to the work plan, if necessary, can be approved and implemented.

Data Validator is responsible for review of all analytical data generated for this project. The data validator will review analytical data and prepare a report documenting if the analytical data is valid and usable. The report will also present data rejection and qualification, where necessary, based on laboratory performance.

3.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

3.1 General

The Quality Assurance (QA) objective for this project is to produce data which is technically valid and of a known quality that meets the needs of its intended use. In this section the data quality objectives (DQOs) are defined by describing the intended use of the data; defining the type of data needed (i.e., physical or analytical); specifying the analytical levels, as established by EPA, appropriate to the data uses; specifying the quality control checks on field and laboratory procedures and frequency of checks; and presenting the quality control acceptance criteria.

Laboratory quality assurance objectives for data measurement are established for each measurement parameter in terms of precision, accuracy, completeness, representativeness and comparability. These terms form an integral part of the laboratory's quality assurance programs in that DQOs are set for each parameter.

3.2 Data Uses and Types

The data to be generated during the proposed work will be completion of SC investigation and health and safety during implementation of the field activities. Both physical data including air monitoring and analytical data from soil and groundwater will be needed to provide the necessary information to complete the steps in the SC investigation. The specific physical and analytical data proposed and its purposes are presented in the SCIWP.

3.3 Data Quality Needs

To support data collection activities in obtaining quality data, EPA has established a series of analytical levels that are appropriate to Site investigation/remediation data uses. The analytical levels are defined as follows:

Level I	Field screening or analysis using portable instruments. Qualitative data.
Level II	Field analyses using more sophisticated portable analytical instruments. Qualitative and quantitative data can be obtained.
Level III	Laboratory analyses using standard EPA and NYSDOH approved procedures/methods.

Level IV — Laboratory analyses with NYSDEC ASP (Analytical Services Protocol) - Category B Data Deliverable Packages with QA/QC protocols and documentation.

Level V — Analyses by non-standard methods.

The data collection activities, the environmental media, the intended use of the data and the corresponding analytical levels that will be used to produce the project data are summarized in Table 1.

Table 1
Summary of Work Tasks and Corresponding Analytical Levels

Data Collection Activities	Sample Media & Description	Data Use[(a)]	Analytical Level
PID Meter Monitoring	Soil Vapors	1	I
Air Monitoring	Air/Ambient Air	2	II
Test Borings and Monitoring Wells, and Soil and Groundwater Sampling	Soil, Groundwater, Surface Water and Sediment for Laboratory Analyses and Field Instrumentation	1, 3 & 4	I (Field Instrumentation) and IV (Laboratory Analyses)
Quality Control Imported Source Materials and Equipment	Driller Water, Totes and Tanks; Filter Sand Used as Monitoring Well Sand Pack; PVC Well Riser and Screen; Driller Augers, Rods and Barrel Samplers; Bottled Water for Field Tool Decontamination; Deionized Water for Final Tool/Equipment Rinse.	1 & 4	IV (Laboratory Analyses)

Note:
(a) Data Uses Key:
1 - Site Characterization.
2 - Health and Safety and Community Air Monitoring During Implementation of Ground Intrusive Field Activities, if required.
3 - Risk Assessment.
4 - Evaluation of Environmental Quality.

Another consideration besides defining the Data Quality Needs is what level of cleanup will be required for the Site, if needed. The applicable or relevant and

appropriate requirements (ARARs) are related to defining satisfactory cleanup efforts. In order to be able to evaluate the data generated with respect to potential ARARs, the samples will need to be analyzed by analytical methods that can achieve detection limits below or at existing ARAR values. The analytical methods selected for this project are designed to achieve ARAR values.

VTDEC has recently promulgated ARAR values for PFCs in Vermont. The Residential Soil Screening criteria value has been established at 0.3 mg/kg, and 20 ng/l for drinking water. The Environmental Protection Agency (EPA) March 2014 Fact Sheet entitled "Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)" indicates that in January 2009, the EPA's Office of Water established a provisional health advisory (PHA) of 0.2 micrograms per liter (ug/l) for PFOS and 0.4 ug/l for PFOA to assess the potential risk from short-term exposure of these chemicals through drinking water (EPA 2009d, 2013a). Also, EPA Region 4 calculated a residential soil screening level of 6 milligrams per kilogram (mg/kg) for PFOS and 16 mg/kg for PFOA (EPA Region 4 2009).

3.4 Quality Control Checks and Acceptance Criteria

To monitor and document the integrity of such factors as the environmental quality of source materials, sample variability, sampling equipment cleanliness, sampling technique, analytical reproducibility and sample handling which can affect data quality, several field quality control checks will be implemented. These will include collecting samples of source materials (i.e., driller water, decontamination water, drilling tools, monitoring well construction material, etc.) prior to importation of these materials to the Site; collecting equipment/field blanks after sampling equipment has been decontaminated to check for cross contamination and equipment cleanliness; taking replicate samples to monitor analytical precision/reproducibility and sampling technique; taking matrix spike/matrix spike duplicate (MS/MSD) samples to monitor sample matrix effect and laboratory accuracy/precision; and preparing laboratory and trip blanks and field trip blanks to be shipped with the sample containers for volatile and PFC analyses to monitor sample handling.

For this project, quality control samples will be collected of the following source materials that will be imported onto the Site to conduct the investigations.

- Water from the drilling contractor for drilling and decontamination.
- Totes and tanks used by the drilling contractor to store water. A rinsate blank will be collected of the totes/tanks by pouring deionized water through the totes/tanks and collecting in laboratory provided containers.
- Filter sand used for the monitoring well sand pack.
- PVC well riser and screen used by the drilling contractor for construction of monitoring wells. A rinsate blank will be collected of the PVC riser and screen by pouring deionized water through and over the riser and screen and collecting in laboratory provided containers.
- Auger casing, rods and split-spoon sampling barrels from the drilling contractor. A rinsate blank will be collected of the auger casing, rods and split-spoon sampling barrels by pouring deionized water through and over the auger casing, rods and split-spoon sampling barrels and collecting in laboratory provided containers.
- Bottled deionized water for decontamination and rinse samples.

The field Quality Control (QC) checks will consist of one (1) equipment/field blank, one (1) replicate sample and one (1) MS/MSD sample during sampling activities for every twenty (20) analytical samples per media type (i.e., soil and groundwater), and one (1) sample for each imported source material. A Laboratory Trip Blank will be prepared for each groundwater sample set to be submitted for volatile organic and PFC analyses. A Field Trip Blank will be prepared in the field for each aqueous sample set to be submitted for PFC analyses.

Internal laboratory quality control checks will be those specified in EPA Methods or in the most recent NYSDEC ASP for the analytical method performed and could consist of some of the following:

- Blanks (method, preparation),
- initial and continuing calibrations,
- surrogate spikes,
- matrix spike/matrix spike duplicates,
- ambient samples,
- duplicate samples, and
- control samples/matrix spike blanks.

The laboratory will be responsible for performing what is necessary for complying with appropriate standards and certifications of the selected EPA method and ASP requirements. The laboratory quality control acceptance criterion is method specific and will be the laboratory's responsibility to meet the most recent ASP criteria.

4.0 SAMPLING PROCEDURES

Procedures for sampling are presented in the Field Sampling Plan (FSP) and include the following:

- Selection of sampling sites and media to be sampled;
- Procedures for the collection of investigation equipment and material rinse blank samples;
- Specific sampling procedures for each environmental media to be sampled, and for QC samples to be taken;
- Field soil screening procedures;
- A description of the containers, procedures and equipment used for sample collection, preservation, transport and storage;
- Procedures for preparing the sample containers and sampling equipment prior to sampling and decontamination of sampling equipment during sampling;
- Chain of custody procedures and forms; and
- Description of the procedures, forms and notebooks to be used to document sampling activities, sample conditions and field conditions.

5.0 SAMPLE CUSTODY

Proper chain of custody will be established and maintained through a series of steps, beginning in the field and ending with final disposition of the analyzed sample(s). At the time of the field sampling, an external chain of custody form will be utilized to track sample collection until delivery to the analytical laboratory. An internal or "intra-laboratory" chain of custody will be used by laboratory personnel to track the sample(s) from the point it is received/logged and passed through the laboratory process. Chain of custody procedures are discussed in detail in the FSP.

6.0 CALIBRATION PROCEDURES

Calibration procedures for field equipment including the photo ionization detector (PID) meter, pH/conductivity/temperature/oxidation-reduction potential (ORP) meter, and turbidity meter are presented in the FSP. Calibration procedures for laboratory equipment/instrumentation consist of the production and use of current certifiable standards and the measurement/adjustment of the instrument response. The laboratory is responsible for maintaining records documenting use of current standards and acceptable instrument responses. The laboratory is required to flag analytical data that has had potential contamination or poor instrument calibration that may have occurred during the analytical process.

7.0 SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

The analytical parameters, sample preparation and analysis methods, acceptable holding times and required method detection limits are presented in Table 2. The analytical methods specified, with the exception of PFCs, reflect the requirements of EPA (see footnote 3 at the bottom of table).

Table 2
Analytical Methods and Requirements

Analytical Parameters	EPA Method	Holding Times(1)	Contract Required Quantitative Limits (as noted)(2)
TCL Volatile Organic Compounds (VOCs)	EPA Analytical Method SW-846 8260C for Water and Soil and EPA Preparation Methods 5030C (Water) and 5035A (Soil)	Water: 7 Days Unpreserved to Analysis, 12 Days Preserved (HCl to pH<2) to Analysis. Soil: 48 hours to freeze, 14 days to analysis once unfrozen.	0.5-5 ug/l (Water) 5 to 20 ug/kg (Soil)
TCL Semi-Volatile Organic Compounds (SVOCs)	EPA Analytical Method SW-846 8270D for Water and Soil and EPA Preparation Methods 3510C (Water) and 3546 (Soil)	5 Days to Extraction, 40 Days to Analyze	0.5-30 ug/l (Water) 17-1,000 ug/kg (Soil)
TCL Pesticides	EPA Analytical Method SW-846 8081B for Soil and Water and EPA Preparation Methods 3510C (Water) and 3546 (Soil)	5 Days to Extraction, 40 Days to Analyze	0.01-1 ug/l (Water) 0.83-33 ug/kg (Soil)
TCL PCBs	EPA Analytical Method SW-846 8082A for Water and Soil and EPA Preparation Methods 3510C (Water) and 3546 (Soil)	5 Days to Extraction, 40 Days to Analyze	0.1-0.2 ug/l (Water) 17 ug/kg (Soil)
TAL Metals (Except Mercury)	EPA Analytical Method SW-846 6010C and 6020A for Water and Soil and EPA Preparation Methods 3005A and 3020A (Water) and 3050B (Soil)	180 Days	0.001-2 mg/l (Water) 0.2-200 mg/kg (Soil)

Analytical Parameters	EPA Method	Holding Times[1]	Contract Required Quantitative Limits (as noted)[2]
Mercury	EPA Analytical and Preparation Methods SW-846 7470A (Water) and SW-846 7471B (Soil)	26 days	0.0002 mg/l (Water) 0.02 mg/kg (Soil)
Cyanide	EPA Analytical and Preparation Method SW-846 9012A for Water and Soil	14 Days	0.01 mg/l (Water) 0.5 mg/kg (Soil)
PFCs[3] (PFBS, PFHpA, PFHxS, PFNA, PFOS, PFOA, PFDA, PFDoA, PFHxA, PFPTA, PFTRDA, PFDOA)	EPA Analytical & Preparation[3] Method 537 Rev. 1.1 Modified for Water and Soil	14 Days to Extraction 28 Days to Analyze	2 to 10 ng/l (Water) 0.40 to 1.6 ng/g (Soil)
Cations (Ca, Mg, Na, K)	EPA Analytical Methods SW-846 6010C and 6020A and EPA Preparation Methods 3005A and 3020A	180 Days	0.004-2 mg/l
Anions (Chloride, Sulfate)	EPA Analytical and Preparation Method SW-846 300.0	28 Days	2-5 mg/l
Anions (Carbonate, Bicarbonate)	EPA Analytical and Preparation Method SW-846 SM2320 B-1997	14 Days	2 mg/l as $CaCO_3$

Note:

1) Holding times are relative to the verifiable receipt at the laboratory.
2) The listed method detection limits are practical quantitation limits (PQLs) derived by the laboratory and updated on an annual basis. The method detection limit (MDL) is the best possible detection. Laboratories report PQLs which are typically 4 times the MDL for liquids and varies for solids depending on the quantity of contamination present. Efforts will be made to obtain the lowest possible detection limit. When the guidance value or standard value is below the detection limit, achieving the detection limit will be considered acceptable for meeting that guidance or standard value.
3) Method 537. Determination Of Selected Perfluorinated Alkyl Acids In Drinking Water By Solid Phase Extraction And Liquid Chromatography/Tandem Mass Spectrometry (Lc/Ms/Ms). EPA Document #: EPA/600/R-08/092, Version 1.1, September 2009. The most recent NYSDEC ASP does not have a method for PFCs. The laboratory uses a modified version of EPA Method 537 for analysis of PFCs in solids. The laboratory utilizes a proprietary sample preparation method as EPA has not developed a sample preparation method.

Where matrix interference is noted, analytical clean-ups will be required to be performed by the laboratory following the procedures specified in SW-846, the most current NYSDEC ASP, or EPA Method 537, as applicable. In general, samples shall not be diluted more than 1 to 5.

8.0 DATA REDUCTION, VALIDATION AND REPORTING

The field measurement data and the laboratory analyses results of detected parameters will be compiled and tabulated to facilitate comparison and evaluation, and will be included in the Final SCI Report. The tabulated data will include at a minimum:

- soil/fill analysis results,
- groundwater analysis results, and
- quality control results [imported source materials (i.e., drilling water and filter sand, material rinse blanks, etc.) results, equipment/field blanks, replicates/duplicates, matrix spike/matrix spike duplicates and trip blanks].

Field logs will also be compiled and included, in part, in the text and appendices of the Final SCI Report, and will consist of:

- monitoring well construction logs,
- subsurface exploration logs,
- organic vapor headspace analysis logs,
- groundwater services field logs,
- environmental services field logs, and
- water level records.

Any observations or problems encountered during field activities which could affect the quality of the data or its validity will be noted on the appropriate field log.

The laboratory will generate ASP Category B Data Deliverable Package(s) that may be submitted as a separate volume to the SCI Report or on a CD within the SCI Report.

Internal data validation will be performed by the laboratory QA officer to ensure that the data package is complete and meets the criteria of the work plan and this QAPP. Any problems encountered in performing the analyses by the laboratory such as out of limits surrogate recoveries, and comments on the quality and limitations of specific data and the validity of the data will be described in the case narrative of the laboratory report.

External data validation will be performed by an independent data validator who will utilize the USEPA National and Regional Validation Guidelines/Procedures to determine the applicable qualifications of the data. The validator will then prepare a Data Usability Summary Report (DUSR). The data validator will not be involved in any other portions of the project. The data validation company for this project is not yet determined. The validator's qualifications and work experience will be presented in Attachment B.

9.0 FIELD & INTERNAL QUALITY CONTROL

Field QC will consist of collecting/generating source material samples, equipment/field blanks, replicate samples, preparing matrix spike/matrix spike duplicate samples and having trip blanks with aqueous volatile organic compounds and PFC sample sets. Field instrumentation will also be calibrated prior to use and the calibration maintained as discussed in the FSP.

Internal laboratory QC will generally consist of:

- Method (instrument) blanks,
- initial and continuing calibrations,
- surrogate spikes,
- matrix spike/matrix spike duplicates,
- duplicate samples, and
- laboratory control samples/matrix spike blanks.

The QC samples will be run in accordance with the protocols and frequencies specified in the NYSDEC ASP, SW-846 and EPA Methods as applicable for the analyses being performed, with the exception of the source material and equipment samples. One (1) sample will be collected of each source material and equipment identified in Section 3.4 for analysis for PFCs to ensure that materials and equipment imported to the Site for the investigation are not cross-contaminated with PFCs. The source equipment will be segregated and will be used for no other purpose from the time that the samples are collected to the time that the equipment is mobilized to the Site for the investigation.

10.0 PERFORMANCE AND SYSTEMS AUDITS

10.1 Field Audits

Field performance audits will consist of taking replicate samples, source material samples (i.e., drilling water and monitoring well construction materials, etc.) and equipment/field blanks and analyzing for the same parameters as other samples, as detailed in the FSP.

Field system audits will be conducted during field operation to ensure that the field activities are being conducted correctly and in accordance with the SCIWP. The project field supervisor will check that the field instrumentation is calibrated prior to use, that field measurements are taken correctly, that equipment is properly decontaminated, and that the field activities are properly documented. Any deficiencies will be reported to the project manager and discussed with the field staff with corrective action taken. The person conducting the field audits will document the field system audits by use of a field report and submit the report to the project manager for review on a bi-weekly (twice per week) basis at a minimum. The project quality assurance officer, scientist/geologist/engineer or project manager will conduct system audits as appropriate or warranted.

The project manager will review the field system audit reports and the field documentation for completeness and correctness, and check that the work is proceeding on schedule and in accordance with the work plans.

10.2 Laboratory Audits

Laboratory system audits are not required, however, if the laboratory is required to maintain Vermont laboratory certification. Part of this certification process typically includes periodic performance evaluations and on-site systems audits.

11.0 PREVENTATIVE MAINTENANCE

C.T. Male Associates keeps an inventory of its' field equipment and it is kept locked in a designated area. The field equipment is signed out when in use and its condition checked upon its return. The equipment is kept in good working order and frequently checked and calibrated by qualified employees. Additionally, select equipment (i.e., PID meter) is routinely serviced for cleaning and calibration by an independent repair facility.

The project geologist/engineer/scientist and field sampler are responsible for assuring that the field equipment is tested, cleaned, charged and calibrated in accordance with the manufacturer's instructions prior to taking the equipment out into the field.

12.0 DATA ASSESSMENT PROCEDURES

The field and laboratory generated data will be assessed for precision, accuracy, representativeness, completeness, and comparability (PARCC parameters). Both quantitative and qualitative procedures will be used for these assessments.

The criteria for assessment of field measurements will be that the measurements were taken in accordance with the procedures specified in the FSP using calibrated instruments. Assessment of the sampling data with respect to field performance will be based on the criteria that the samples were properly collected and handled. Field replicate and equipment/field blank sample results will be used in assessing the sampling technique and representativeness of the samples collected.

The laboratory will calculate and report the precision, accuracy, and completeness of the analytical data. Precision will be expressed as the relative percent difference (RPD) between values of duplicate samples. Accuracy will be expressed as percent difference (PD) for surrogate standards and matrix spike compounds. Completeness is a measure of the amount of valid data derived from a set of samples based on the total amount expected to be derived under normal conditions. The precision and accuracy results will be compared to the QC acceptance criteria specified for each test method in the most recent EPA Methods.

The representativeness of the analysis is dictated primarily by the field sampling technique and sample location, as opposed to laboratory operations. The laboratory will take steps to ensure that the analysis is representative of the sample being submitted. The criteria for ensuring representativeness of the analysis are careful aliquot selection and proper compositing techniques. Laboratory performance will be based on the criteria that the samples were properly handled prior to submission to the laboratory, that the laboratory aliquots taken for analysis are representative (i.e., oversized particles discarded, sample thoroughly mixed except when dealing with volatile organics), that the samples were analyzed within holding times, and that no cross-contamination has occurred based on the method blank results. Data comparability will be assessed based on analyses being performed within required holding times, on consistent units of measure, and that analyses were performed in adherence with VTDEC and EPA analytical methods/protocols.

13.0 CORRECTIVE ACTIONS

The investigation will be performed in accordance with the approved SCIWP, the contents of the approved FSP and the approved QAPP. Any persons identifying unacceptable conditions or deficiencies in the work being performed such as deviation from or omission of health and safety procedures, sampling procedures or other field procedures, will immediately notify the project field supervisor, where applicable, and the project manager. The unacceptable conditions or deficiencies will be documented and submitted to the project manager. The project manager, with assistance from the technical quality review staff, if necessary, will be responsible for developing and initiating appropriate corrective action, documenting the corrective action and verifying that the corrective action has been effective.

Depending on the significance and potential impact of the problem or deficiency requiring corrective action, the VTDEC and Saint-Gobain will be notified, as warranted, as soon as practical after becoming aware of the situation.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Field system audit/field reports from the project team, where applicable, will be submitted to the project manager on a bi-weekly basis at a minimum. The field report will include the project name, location, time, date, weather, temperature range, work in progress, conformance with schedule, persons present at the Site (arrival and departure times), observations, work start-up and stoppage, items to verify, information or action required, any attachments identified, and the reporting persons signature. The field report notifies the management as to the progress, conformance with the work plan, and any problems that may affect quality control. Field personnel will also keep field notebooks that will discuss day to day procedures followed, any problems encountered, etc. A copy of the field notes will be given to the project manager at least bi-weekly to keep the project manager informed of the project status and as a quality control check. The project manager will review the reports and field notes to assess the quality of the investigate data gathering efforts to make sure the objectives of the work are being met, to make sure the work is progressing on schedule, that the work is being conducted in accordance with the work plan, and that any problems encountered are addressed. These reports will be utilized in assessing the data quality with respect to field activities and the findings will be discussed in the SC Report where applicable.

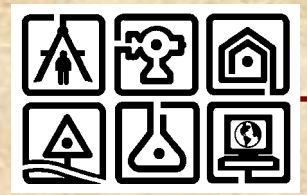
Documentation of each phase of the project and all work tasks performed are kept in the file on the project. The documentation is available at all times for review by the Quality Assurance Officer, who will randomly check files for their completeness.

If any occurrences or conditions are encountered during the course of work that may require a change in the scope of work or departure from the approved work plan, the VTDEC and Saint-Gobain will be notified and the situation reported as soon as possible.

FIGURE 1

Project Organizational Chart

C.T. Male Project Organizational Chart



Saint-Gobain Performance Plastics Corporation

Client/Requestor

Daniel Reilly, P.E.
Project Principal

Kirk Moline, CEI, CES
Project Manager

Elizabeth W. Rovers, P.E.
Quality Assurance Officer

Steve Bieber, CHMM
Environmental Scientist

Jonathan Dippert
Project Geologist

Larene Cameron
Project Scientist

Brittany Winslow
Project Scientist

Subconsultants & Contractors
- Laboratory Services
- Drilling Services
- Data Validation Services

ATTACHMENT A

Laboratory Certifications

VERMONT
DEPARTMENT OF HEALTH

State of Vermont Department of Health

Drinking Water Laboratory Certification

Eurofins Eaton Analytical, Inc.

South Bend, Indiana

Is certified to perform inorganic and organic analyses on drinking water pursuant to the certification letter dated November 15, 2015.

Commissioner of Health

Laboratory Director

Laboratory Certification Officer

November 15, 2015
Date certified

VT - 8775
Laboratory Number

November 15, 2016
Certificate expiration date

Vermont Drinking Water Certification
Analytical Methods
Issued November 15, 2015 as provided for in 18 VSA 501b
Expiration Date November 15, 2016
This listing is not valid without accompanying Vermont Certificate

Eurofins Eaton Analytical, Inc.
South Bend, IN

DRINKING WATER METALS

Aluminum:
EPA 200.8
Antimony:
EPA 200.8
Arsenic:
EPA 200.8
Barium:
EPA 200.8
Beryllium:
EPA 200.8
Cadmium:
EPA 200.8
Calcium:
EPA 200.7
Chromium:
EPA 200.8
Hexavalent Chromium:
EPA 218.6 EPA 218.7
Copper:
EPA 200.8
Iron:
EPA 200.7
Lead:
EPA 200.8
Magnesium:
EPA 200.7
Manganese:
EPA 200.8
Mercury:
EPA 245.1
Molybdenum:
EPA 200.8
Nickel:
EPA 200.8
Selenium:
EPA 200.8
Silver
EPA 200.8
Sodium:
EPA 200.7
Thallium:
EPA 200.8
Uranium:
EPA 200.8
Vanadium:
EPA 200.8
Zinc:
EPA 200.8

DRINKING WATER INORGANIC CONTAMINANTS

Alkalinity:
SM 2320 B
Bromate:
EPA 300.1 EPA 317.0
Bromide:
EPA 300.0
Chlorate:
EPA 300.0
Chlorite:
EPA 300.0
Chloride:
EPA 300.0
Chlorine, Free & Total:
SM 4500Cl G
Color:
SM 2120B
Conductivity(Specific Conductance):
SM 2510 B
Corrosivity (Langlier Index):
SM 2330 B
Cyanide, Total:
EPA 335.4
DOC:
SM 5310 C
Fluoride:
EPA 300.0 SM 4500-F- C
Hardness:
SM 2340 B
Hardness (Calc.):
SM 200.7
Nitrate-N:
EPA 300.0 EPA 353.2
Nitrate (calc.):
EPA 353.2
Nitrate-Nitrite, Total:
EPA 353.2
Nitrite-N:
EPA 353.2
Orthophosphate:
SM 4500P-E
pH:
EPA 150.1
Perchlorate:
EPA 331.0
Residue, Total Filterable (TDS):
SM 2540 C
Sulfate:
EPA 300.0

DRINKING WATER INORGANIC CONTAMINANTS (cont.)

TOC:
SM 5310 C

Turbidity:
EPA 180.1
UV-254:
SM 5910B
Silica:
EPA 200.7

DRINKING WATER ACIDS, BASE/NEUTRALS

Benzo(a)pyrene:
EPA 525.2
Di(2-ethylhexyl)adipate:
EPA 525.2
Di(2-ethylhexyl)phthalate:
EPA 525.2
Butyl Benzyl Phthalate:
EPA 525.2
Di-n-Butyl Phthalate:
EPA 525.2
Diethyl Phthalate:
EPA 525.2
Dimethyl Phthalate:
EPA 525.2

DRINKING WATER CARBAMATES

Aldicarb:
EPA 531.2
Aldicarb Sulfone:
EPA 531.2
Aldicarb Sulfoxide:
EPA 531.2
Baygon (Propoxur):
EPA 531.2
Carbaryl:
EPA 531.2
Carbofuran:
EPA 531.2
3-Hydrocarbofuran:
EPA 531.2
Methiocarb:
EPA 531.2
Methomyl:
EPA 531.2
Vydate (Oxamyl):
EPA 531.2

DRINKING WATER HERBICIDES

Acifluorfen:
EPA 515.3
Bentazon:
EPA 515.3
2,4-D:
EPA 515.3
2,4-DB:
EPA 515.3
Dalapon:
EPA 515.3
Dacthal (DCPA):
EPA 515.3

DRINKING WATER HERBICIDES (cont.)

Dicamba:
EPA 515.3
3,5-Dichlorobenzoic Acid:
EPA 515.3
Dichloroprop:
EPA 515.3
Dinoseb:
EPA 515.3
Pentachlorophenol:
EPA 515.3
Picloram:
EPA 515.3
2,4,5-T:
EPA 515.3
2,4,5-TP (Silvex):
EPA 515.3

DRINKING WATER INSECTICIDES (PESTICIDES)

Alachlor:
EPA 525.2
Aldrin:
EPA 525.2
Atrazine:
EPA 525.2
Bromacil:
EPA 525.2
Butachlor:
EPA 525.2
Chlordane:
EPA 505
4,4'-DDD:
EPA 525.2
4,4'-DDE:
EPA 525.2
4,4'-DDT:
EPA 525.2
Dieldrin:
EPA 525.2
Endrin:
EPA 525.2
EPTC
EPA 525.2
Heptachlor:
EPA 525.2
Heptachlor Epoxide:
EPA 525.2
Hexachlorobenzene:
EPA 525.2
Hexachlorocyclopentadiene:
EPA 525.2
Lindane:
EPA 525.2
Methoxychlor:
EPA 525.2
Metolachlor:
EPA 525.2
Metribuzin:
EPA 525.2
Molinate:
EPA 525.2
Propachlor:
EPA 525.2

DRINKING WATER INSECTICIDES (PESTICIDES) (cont.)

Simazine:
EPA 525.2
Toxaphene:
EPA 505
Terbacil:
EPA 525.2

INDIVIDUAL DRINKING WATER ORGANIC CONTAMINANTS

DBCP
EPA 504.1
EDB:
EPA 504.1
Diquat:
EPA 549.2
Endothall:
EPA 548.1
PCBs as Aroclors:
EPA 505
1,2,3 Trichloropropane:
EPA 524.2
Glyphosate:
EPA 547

DRINKING WATER TRIHALOMETHANES

Bromodichloromethane:
EPA 524.2 EPA 551.1
Bromoform:
EPA 524.2 EPA 551.1
Chlorodibromomethane:
EPA 524.2 EPA 551.1
Chloroform:
EPA 524.2 EPA 551.1
Total Trihalomethanes:
EPA 524.2 EPA 551.1

DRINKING WATER VOLATILE ORGANICS

Benzene:
EPA 524.2
Bromobenzene:
EPA 524.2
Bromochloromethane:
EPA 524.2
Bromodichloromethane:
EPA 524.2
Bromoform:
EPA 524.2
Bromomethane:
EPA 524.2
n-Butylbenzene:
EPA 524.2
sec-Butylbenzene:
EPA 524.2
tert-Butylbenzene:
EPA 524.2
Carbon Tetrachloride:
EPA 524.2
Chlorobenzene:
EPA 524.2

DRINKING WATER VOLATILE ORGANICS (cont.)

Chloroethane:
EPA 524.2
Chloroform:
EPA 524.2
Chloromethane:
EPA 524.2
2-Chlorotoluene:
EPA 524.2
4-Chlorotoluene:
EPA 524.2
Dibromochloromethane:
EPA 524.2
Dibromomethane:
EPA 524.2
1,2-Dichlorobenzene:
EPA 524.2
1,3-Dichlorobenzene:
EPA 524.2
1,4-Dichlorobenzene:
EPA 524.2
Dichlorodifluoromethane:
EPA 524.2
1,1-Dichloroethane:
EPA 524.2
1,2-Dichloroethane:
EPA 524.2
c-1,2-Dichloroethene:
EPA 524.2
t 1,2-Dichloroethylene:
EPA 524.2
1,1-Dichloroethylene:
EPA 524.2
Dichloromethane:
EPA 524.2
1,2-Dichloropropane:
EPA 524.2
1,3-Dichloropropane:
EPA 524.2
2,2-Dichloropropane:
EPA 524.2
1,1-Dichloropropene:
EPA 524.2
c 1,3-Dichloropropene:
EPA 524.2
t 1,3-Dichloropropene:
EPA 524.2
Ethylbenzene:
EPA 524.2
Hexachlorobutadiene:
EPA 524.2
Isopropylbenzene:
EPA 524.2
4-Isopropyltoluene:
EPA 524.2
Methyl t-Butyl Ether (MTBE):
EPA 524.2
Naphthalene:
EPA 524.2
n-Propylbenzene:
EPA 524.2
Styrene:
EPA 524.2
1,1,1,2-Tetrachloroethane:
EPA 524.2
1,1,2,2-Tetrachloroethane:
EPA 524.2

DRINKING WATER VOLATILE ORGANICS (cont.)

Tetrachloroethylene:
EPA 524.2
Toluene:
EPA 524.2
1,2,3-Trichlorobenzene:
EPA 524.2
1,2,4-Trichlorobenzene:
EPA 524.2
1,1,1-Trichloroethane:
EPA 524.2
1,1,2-Trichloroethane:
EPA 524.2
Trichloroethylene:
EPA 524.2
Trichlorofluoromethane:
EPA 524.2
1,2,3 Trichloropropane:
EPA 524.2
1,2,4-Trimethylbenzene:
EPA 524.2
1,3,5-Trimethylbenzene:
EPA 524.2
Total Xylenes:
EPA 524.2
Vinyl Chloride:
EPA 524.2

DRINKING WATER ORGANIC DISINFECTION BY-PRODUCTS/HALOACETIC ACIDS

Bromoacetic Acid:
EPA 552.2
Bromochloroacetic Acid:
EPA 552.2
Bromodichloroacetic Acid:
EPA 552.2
Chloroacetic Acid:
EPA 552.2
Dibromoacetic Acid:
EPA 552.2
Dibromochloroacetic Acid:
EPA 552.2
Dichloroacetic Acid:
EPA 552.2
Tribromoacetic Acid:
EPA 552.2
Trichloroacetic Acid:
EPA 552.2
Total Haloacetic Acids:
EPA 552.2

By:

William G. Mills
Certification Officer
Date signed and effective November 15, 2015

11/23/15

As of November 15, 2015this list supersedes all previous lists for this certificate number.
Vermont Certification is based in part upon current Florida Accreditation Certificate of Approval number E87775, July 01, 2015 through June 30, 2016. Laboratories are certified in Vermont based, in part, upon its Primary Accrediting Authority(ies) drinking water accreditation. Also, loss of drinking water primary accreditation (in part or whole) constitutes loss of certification in Vermont for the same drinking water tests.

VERMONT
DEPARTMENT OF HEALTH

State of Vermont Department of Health

Drinking Water Laboratory Certification

Eurofins Lancaster Laboratories Environmental, LLC

Lancaster, Pennsylvania

Is certified to perform microbiological, inorganic and organic chemical analyses on drinking water pursuant to the certification letter dated October 28, 2015.

Commissioner of Health

Laboratory Director

Laboratory Certification Officer

October 28, 2015
Date certified

VT – 36037
Laboratory Number

October 28, 2016
Certificate expiration date

Vermont Drinking Water Certification
Analytical Methods
Issued October 28, 2015 {Corrected/Amended 1/14/2016} as provided for in 18 VSA 501b
Expiration Date October 28, 2016
This listing is not valid without accompanying Vermont Certificate

Eurofins Lancaster Laboratories Environmental, LLC

Lancaster, Pennsylvania

DRINKING WATER MICRO

Total Coliform & E. coli:
Chromogenic/fluorogenic substrate test, total coliform
Colilert, SM 9223 B

DRINKING WATER METALS

Aluminum:
EPA 200.7
Antimony:
EPA 200.8
Arsenic:
EPA 200.8
Barium:
EPA 200.7 EPA 200.8
Beryllium:
EPA 200.7 EPA 200.8
Cadmium:
EPA 200.7 EPA 200.8
Calcium:
EPA 200.7 EPA 200.8
Chromium:
EPA 200.7 EPA 200.8
Copper:
EPA 200.7 EPA 200.8
Iron:
EPA 200.7 EPA 200.8
Lead:
EPA 200.8
Magnesium:
EPA 200.7 EPA 200.8
Manganese:
EPA 200.7 EPA 200.8
Mercury:
EPA 245.1
Nickel:
EPA 200.7 EPA 200.8
Selenium:
EPA 200.8
Silver:
EPA 200.7
Sodium:
EPA 200.7 EPA 200.8
Strontium:
EPA 200.7
Thallium:
EPA 200.8
Vanadium:
EPA 200.7
Zinc:
EPA 200.7 EPA 200.8

DRINKING WATER INORGANIC CONTAMINANTS

Alkalinity:
SM 2320 B
Bromide:
EPA 300.0
Chloride:
EPA 300.0

DRINKING WATER INORGANIC CONTAMINANTS (cont.)

Chlorine, Total:
SM 4500 Cl F
Color:
EPA 110.2 SM 2120 B
Conductivity (specific Conductance):
SM 2510 B
Cyanide, Total:
EPA 335.4
Fluoride:
EPA 300.0 SM 4500-F- C
Fluoride (Preliminary Distillation):
SM 4500-F-B
Hardness
SM 2340 C
Hardness (Calc.):
EPA 200.7
Nitrate-N:
EPA 300.0 EPA 353.2
Nitrate (Calc.):
EPA 353.2
Nitrate-Nitrite, total:
EPA 353.2
Nitrite-N:
EPA 300.0 EPA 353.2
pH:
EPA 150.1 SM 4500H^+ B
Orthophosphate:
SM 4500P-E
Residue, Total Filterable (TDS):
SM 2540 C
Silica:
SM 4500 SiO2C
Sulfate:
EPA 300.0
Surfactants:
SM 5540 C
TOC:
SM 5310 C
Turbidity:
EPA 180.1 SM 2130 B

DRINKING WATER ACIDS, BASE/NEUTRALS

Benzo(a)pyrene:
EPA 525.2
Di(2-ethylhexyl)adipate:
EPA 525.2
Di(2-ethylhexyl)phthalate:
EPA 525.2
Butyl Benzl Phthalate:
EPA 525.2
Di-n-Butyl Phthalate:
EPA 525.2
Diethyl Phthalate:
EPA 525.2
Dimethyl Phthalate:
EPA 525.2

DRINKING WATER CARBAMATES

Aldicarb:
EPA 531.1
Aldicarb Sulfone:
EPA 531.1
Aldicarb Sulfoxide:
EPA 531.1
Carbaryl:
EPA 531.1
Carbofuran:
EPA 531.1
3-Hydrocarbofuran:
EPA 531.1
Methomyl:
EPA 531.1
Vydate (Oxamyl):
EPA 531.1

DRINKING WATER HERBICIDES

2,4-D:
EPA 515.1
Dalapon:
EPA 515.1
Dicamba:
EPA 515.1
Dinoseb:
EPA 515.1
Pentachlorophenol:
EPA 515.1
Picloram:
EPA 515.1
2,4,5-T:
EPA 515.1
2,4,5-TP (Silvex):
EPA 515.1

DRINKING WATER INSECTICIDES (PESTICIDES)

Alachlor:
EPA 507 EPA 525.2
Aldrin:
EPA 525.2
Atrazine:
EPA 507 EPA 525.2
Butachlor:
EPA 525.2
Dieldrin:
EPA 525.2
Endrin:
EPA 525.2
Heptachlor:
EPA 525.2
Heptachlor Epoxide:
EPA 525.2
Hexachlorobenzene:
EPA 525.2
Hexachlorocyclopentadiene:
EPA 525.2
Methoxychlor:
EPA 525.2
Metolachlor:
EPA 525.2
Metriuzin:
EPA 525.2
Propachlor:
EPA 525.2
Simazine:
EPA 525.2

INDIVIDUAL DRINKING WATER ORGANIC CONTAMINANTS

DBCP
EPA 504.1 EPA 524.2
EDB:
EPA 504.1 EPA 524.2
1,2,3 Trichloropropane:
EPA 504.1 EPA 524.2
2,3,7,8-TCDD:
EPA 1613B

DRINKING WATER TRIHALOMETHANES

Bromodichloromethane:
EPA 524.2
Bromoform:
EPA 524.2
Chlorodibromomethane:
EPA 524.2
Chloroform:
EPA 524.2
Total Trihalomethanes:
EPA 524.2

DRINKING WATER VOLATILE ORGANICS

Benzene:
EPA 524.2
Bromobenzene:
EPA 524.2
Bromochloromethane:
EPA 524.2
Bromodichloromethane:
EPA 524.2
Bromoform:
EPA 524.2
Bromomethane:
EPA 524.2
n-Butylbenzene:
EPA 524.2
sec-Butylbenzene:
EPA 524.2
tert-Butylbenzene:
EPA 524.2
Carbon Tetrachloride:
EPA 524.2
Chlorobenzene:
EPA 524.2
Chloroethane:
EPA 524.2
Chloroform:
EPA 524.2
Chloromethane:
EPA 524.2
2-Chlorotoluene:
EPA 524.2
4-Chlorotoluene:
EPA 524.2
Dibromochloromethane:
EPA 524.2
Dibromomethane:
EPA 524.2
1,2-Dichlorobenzene:
EPA 524.2
1,3-Dichlorobenzene:
EPA 524.2
1,4-Dichlorobenzene:
EPA 524.2
Dichlorodifluoromethane:
EPA 524.2
1,1-Dichloroethane:
EPA 524.2
1,2-Dichloroethane:
EPA 524.2

DRINKING WATER VOLATILE ORGANICS (cont.)

c-1,2-Dichloroethene:
EPA 524.2
t 1,2-Dichloroethylene:
EPA 524.2
1,1-Dichloroethylene:
EPA 524.2
Dichloromethane:
EPA 524.2
1,2-Dichloropropane:
EPA 524.2
1,3-Dichloropropane:
EPA 524.2
2,2-Dichloropropane:
EPA 524.2
1,1-Dichloropropene:
EPA 524.2
c 1,3-Dichloropropene:
EPA 524.2
t 1,3-Dichloropropene:
EPA 524.2
Ethylbenzene:
EPA 524.2
Hexachlorobutadiene:
EPA 524.2
Isopropylbenzene:
EPA 524.2
4-Isopropyltoluene:
EPA 524.2

Methyl t-Butyl Ether (MTBE):
EPA 524.2
Naphthalene:
EPA 524.2

DRINKING WATER VOLATILE ORGANICS (cont.)

n-Propylbenzene:
EPA 524.2
Styrene:
EPA 524.2
1,1,1,2-Tetrachloroethane:
EPA 524.2
1,1,2,2-Tetrachloroethane:
EPA 524.2
Tetrachloroethylene:
EPA 524.2
Toluene:
EPA 524.2
1,2,3-Trichlorobenzene:
EPA 524.2
1,2,4-Trichlorobenzene:
EPA 524.2
1,1,1-Trichloroethane:
EPA 524.2
1,1,2-Trichloroethane:
EPA 524.2
Trichloroethylene:
EPA 524.2
Trichlorofluoromethane:
EPA 524.2
1,2,3-Trichloropropane:
EPA 524.2
1,2,4-Trimethylbenzene:
EPA 524.2
1,3,5-Trimethylbenzene:
EPA 524.2
Total Xylenes:
EPA 524.2
Vinyl Chloride:
EPA 524.2

By:

William G. Mills
Certification Officer
Date signed and effective October 28, 2016 {Corrected/Amended 1/14/2016}

As of October 28, 2016 {Corrected/Amended 1/14/2016} this list supersedes all previous lists for this certificate number. Vermont certification is based in part upon current Pennsylvania Accreditation Certificate Number 014 for lab 36-00037, expiration date January 31, 2016. New Jersey Laboratory number PA011 Expiration 6/30/2015 extended until 10/30/2015. Laboratories are certified in Vermont based, in part, upon its Primary Accrediting Authority(ies) drinking water accreditation. Also, loss of drinking water primary accreditation (in part or whole) constitutes loss of certification in Vermont for the same drinking water tests.

ATTACHMENT B

Data Validator Qualifications and Experience

(Pending)

Appendix B

Field Sampling Plan

August 2017

Field Sampling Plan

Saint-Gobain Performance Plastics
Town of Bennington
Town of Bennington Landfill and
Village of North Bennington
Bennington County, Vermont

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C.T. MALE ASSOCIATES, ENGINEERING, SURVEYING, ARCHITECTURE & LANDSCAPE ARCHITECTURE, D.P.C.

FIELD SAMPLING PLAN
TOWN OF BENNINGTON,
TOWN OF BENNINGTON LANDFILL, AND VILLAGE OF NORTH BENNINGTON
BENNINGTON COUNTY, VERMONT

TABLE OF CONTENTS

1.0 INTRODUCTION

This Field Sampling Plan (FSP) applies to work plans that have been developed to further assess the distribution of perfluorochemicals (PFCs) in and around the Town of Bennington, the Town of Bennington Landfill, the Village of North Bennington, and surrounding areas of Vermont (collectively, the Site) on behalf of Saint-Gobain Performance Plastics (SGPP). A description of study areas, background information, objectives, and proposed scopes of work at the Site are presented in individual work plans.

This FSP is a supplement to these individual work plans in that it presents the standard field sampling and data gathering procedures to be followed during implementation of the field activity portion of the scope of work. This plan addresses sampling and drilling methods including advancement of soil borings and installation of monitoring wells, decontamination procedures, sampling procedures, field screening and testing procedures, field instrumentation operating procedures, field measurements, sample handling and chain of custody procedures, and water level measurement procedures. Sampling locations, media, and analytical parameters are specified in the work plans.

The applicable portions of the work plans that coincide with the FSP will be provided to, and followed by, the field team. This FSP is intended to be applicable to field sampling activities conducted by the field team, that is, representatives of C.T. Male Associates (C.T. Male), Barr Engineering Company (Barr), and their subcontractors.

The FSP forms an integral part of the Quality Assurance Project Plan (QAPP). The field sampling and data gathering procedures presented in this FSP are incorporated into the QAPP by reference. The FSP and the QAPP document the laboratory quality assurance/quality control procedures to be followed during analysis of samples collected in the field so that valid data of a known quality is generated.

The FSP has been prepared, in part, in general accordance with the following Vermont Department of Environmental Conservation (VTDEC) and U.S. Environmental Protection Agency (EPA) guidance documents:

- Investigation and Remediation of Contaminated Properties Procedure, State of Vermont Agency of Natural Resources, Effective April 2012.

- A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, USEPA, December 1987.

Forms to be used during completion of field tasks are included as Attachment A.

2.0 MEDIA TO BE SAMPLED

Sampling will be performed for volatile organic vapor screening, subjective media assessment, laboratory analyses, and for geologic and hydrogeologic characterization of the project Site. The environmental media to be sampled may include:

- Raw sewage,
- Shallow Soil/Fill,
- Subsurface Soil,
- Bedrock, and
- Groundwater.

Raw sewage samples may be collected for laboratory analysis from public sewer system manholes located in the area.

Soil, fill, and bedrock samples may be collected to meet the objectives outlined in each work plan. Soil samples will be collected at the depths specified in the work plans. Samples for laboratory analysis may be skewed towards organic rich soil horizons, if present.

Select test borings will be converted into monitoring wells to aid in the collection of groundwater samples for laboratory analysis. Groundwater samples will also be collected from existing monitoring wells.

Detailed descriptions of the proposed investigative tasks, including soil sampling, soil logging, field screening, groundwater sampling, and laboratory analysis are presented in each work plan.

3.0 SITE INVESTIGATION OVERVIEW

3.1 General

The proposed investigations may include: collection and laboratory analysis of quality control samples of source materials and rinse blanks of equipment that will be imported onto the Site to conduct investigations; collection and laboratory analysis of raw sewage samples; advancement of shallow and deep soil/fill borings; collection and laboratory analysis of shallow and deep soil/fill samples for subjective and laboratory analysis; conversion of select borings into monitoring wells; advancement of bedrock borings; completion of geophysical and flow logging in bedrock borings; conversion of bedrock borings into monitoring wells; development of new deep soil and bedrock monitoring wells; collection of groundwater samples from new and existing monitoring wells for laboratory analysis, and replacement of domestic water supply wells, and collection of groundwater samples from new and existing domestic wells for laboratory analysis.

3.1.1 Source Materials and Equipment Rinse Blanks

Quality control samples will be collected of source materials and equipment that is anticipated to be imported onsite for the investigations. Source materials that will be sampled include water used by the drilling contractor for drilling and decontamination, bottled water used as final decontamination rinse water, and filter sand used for the monitoring well sand pack. Equipment rinsate blank samples will be collected by pouring bottled deionized water over and through driller water totes and tanks, drill augers, drill rods, well riser pipe and screen. The aforementioned samples will be analyzed for PFCs and the analytical results will be reviewed prior to Site mobilization. Mobilization to the Site will only be permitted if analytical results depict PFCs below detection limits or at concentrations that are not expected to cross-contaminate environmental samples.

3.1.2 Raw Sewage Sampling

Raw sewage samples may be collected from public sewer system manholes in the area. The samples will be collected with new nitrile gloves and either a new disposable bailer or peristaltic pump with new disposable tubing. The samples will be analyzed in the laboratory for PFCs.

3.1.3 Shallow and Deep Soil/Fill Sampling

Shallow and deep soil/fill samples will be collected in accordance with details outlined in individual work plans. The samples will be collected employing a hand auger, a portable vibra-coring device, a direct-push sampling unit (e.g., Geoprobe®), rotosonic, and/or hollow stem auger drilling methods. The shallow and deep soil/fill samples collected will be analyzed for the parameters listed in the work plans, which may include PFCs, Total Organic Carbon (TOC), moisture content, soil pH, and grain size analysis.

If subjective impacts (elevated Photoionization Detector (PID) readings, oily liquid, strongly odiferous soils/fill, staining, etc.) are noted in the fill and/or soil above the water table, a sample of the fill/soil may be collected for laboratory analysis for the Target Compound List (TCL) of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides and PCBs, Target Analyte List (TAL) of metals, cyanide (CN), PFCs, TOC, moisture content and grain size analysis.

3.1.4 Groundwater Sampling

Select soil borings may be converted into two-inch diameter monitoring wells with protective enclosures to aid in the collection of groundwater samples for laboratory analysis as specified in the work plans. The wells will be developed and purged, and groundwater samples collected may be analyzed for PFCs, TAL metals/cations (excluding cyanide and mercury), anions, ammonia, orthophosphate, and total Kjeldahl nitrogen (TKN).

Additional potential analytical parameters for groundwater samples collected from wells at or near the-Town of Bennington Landfill Site include PFC precursors, VOCs, and 1,4-dioxane.

Groundwater samples may also be collected from existing monitoring wells installed by others. Groundwater samples collected from the existing wells may be analyzed for PFCs, PFC precursors, VOCs, metals/cations, anions (Cl, SO_4, CO_3 and $HCO_{3)}$, ammonia, orthophosphate, TKN, and 1,4-dioxane.

3.2 Observation of Drilling Operations and Monitoring Well Installations

All drilling, monitoring well installation and other associated field work to be performed by C.T. Male subcontractors will be observed by a full-time, on-site, C.T. Male representative (including other qualified members of the project team). This representative will be responsible for the collection of soil/fill samples, soil classification, field screening of soil/fill samples, recording of drilling and sampling data, recording of groundwater data, directing geophysical and flow logging; deciding on the final drilling depths and monitoring well screened intervals (with input from the project manager), recording the monitoring well construction procedures, and monitoring the decontamination procedures. The C.T. Male representative will also develop and purge the monitoring wells and conduct groundwater sampling.

Field system audits will be conducted and field reports will be prepared that document the daily activities and their conformance to the work plan (described further in the QAPP). A copy of the forms to be utilized by the applicable field team personnel as part of the field quality assurance/quality control (QA/QC) procedures are presented in Attachment A of this FSP.

The project manager will be kept informed of the progress of work and any problems encountered during the investigations so appropriate corrective action can be implemented in consultation with SGPP and VTDEC.

3.3 Drilling and Sampling of Overburden for Installation of Monitoring Wells

Drilling techniques that may be utilized to aid in the collection of shallow and deep soil/fill samples and for installation of monitoring wells include direct-push, hollow stem auger and rotosonic drilling techniques. Drilling technique will be specified in the individual work plans. The following sections provide an overview of each drilling technique and the associated investigative tasks that they are applied to.

3.3.1 Direct-Push Drilling

Direct-push drilling techniques may be employed for shallow soil test borehole locations due to mobility and space constraints. A 5′ long by 2″ diameter macro-core sampler with new acetate liner will be continuously advanced to the terminus depth of the test boring. At each five (5) foot depth interval, the core sampler will be extracted from the

overburden and the soils within the acetate liner will be examined for soil classification, screening and soil sampling.

3.3.2 Hollow-Stem Auger Drilling

Hollow Stem Auger drilling techniques may be employed at the Site. The test boreholes will be advanced through the overburden using hollow-stem augers having a minimum 4.25-inch inside diameter (ID) for installation of the monitoring wells. Soil samples will be collected in general accordance with the procedures of ASTM D-1586, Standard Method for Penetration Test and Split Barrel Sampling of Soils, at intervals specified in the work plans. A standard split barrel sampler, which is 24-inches long and 2-inches in diameter, will be used for sampling.

3.3.3 Rotosonic Drilling

Rotosonic drilling techniques will be employed for the deep overburden and select bedrock test boring locations. A five (5) foot long by four (4) inch diameter (or six (6) inch diameter for bedrock wells) core sampler will be continuously advanced to the terminus depth of each overburden test boring. At each five (5) foot interval, the core sampler will be extracted from the overburden and the soils within the core sampler will be examined for soil classification, screening and sampling. Prior to retrieving the core sampler, steel overcasing having a diameter of six (6) inches (or eight (8) inches for bedrock wells) will be advanced around the core sampler to maintain the integrity of the borehole. The overcasing will be advanced to the terminus depths of the overburden test borings and will be removed upon installation of the monitoring wells. In the event that an upper and lower hydro-stratigraphic unit is encountered requiring installation of shallow and deep monitoring well couplets, overcasing will remain in the ground at a strategic depth interval to preclude the mixing of the upper and lower hydro-stratigraphic units.

For the bedrock borings, six (6) inch casing will be advanced from the ground surface to approximately five (5) feet into bedrock and set in place. Grout will be placed between the exterior of the casing and the borehole wall. Thereafter, the bedrock will be drilled to the target depth. The open borehole within the bedrock will serve as the bedrock monitoring well.

3.3.4 Soil Classification

All soils will be visually classified in the field using the Unified Soil Classification System in general accordance with ASTM D-2488, Standard Practice for Description and Identification of Soils. The soil description may include matrix and clast descriptions, moisture content, color, appearance, odor, behavior of the material and other pertinent observations. This information will be recorded on a subsurface exploration log form along with the boring identification and elevation, date started and completed, sampling intervals, standard penetration values, length of recovered sample and depth of first groundwater encountered. During the drilling, a PID meter will be used to monitor the volatile organic vapors exiting the borehole and soil cuttings, and of all recovered subsurface samples. These visual observations and field measurements will be recorded on the Subsurface Exploration Log. A blank copy of a Subsurface Exploration Log form is enclosed in Attachment A.

3.3.5 Borehole Abandonment and Drill Cuttings

In the event a borehole is not converted into a monitoring well, it will be abandoned by grouting it from the bottom depth of the boring to grade with a cement/bentonite grout mixture (approximately 20 to 1 ratio).

Drill cuttings generated beyond the Town of Bennington Landfill will be spread on the ground in the vicinity of the boring at which it was generated, in consultation with the property owner and as appropriate for the parcel.

Drill cuttings generated at the Town of Bennington Landfill will be placed in labeled DOT 17H approved 55-gallon open top steel drums pending screening for hazardous waste determination, including analyses for VOCs, metals (including mercury), and SVOCs including PCB homologues. If the soil cuttings are determined to be non-hazardous, they will be thin spread in the vicinity of the boring. If soil is determined to be hazardous, the drum will be transferred to and staged at the SGPP 1030 Water Street and/or the Town of Bennington Landfill Sites, or other approved location near the Site. The contents of the drums will be subsequently characterized and profiled for off-site disposal in consultation with VTDEC.

3.4 Soil Sampling and Soil Field Screening Procedures

3.4.1 Shallow Soil/Fill Sampling

Shallow soil/fill samples may be collected manually utilizing a decontaminated hand auger or a decontaminated core sampler in conjunction with direct-push drilling methods.

Hand Auger

The soil sampling procedures that will be followed for the collection of shallow soil/fill samples utilizing a hand auger includes the following.

1. Place and secure a new 5' by 5' sheet of plastic sheeting over the sampling location and remove a 6" by 6" opening in the center of the sheeting.

2. Remove vegetation and/or humus, where present, down to ground surface. If the sampling location is within asphalt pavement, the pavement will be removed using a pre-cleaned thin wall core barrel and electric vertical drill stand. In this instance, the collection of the soil samples will be initiated at the ground surface at the bottom depth of the asphalt and granular sub-base, if present.

3. A cleaned (per Section 3.7) 3-inch diameter stainless steel hand auger will be used by the on-site sampling personnel for collection of the shallow soil/fill samples. New disposable nitrile gloves will be worn when handling the sampling equipment.

4. At each sampling location, soil samples will be collected from ground surface to a depth of two (2) feet. Samples from each sampling location will be collected at 6-inch intervals (0 to 6", 6" to 12", 12" to 18"and 18" to 24"). Sampling personnel will don new, disposable nitrile gloves at each sampling location and sampling depth interval.

5. Immediately upon collecting the soil sample, the sample will be transferred to a pre-cleaned stainless steel bowl and homogenized with a pre-cleaned stainless steel spoon or by hand wearing new nitrile gloves. An aliquot of the sample will then be transferred to laboratory provided sample containers. The PFC sample will be collected first, followed by the samples for the other work plan specified

analyses including TOC, pH and moisture content (separate container). The remaining portion of the sample will be placed in a new plastic zip lock bag, not more than one-half full, and sealed. This bag sample will be for head space analysis screening in the field for volatile organic compounds (VOCs) using a PID meter, and subsequent grain size analysis.

6. For samples to be collected for laboratory analysis, the sample container label will be completed with the shallow soil sample location, sample interval, sampler's initials, date, and time. The client, project name, Site location, matrix, sample type (grab/composite) and laboratory analyses to be performed will also be recorded on the sample label.

7. For sampling locations that will not be advanced to deeper depths utilizing hollow stem auger drilling techniques, backfill each sampling location in vegetated areas with topsoil purchased at a national home improvement store and compact. Backfill each sampling location in paved areas with crusher run and compact, and restore the surface with sub base and asphalt having the same thickness and placement as surrounding sub base and asphalt.

8. The soil sample will be classified per Section 3.3 and a Subsurface Exploration Log will be completed.

9. The sampling equipment will be decontaminated between each sampling interval per Section 3.7.

Direct Push

The soil sampling procedures that will be followed for the collection of shallow soil/fill samples utilizing a core sampler in conjunction with direct push drilling methods includes the following:

1. A pre-cleaned (per Section 3.7) core sampler barrel will be given to the driller or driller's assistant who will attach it to the sampling rod. New disposable nitrile gloves will be worn when handling the core barrel.

2. A soil sample will be collected by advancing the core sampler employing direct push drilling techniques the desired 5-foot sampling interval.

3. For samples to be collected for laboratory analysis, the sample container label will be completed with the sample location (boring nomenclature), sample interval, sampler's initials, date, and time. The client, project name, Site location, matrix, sample type (grab/composite) and laboratory analyses to be performed will also be recorded on the sample label.

4. The recovered soil sample from the direct push drilling core sampler will be contained in a new acetate liner. The acetate liner will be placed on clean polyethylene sheeting and the acetate liner opened to expose the sample.

5. Immediately upon collecting the soil sample, the sample will be transferred to a pre-cleaned stainless steel bowl and homogenized with a pre-cleaned stainless steel spoon or by hand wearing new nitrile gloves. An aliquot of the sample will then be transferred into laboratory provided sample containers. The PFC sample will be collected first, followed by the samples for the other work plan-specified analyses, including TOC, pH and moisture content. The remaining portion of the sample will be placed in a new plastic zip lock bag, not more than one-half full, and sealed. This bag sample will be for head space analysis screening in the field for volatile organic compounds (VOCs) using a PID meter, and subsequent grain size analysis.

6. The soil samples will be classified and the Subsurface Exploration Log completed as described in Section 3.3

7. The sampling equipment will be decontaminated per Section 3.7.

All of the soil samples, where sufficient sample is recovered to generate a headspace sample, will be screened in the field with a PID meter on a daily basis. The sample will be allowed to equilibrate to ambient temperature; the plastic bag will be shaken and the bag will be pierced with the tip of the PID meter; and the reading taken. The readings will be recorded on an Organic Vapor Headspace Analysis Log form. A blank copy is included in Attachment A. The PID meter calibration procedures are discussed in Section 7.0.

3.4.2 Shallow and Deep Soil Samples from Test Borings

Soil samples may be collected utilizing a decontaminated split-spoon sampler in conjunction with hollow stem auger drilling methods and/or a decontaminated core barrel in conjunction with rotosonic drilling methods.

The soil sampling procedures that will be followed during advancement of the test borings includes the following.

1. A pre-cleaned (per Section 3.7) split-spoon sampler or core sampler barrel will be given to the driller or driller's assistant who will attach it to the sampling rod. New disposable nitrile gloves will be worn when handling the split-spoon sampler or core barrel.

2. A soil sample will be collected by advancing the sampler with a 140 pound drive hammer pushing the split-spoon sampler the desired two (2)-foot sampling interval per procedure ASTM D-1586 or by advancing the core sampler employing sonic drilling techniques the desired five (5)-foot sampling interval.

3. For samples to be collected for laboratory analysis, the sample container label will be completed with the sample location (boring nomenclature), sample interval, sampler's initials, date, and time. The client, project name, Site location, matrix, sample type (grab/composite) and laboratory analyses to be performed will also be recorded on the sample label.

4. The recovered split-spoon sampler will be placed on clean polyethylene sheeting. The end caps will be unscrewed and the sampling spoon opened to expose the sample. The recovered soil sample from the sonic drilling core sampler will be transferred from the core sampler into a clean plastic bag. The plastic bag will be placed on clean poly and the plastic bag will be opened to expose the sample.

5. Immediately upon collecting the soil sample, the sample will be transferred to a pre-cleaned stainless steel bowl and homogenized with a pre-cleaned stainless steel spoon or by hand wearing new nitrile gloves. An aliquot of the sample will then be transferred into laboratory provided sample containers. The PFC sample will be collected first, followed by the samples for the other work plan-specified analyses, including TOC, pH and moisture content. The remaining portion of the

sample will be placed in a new plastic zip lock bag, not more than one-half full, and sealed. This bag sample will be for head space analysis screening in the field for volatile organic compounds (VOCs) using a PID meter, and subsequent grain size analysis.

6. The soil samples will be classified and the Subsurface Exploration Log completed as described in Section 3.3

7. The sampling equipment will be decontaminated per Section 3.7.

All of the soil samples, where sufficient sample is recovered to generate a headspace sample, will be screened in the field with a PID meter on a daily basis. The sample will be allowed to equilibrate to ambient temperature; the plastic bag will be shaken and the bag will be pierced with the tip of the PID meter; and the reading taken. The readings will be recorded on an Organic Vapor Headspace Analysis Log form. A blank copy is included in Attachment A. The PID meter calibration procedures are discussed in Section 7.0.

3.5 Monitoring Well Installation

Monitoring wells may be installed within select boreholes completed utilizing direct-push, hollow stem auger, or rotosonic drilling methods. For the direct-push boreholes, one (1)-inch diameter monitoring wells with slotted screens will be installed in the open boreholes. For the hollow stem auger and rotosonic drilling boreholes completed in unconsolidated sediments, two (2)-inch diameter monitoring wells with slotted screens will be installed within the flush hollow stem augers or casing in accordance with standard practices. Typical monitoring well construction details are shown in Attachment A. All wells will be constructed of flush-threaded joint, Schedule 40 PVC riser pipe, machine slotted screen, bottom plug, and cap. The screens will be 0.010-inch slotted and generally ten feet in length.

Each well will be assembled as it is lowered into the borehole. The annulus around the well screen will be packed with clean #1 silica sand to a maximum of two feet above the screen. Additionally, a one-half foot choke of fine-grained #0 sand will be placed on top of the sand pack to preclude the migration of the seal material into the sand pack. A minimum two-foot bentonite seal will be installed in the annulus. The seal will consist

of bentonite pellets/chips or slurry. The remainder of the annulus will be filled with cement/bentonite grout (ratio of 20 to 1). A steel monitoring well guard pipe or curb box will be set over each well head and cemented in place. A positive grade will be constructed of cement around the well to divert surface water away from the well. A permanent mark will be made at the top of the PVC riser to serve as a datum for all subsequent static water level measurements. Upon completion, a locking gripper well cap will be installed and locked. Monitoring well depths, and screen lengths and depths will be calculated by the environmental scientist/geologist by maintaining accurate measurements of screen and casing placed in the borehole. Monitoring Well Construction Log forms (Attachment A) for the monitoring wells will be completed that documents the well materials and depths.

Bedrock wells will consist of steel casing (diameter specified in the work plans) set approximately five (5) feet into bedrock, with an open hole in the bedrock. Grout will be placed in the annulus between the exterior of the casing and the borehole wall. Thereafter, the bedrock will be drilled to the target depth specified in the work plan. The open borehole within the bedrock will serve as the bedrock monitoring well.

3.6 Monitoring Well Development

Once installed, each monitoring well will be developed by over pumping in order to remove any accumulated fine sediment within the well and to establish a hydraulic connection with the surrounding aquifer. Monitoring wells will be developed by surging and purging until water is clear, when field measured turbidity values are below 50 Nephelometric Turbidity Units (NTU) and/or the turbidity values have stabilized, or when ten well volumes are removed. During well development, pH, temperature, and specific conductance will be measured and recorded. Purge water will be containerized in DOT approved 55-gallon drums, labeled and stored in a secure location approved near the Site until laboratory analytical results of the soil and groundwater samples indicate the proper method of treatment or disposal.

Well development will be completed using new, clean tubing and nitrile gloves will be changed between wells, to prevent cross-contamination. Sampling equipment, such as the water level probe, will be decontaminated between wells.

3.7 Decontamination of Drilling and Sampling/Gauging Equipment

Drilling equipment including augers, rods, plugs, samplers, tools, drill unit and any piece of equipment that can come in contact with the formation will be cleaned with a high temperature/high pressure steam cleaner prior to the start of work and between each boring to prevent cross-contamination between borings. The equipment will also be cleaned using the same procedure at completion of the work to prevent any contamination from leaving the Site.

The sampling equipment (split-spoon and core samplers, stainless steel trowels, hand spades, hand augers, water level meter, etc.) will be cleaned prior to use, in between each sampling location, in between each sampling interval, and at completion of the work using the following procedure:

1. Remove any excess soil remaining on the sampling/gauging equipment.
2. Rinse sampling/gauging equipment with imported water.
3. Vigorously scrub the sampling/gauging equipment with a brush and laboratory-grade standard detergent (e.g., Alconox® or Liquinox®) and imported water.
4. Rinse the sampling/gauging equipment with bottled deionized water.
5. New disposable nitrile gloves will be worn when cleaning and handling the equipment to avoid contamination.
6. The water in the wash and rinse buckets will be changed between sampling locations to avoid cross contamination.

The decontamination rinse water will be collected and placed in DOT approved 55-gallon drums, labeled and stored at an approved location near the Site until laboratory analytical results of the soil and groundwater samples indicates the proper method of treatment or disposal. Disposable protective clothing will be placed in a garbage bag and disposed of as a solid waste. The personnel decontamination procedures are detailed in the Site Specific Health and Safety Plan.

3.9 Domestic Water Supply Well Equipment Cleaning

Equipment cleaning and well disinfection procedures are applicable to any work on domestic water supply wells to avoid contamination to a well.

All equipment that will be used in a water supply well will be unloaded and cleaned onsite prior to deployment in the well. All small equipment such as water level transducers and cables, water level measuring tapes, geophysical logging tools, drop pipe, pumps and any associated drilling tools or equipment necessary to enter the well will be cleaned with a non-phosphate detergent and potable water solutions and rinsed with a solution of sodium or calcium hypochlorite and potable water having a chlorine residual of not less than 200 milligrams per liter (mg/l). Once cleaned, all equipment not immediately deployed in the well will be stored in a clean storage container or wrapped in plastic until ready for deployment. If necessary, larger pieces of equipment that cannot be efficiently hand washed with the non-phosphate detergent solution may be steam cleaned prior to being brought onsite and then rinsed with the hypochlorite solution once onsite.

3.10 Domestic Water Supply Well Disinfection

After well testing and/or installation of well testing equipment, the well will be disinfected in general accordance with the American Water Works Association Standard C654-13 *Disinfection of Wells* and Vermont Department of Environmental Conservation (VTDEC), Environmental Protection Rules, Chapter 21, *Water Supply Rule*. These standards includes treating water in the well casing with sodium or calcium hypochlorite to provide a chlorine residual of no less than 50 mg/l throughout the entire water column in the well and providing a 12-hour contact time. Upon completion of the disinfection period, the well will be pumped and periodically tested for chlorine residual. Once chlorine residual is no longer detected, the well will be pumped for an additional 15 minutes prior to bacteriological testing sample collection.

Bacteriological testing will be conducted and the sample analyzed for total coliform/*E. coli* bacteria as recommended by Vermont Department of Health (VDH) factsheet for testing drinking water from private water supplies. If the results of the test are negative, the well can be placed back into service. If test results are positive for total coliform/*E. coli*, the well disinfection procedure will be repeated and the water retested.

4.0 GROUNDWATER SAMPLING PROCEDURES

4.1 General

During groundwater sampling, it is important to follow strict acceptable protocol during the collection and transportation of groundwater samples. This minimizes the potential for sample variation from well to well due to sampling and transportation techniques. Quality control measures will be instituted as discussed in this document and the QAPP as a check on the procedures being utilized so that the quality of the data can be assessed. The groundwater samples will be analyzed in the laboratory by standard methods following the QA/QC procedures outlined in the QAPP.

Prior to sampling, the water level in the well will be measured, and the well will be purged and allowed to recover to near static conditions. Groundwater samples will be taken employing low flow sampling techniques for field and laboratory analyses. The field parameters to be determined are pH, temperature, turbidity, specific conductance and oxidation-reduction potential (ORP). All pertinent groundwater sampling information will be recorded on a Groundwater Services Field Log. A separate log will be completed for each monitoring well sampled. Logs will be dated and signed by the person making the entries and will be submitted to the project manager for inclusion in the project files. The following information will be included on the log forms:

1. Project name and location.
2. Date and times.
3. Monitoring well identification number.
4. Sampling method (i.e. low-flow sampling with peristaltic pump).
5. Well development data.
6. Physical characteristics of samples.
7. Field analyses results.
8. Name of sampler(s).
9. Recovery times of wells.
10. Other observations/information.

An Environmental Services Field Log will also be completed for the groundwater sampling event. Blank copies of the referenced forms are included in Attachment A.

4.2 Preparation for Groundwater Sampling

Prior to groundwater sampling, the equipment and containers needed for sampling will be prepared. If possible, a peristaltic pump with new disposable tubing will be utilized to complete groundwater sampling. Deep groundwater sampling may require the use of a submersible pump. Domestic well sampling will be completed using the existing installed pumps. New disposable nitrile gloves will be worn during equipment cleaning and decontamination and handling of the media being sampled. Only new pre-cleaned laboratory provided sample containers and caps will be used for sample collection/analyses. All sample containers required to be fixed with a preservative, will be prepared by the laboratory before each sampling event. The container type, cap type and preservative requirements for the analytical parameters (water) to be analyzed are summarized in Table 1.

TABLE 1
Analytical Requirements for Containers and Preservatives for Water Samples and Equipment Blank Samples

PARAMETER	CONTAINER	TOP	PRESERVATION	COMMENTS
PFCs per EPA 537 Rev 1.1 (Water)	2 or 3-250 ml HDPE Plastic	HDPE Plastic	TRIZMA Preset Crystals (pH 7.0) Cool, ≤6° C	After the sample container is filled and sealed, gently agitate to dissolve the preservative.
TCL VOCs per EPA 8260C (Water)	3-40 ml vials (preserved)	Septum	HCl to pH<2 Cool, 4°C	None
TCL SVOCs per EPA 8270D, TCL PCBs per EPA 8082A and TCL Pesticides per EPA 8081B (Water)	3-1L amber Glass	Teflon	0.008% $Na_2S_2O_3$ Cool, 4°C	Store in dark.

PARAMETER	CONTAINER	TOP	PRESERVATION	COMMENTS
TAL Metals (Including Major Cations and Mercury) per EPA 6010C, 6020A and 7470A (Water)	500 ml Plastic	Poly	HNO_3 to pH <2 Cool, 4°C	None
Cyanide per EPA 9012A (Water)	250 ml Plastic	Poly	NaOH to pH ≥12 Cool, 4°C	None
Anions per EPA 300.0	2 X 40 ml Vial	Teflon Lined Septa	Cool, 2°C- 4°C	If Requested, NO_3 and NO_2 Have 48-Hour Hold Times
Alkalinity (Carbonate, Bicarbonate) per EPA SM2320 B-1997	250 ml Plastic	Poly	Cool, 4°C	No Headspace
Ammonia per EPA 350.1	250 ml Plastic	Poly	H_2SO_4 to pH<2 Cool, 4°C	None
Orthophosphate per SM 4500P-E	250 ml Plastic	Poly	Cool, 4°C	48 Hour Hold Time. Sample Must Be Field Filtered (0.45 Micron) Within 15 Minutes Of Collection To Meet Regulatory Requirements, If The Sample Is Not Filtered, A Comment Will Be Added To The Laboratory Report
Total Kjeldahl Nitrogen (TKN) per EPA 351.2	250 ml Plastic	Poly	H_2SO_4 to pH<2 Cool, 4°C	None

PARAMETER	CONTAINER	TOP	PRESERVATION	COMMENTS
1,4-Dioxane per EPA 8270C SIM with Isotope Dilution	2 X 250 ml Amber Glass	Teflon Lined	Cool, 4°C	None
PFC Precursors per Total Oxidizable Precursor (TOP) Assay	4 X 250 ml Plastic	Poly	Cool, 4°C	None

Sample labels will be prepared prior to sampling and affixed to the sample containers. The client, project name, Site location, matrix, sample type (grab/composite), preservative and laboratory analyses to be performed will be recorded on the sample labels by the laboratory. The sample location (i.e., monitoring well ID), date, sampler's initials and time will be filled out on the sample label at the time of sampling.

Upon arrival at the sampling location, the well will be observed for any damage, the cover of the guard pipe or curb box will be cleared of any debris and unlocked or unbolted. Clean polyethylene sheeting will be placed adjacent to the well to protect purging and sampling equipment from contamination. The cap and top of the well casing will be wiped with a clean cloth and then the cap removed. A PID meter reading will be collected when the well cap is removed. The water level in the well will then be measured.

4.3 Measuring the Water Level

Prior to purging and sampling, static water heights will be measured using a water level indicator to determine the standing water column height. Water levels will be collected from all wells that are slated for sampling prior to initiating the purging/water sampling. The water column height and depth of the well are used to calculate the well water volume. Non-vented well caps will be removed for a period of ten minutes to allow the water column to reach static conditions prior to taking the water level measurements.

4.4 Well Purging Procedures

Prior to groundwater sampling, it is necessary to purge the wells. Purging of the wells allows for a representative sample to be taken from the screened interval of the well by removing stagnant water from the well.

Three (3) to five (5) well volumes of standing water will be removed from the well. The volume of standing water in the well is calculated by subtracting the water level height from the well depth measurement, and multiplying this value by a conversion factor. The conversion factor is based on the well casing diameter and converts linear feet of water into gallons. In cases where the water recharges at a slow rate, the well will be purged dry when possible.

A low flow peristaltic pump with new, factory sealed tubing will be used to purge each well, if possible. Deeper wells may require the use of a submersible pump. Physical observations of the purge water will be noted and recorded on the Groundwater Services Field Log form. The actual quantity of purge water removed from the well will be measured by using a bucket graduated in gallons, and the volume will be recorded. Once purging is complete, the peristaltic pump tubing will be removed from the well and placed on the clean polyethylene sheeting adjacent to the well, until completion of the groundwater sampling.

All of the purge water from the non-landfill monitoring and domestic wells will be placed in DOT approved 55-gallon drums, labeled and stored at the former Chemfab facility located at 1030 Water Street until laboratory analytical results of the soil and groundwater samples indicates the proper method of treatment or disposal.

Purge water from monitoring wells located at the landfill site will disposed on the ground in the vicinity of the boring at which it was generated.

4.5 Groundwater Sample Collection

Prior to sample collection, the wells will be allowed to recover to at least 80% of their initial static water level. Slow recharging wells will be allowed to recover for a period of

four hours before sampling. Recovery times and water depths will be recorded on the Groundwater Services Field Log form.

Samples from shallow wells will be collected using a peristaltic pump, with new tubing at each monitoring well location. Deeper wells will require a submersible or bladder pump. A new pair of disposable nitrile gloves will be used to handle the sampling equipment and containers at each sampling location. Only non-powdered nitrile sampling gloves will be used during sampling.

Groundwater sampling from bedrock boreholes will be completed by a geophysical contractor at the direction of the C.T. Male or Barr representative. The geophysical contractor will complete the sampling in accordance with their procedures and practices.

The disposable tubing will be lowered slowly into the well to minimize the aeration of the samples. Using new nitrile gloves collect the sample for PFCs and PFC precursors first, prior to collecting samples for any other parameters into any other containers; this avoids contact with any other type of sample container, bottles or package materials. Volatile samples will be collected next, followed by field parameters and then in decreasing order of the volatility of the parameters being analyzed for; 1,4-dioxane, SVOCs, PCBs, Pesticides, metals (including cations), anions, cyanide, ammonia, orthophosphate and TKN.

In order to insure the integrity of samples, sample containers must be filled properly. The following sections contain general procedures for sampling and specific procedures for sampling volatile organic compounds and PFCs. Care shall be taken in sampling to assure that analytical results represent the actual sample composition.

A. General Sampling

1. Don't remove caps until the actual sampling time and only long enough to fill the container.
2. Identify every container by filling out the label with all the required data.
3. Fill all containers completely.
4. Some bottles may contain a fixative which should not be rinsed out of the bottle. Read the sample label treatment and fixative section to determine if a preservative/fixative

has been added. Be careful not to contact fixatives with skin or clothing. If this should occur, rinse liberally with water.

5. After the sample is taken, wipe the container with a paper towel and place the container in a cooler with bagged wet ice, to maintain the cooler at 4°C.
6. Complete the Groundwater Services Field Log and Chain of Custody Record forms.
7. Deliver or ship samples to the laboratory within 24 hours.

B. Sampling for PFCs

1. To prevent cross-contamination or sample interference, possible PFOA containing items will be avoided during the sampling. These items include (but are not limited to) Teflon-containing materials, Tyvek clothing, clothes treated with stain or rain-resistant coatings, Teflon sample containers, aluminum foil, blue ice, packaged foods, and post-its.

2. Samples are to be collected in laboratory provided 250 ml HDPE plastic bottles with screw-on HDPE plastic caps. **Do not collect samples in glass containers.** Sample containers will have TRIZMA Preset Crystals (pH 7.0) added to them as a preservative. This preservative must <u>not</u> be rinsed out.

3. New, powder-free nitrile gloves must be donned prior to sample collection.

4. Fill laboratory provided containers slowly to avoid matrix agitation. Fill containers to the bottom of the sampling container bottle neck. Immediately close sampling container with screw-on cap.

5. Lightly agitate the sample to dissolve the preservative crystals.

6. Place sampling container in cooler with bagged wet ice to maintain sample temperature of ≤6°C.

At completion of the sampling the well cap will be replaced; and the cover to the protective guard pipe or curb box will be bolted in place. The tubing, gloves, and sheeting will be properly disposed of as solid waste.

C. Sampling for Volatile Organic Compounds

1. Samples are to be collected in glass containers having a total volume in excess of 40 ml with open-top screw caps with Teflon-faced silicone septa. Sample containers will have hydrochloric acid (HCL) added to them as a preservative. This preservative must not be rinsed out.

2. A trip blank should be prepared from reagent grade water and carried through the sampling and handling procedure. It will serve as a check for transport and container contamination.

3. Fill sample container slowly to minimize aeration of the sample, until a curved meniscus is observed over the bottle rim.

4. Float the septa, Teflon™ side down on the liquid meniscus. The Teflon™ side is the thin layer observed when viewing the septum from the side horizontally.

5. Carefully set on septum, expelling excess sample and being careful to exclude air. Then screw open-top cap down.

6. Check for a good seal by inverting bottle and tapping and checking for visible air bubbles.

7. If air bubbles are visible or there is a bad seal, remove cap and add additional sample and repeat steps 4 to 6.

8. Groundwater samples for volatile analysis will be taken in triplicate.

4.6 Groundwater Field Analyses

The field analyses of groundwater include pH, temperature, specific conductivity, turbidity and ORP. The field analyses will be measured in the field since these constituents change during storage. A minimum 40 ml sample will be collected and placed in clean unpreserved polyethylene or glass containers for analysis. The containers will be covered if the measurements are not recorded immediately.

The pH, temperature, ORP and conductivity of a sample are measured with a portable unit capable of measuring all four (4) parameters concurrently. The portable unit

automatically adjusts to compensate for the temperature of the sample. The turbidity of a sample is measured with a separate portable unit. The pH, temperature, conductivity, turbidity and ORP will be recorded on the Groundwater Services Field Log. These units will be calibrated to known standards prior to the start of field activities. Measurement and operating procedures for these field analyses are presented in Section 7.0 of this FSP.

5.0 SOIL SAMPLING PROCEDURES

5.1 Headspace Analysis

The soil samples will be screened for the presence of petroleum/chemical related hydrocarbons by headspace analysis utilizing a PID meter to subjectively assess the recovered samples for evidence of petroleum/chemical contamination. The sample is transferred into a zip lock bag, sealed, shaken and then allowed to sit for several minutes. Once the sample has had a chance to sit or "volatilize," the vapor space inside the bag will be analyzed by inserting the tip of the PID meter through the bag, as described in Section 3.4.

5.2 Analytical Soil Sampling

The soil samples will be subjected to laboratory analysis to assist in characterizing the environmental quality of soil at the Site. The samples will be extracted from the sampling equipment in a timely fashion such that the sample has limited exposure to the outside air reducing the chance for volatilization. Only new pre-cleaned laboratory provided sample containers and caps will be used for sample collection/analyses. All sample containers required to be fixed with a preservative, will be prepared by the laboratory before each sampling event. The container type, cap type and preservative requirements for the analytical parameters to be analyzed are summarized in Table 2.

TABLE 2
Analytical Requirements for Containers and Preservatives for Soil Samples

PARAMETER	CONTAINER	TOP	PRESERVATION	COMMENTS
PFCs per EPA 537 Ver. 1.1 (Modified) (Soil)	250 ml HDPE Plastic	HDPE Plastic	Cool, ≤6°C	None
TCL VOCs per EPA 8260C (Soil)	Terra Core Kit with Three (3), 40 mL Glass Vials	Septum	Two (2) Vials with Water – HCl to pH<2, One (1) Vial with Methanol, Cool 4°C, Freeze Within 48 Hours.	None

PARAMETER	CONTAINER	TOP	PRESERVATION	COMMENTS
TCL SVOCs per EPA 8270D, PCBs per EPA 8082A and Pesticides per EPA 8081B (Soil)	8 oz Glass	Teflon	Cool 4°C	None
TAL Metals per EPA 6010C and 6020A and Mercury per EPA 7471B (Soil)	8 oz Glass	Teflon	Cool 4°C	None
Cyanide per EPA 9012A (Soil)	4 oz Glass	Teflon	Cool 4°C	None
Total Organic Carbon (TOC) per EPA SM5310B Modified-2000 (Soil)	4 oz Glass	Teflon	Cool 4°C	None
pH in Soil by EPA 9045D	125 ml Wide Mouth Glass	Teflon Lined	Cool, 4°C	None
Moisture Content by SM 2540G-97	125 ml Wide Mouth Glass	Teflon Lined	Cool, 4°C	None

6.0 FIELD QUALITY CONTROL

6.1 Source Materials

Because PFCs (including PFOA) are found in several everyday items, samples will be collected of source materials prior to being imported onto the Site to aid in the investigation and sampling process. These include water used by the drilling contractor for advancement of test borings, construction of monitoring wells and decontamination of drilling and sampling equipment; water used by the sampling technician to decontaminate sampling equipment; totes and tanks used by the drilling contractor for temporary storage of drilling water; drill rig augers, casing and rods used by the drilling contractor for advancement of test borings; monitoring well construction materials (PVC riser and screen) used by the drilling contractor for construction of the monitoring wells; filter sand used by the drilling contractor for the monitoring well sand pack; and rinse (deionized) water used as a final rinse for decontaminating non-disposable sampling equipment. As a note, all water imported onsite for investigation/sampling purposes must be from a municipal potable water source located outside the limits of the Town of Bennington and the Village of North Bennington, and the source of water must be identified. Table 3 summarizes the quality control sampling protocols that will be employed for the source materials.

TABLE 3: SOURCE MATERIALS SAMPLING PROTOCOLS

Sample Type	Sample Frequency	Sampling Procedure
Imported Drilling Water	One Time	Obtain one (1) grab sample of driller water at each drilling contractor's place of business prior to Site mobilization and analyze for PFCs. Analytical results must indicate PFCs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to mobilization of the drilling contractor to the Site.

TABLE 3: SOURCE MATERIALS SAMPLING PROTOCOLS

Sample Type	Sample Frequency	Sampling Procedure
Imported Sampling Equipment Decontamination Water	One Time	Obtain one (1) grab sample of each sampling equipment decontamination water (bottled water) source(s) to be used during the project prior to Site mobilization and analyze for PFCs. Analytical results must indicate PFCs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to conducting media sampling at the Site.
Driller Totes and Tanks	One Time	Obtain one (1) grab rinsate blank sample from each water storage tote to be used at each drilling contractor's place of business prior to Site mobilization and analyze for PFCs. Sampling method to include pouring water through each representative totes/tanks and capturing the water in laboratory provided containers. Analytical results must indicate PFASs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to mobilization of the drilling contractor to the Site.
Drill Rig Augers, Drill Rods, Split Spoons, Plugs	One Time	Obtain one (1) grab rinsate blank sample from each of the drilling tools to be in contact with the subsurface soils. Samples will be collected at each drilling contractor's place of business prior to Site mobilization and analyzed for PFCs. Sampling method to include pouring water over/through representative tools and capturing the water in laboratory provided containers. Analytical results must indicate PFCs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to mobilization of the drilling contractor to the Site.
Monitoring Well Construction Materials	One Time	Obtain one (1) grab rinsate blank sample of monitoring well construction materials at each drilling contractor's place of business prior to Site mobilization and analyze for PFCs. Sampling method to include pouring bottled water through and over representative riser/screen and capturing the water in laboratory provided containers. Analytical results **must** indicate PFCs as **Non Detect** or

TABLE 3: SOURCE MATERIALS SAMPLING PROTOCOLS

Sample Type	Sample Frequency	Sampling Procedure
		at concentrations that are not expected to cross-contaminate environmental samples prior to mobilization of the drilling contractor to the Site.
Filter Sand	One Time	Obtain one (1) grab sample of each filter sand to be used from each drilling contractor's place of business prior to Site mobilization and analyze for PFCs. Analytical results must indicate PFCs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to mobilization of the drilling contractor to the Site.
Rinse (Bottled) Water	One Time	Obtain one (1) grab sample of bottled water and analyze for PFASs. Analytical results must indicate PFASs as Non Detect or at concentrations that are not expected to cross-contaminate environmental samples prior to importation of bottled water onto the Site.

6.2 Field Sampling

Quality control samples will be taken during the field sampling to evaluate sampling technique, sampling equipment cleanliness, sample variability, sample handling and laboratory performance (analytical reproducibility). The quality control samples will include replicate samples, equipment/field blanks, matrix spike/matrix spike duplicate (MS/MSD) samples and trip blanks.

Replicate Samples

Replicate samples are samples taken from the same location with the same sampling device. Replicate samples are used to check on laboratory reproducibility, sampling technique and sample variability. The replicate samples will be coded so that the laboratory is not biased in performing the analyses. The code that is used will be identified in the field notes and on the sampling logs, but not on laboratory correspondence.

One (1) replicate soil sample and one replicate groundwater sample will be taken for every twenty (20) samples submitted to the laboratory for analysis. Replicate samples are collected simultaneously using identical procedures, but placing the samples in separate containers. Any replicate soil samples that will undergo VOC analysis with the TerraCore sampling kit due to the presence of subjective impacts will be collected by filling the parent sample containers first followed by the replicate sample containers. The replicate shallow soil samples will be collected by homogenizing the sample and transferring equal amounts into the various sample containers.

The replicate groundwater samples will be taken by splitting the sample by alternating the discharge of the sampling equipment between both sets of containers (sample and replicate containers) until the containers are filled. The replicate groundwater samples for VOCs analysis will be taken by filling one container completely and then filling the replicate container completely. Groundwater samples for VOCs analysis are typically taken in triplicate, so this procedure will be repeated three times.

The replicate samples will be analyzed for the same parameters as the original sample, yet the sample designation is "blind" so that the laboratory can't determine which sample it is a duplicate of. No time or a different time will be used for the replicate samples on the chain of custody record so they are a blind sample to the laboratory.

Equipment/Field Blanks

Equipment/field blanks are samples taken to monitor sampling equipment cleanliness and decontamination procedures during field sampling. One equipment/field blank will be taken during soil and groundwater sampling for every twenty (20) samples submitted to the laboratory for analysis of all of the parameters of concern. The equipment/field blanks will be taken as follows per the environmental media being sampled:

Soil Sampling - After the sampling hand auger, core sampler and split-spoon sampler have been decontaminated and are ready for sampling, pour bottled water through and/or over the sampling equipment and capture in laboratory provided sample container(s).

Groundwater - After the peristaltic pump tubing is removed from its packaging and ready for sampling, pour bottled water through and/or over the tubing and capture in laboratory provided sample container(s).

The equipment/field blanks will be identified as such and by the location to be sampled (i.e., equipment blank before MW-5) in the Environmental Services Field Log.

Matrix Spike/Matrix Spike Duplicate

MS/MSD samples are used to check on sample matrix effect and laboratory accuracy and precision.

One MS/MSD soil and groundwater sample each will be taken for every twenty (20) samples submitted to the laboratory for analysis. The MS/MSD samples for VOC analysis will be collected by equally splitting the sample into the various analytical containers. MS/MSD samples that will not undergo VOC analysis will be homogenized and transferred into the various sample containers.

Laboratory Trip Blanks

Laboratory Trip Blanks are prepared when VOC and PFC analysis is to be performed on aqueous samples, and they are prepared in the laboratory when the sample containers are prepared.

For VOCs, trip blanks will be prepared in triplicate by filling 40 ml glass containers (with Teflon™ lined septum) with reagent grade water. For PFC analysis, trip blanks will be prepared by filling one (1) 250 ml plastic container with reagent grade water.

Field Trip Blanks

Field Trip Blanks are prepared by the laboratory for analysis of PFCs only. During sampling, a 250-ml laboratory provided plastic container of reagent grade water will be poured into an empty 250-ml laboratory provided sampling container. The Field Trip Blank is collected and analyzed to evaluate if PFCs are being introduced into the sampled matrix during field collection of samples.

The Laboratory and Field Trip Blanks are taken to monitor whether the samples have been contaminated during transport, as a result of handling in the field, during shipment or during storage in the laboratory. One trip blank will accompany each set of aqueous samples that are shipped/delivered to the laboratory for VOC and PFC analysis.

The field replicate samples will be identified as FD01, FD02, etc. The equipment/field

blanks will be identified as EB01, EB02, etc. The sampling interval and location where the field replicates are collected will be identified in the Environmental Services Field Log. The MS/MSD samples will be labeled as required for the sample location except that in the comment section of the chain of custody record it shall read "use this sample for the MS/MSD" or equal.

7.0 FIELD INSTRUMENTATION OPERATING PROCEDURES

7.1 General

The field instruments that will be utilized during implementation of the Site investigations are: a PID meter for air monitoring of the total VOCs during drilling, and for headspace analysis of soil samples for total VOCs; a temperature/pH/ORP/conductivity meter; and a turbidity meter for field analysis of groundwater samples for these parameters. The field instruments used will be calibrated and operated in accordance with the manufacturer's instructions and the procedures identified in the following sections.

7.2 Photoionization Detector Meter

A MiniRae PID meter and data logger with a 10.6 eV lamp will be utilized to measure total VOCs. The instrument is calibrated at the factory upon purchase and annually thereafter using certified service shops who utilize standards of benzene and isobutylene. Prior to use in the field, the instrument will be calibrated in accordance with the manufacturer's instructions using a disposable cylinder containing isobutylene obtained from a reputable supplier. The calibration value varies by the manufacturer, however, 100 parts per million is commonly utilized by C.T. Male and Barr. During use the PID meter will be calibrated at least once every 8 hours. The calibration procedure is contained in the MiniRea PID meter User's Manual.

Care will be taken when handling and using the PID meter to prevent any debris from entering the sample line which will affect the instrument's operation. If this occurs, the field personnel will clean the unit or replace it with a functional PID meter.

7.3 Temperature, PH, ORP and Specific Conductivity Meter

7.3.1 General

The YSI Pro Plus or equal unit will be used to measure temperature, pH, ORP and specific conductivity. This instrument is equipped with an automatic temperature control for accurate adjustment to the temperatures of the samples and calibration standards.

7.3.2 pH

Prior to collecting the pH readings, the instrument will be calibrated with standard buffer solutions of pH 4.0, 7.0 and 10.0 with the unit automatically correcting the temperature. The instrument will be calibrated prior to use each day to ensure accurate measurements. Calibration procedures are presented in the manufacturer's operating instructions.

The pH measurement will be taken by setting the meter function to pH mode, immersing the electrode in the sample (after rinsing the probe with deionized water), gently stirring the water with the electrode probe until equilibrium is reached, and recording the pH when the instrument displays "ready." The pH electrode will be rinsed with deionized water after taking a measurement. The manufacturer recommends that the electrode be stored in an electrode storage solution when not in use.

7.3.3 Specific Conductivity

Prior to collecting specific conductance readings, the instrument will be calibrated prior to use each day to ensure accurate measurements. Calibration will be performed using standards of 147.0, 717.8 and 1,413 umhos/centimeter, being sure the instrument is showing automatic temperature correction. Calibration procedures are presented in the manufacturer's operating instructions.

The conductivity cell will be rinsed with deionized water before and after use. The measurement will be taken after rinsing the conductivity probe twice with the sample, immersing the probe in the sample, and recording the measured value when the instrument reads "ready."

7.4 Turbidity Meter

A LaMotte Turbidimeter (Model 2008), or equal unit, will be used to measure turbidity. The Model 2008 is a true nephelometer, measuring the amount of light scattered at right angles from a beam of light passing through the test sample. The instrument range is 0 to 19.99 NTU (20 scale) and 0-199.9 (full scale). The accuracy of this instrument is ±2% of the reading or 0.05 NTU, whichever is greater. The turbidity is pre-calibrated from the manufacturer, but will be calibrated daily to known standards of typically 4 and 40 NTU.

The turbidity measurement is collected by pouring a sample into a dedicated VOA vial

or cuvette. The cuvette is wiped clean and them inserted into the instrument's chamber and covered. The reading is noted once stabilized.

8.0 SAMPLE HANDLING AND CHAIN OF CUSTODY PROCEDURES

Prior to sampling and filling the sample containers, the label on the container will be completed with the required information. After filling the sample containers they will be wiped with a paper towel. The container(s) will immediately be placed in a cooler with double bagged wet ice, to maintain a temperature of ≤6°C for the samples to be analyzed for PFCs and PFC Precursors, and 4°C for the samples to be analyzed for the TCL/TAL parameters, CN, the major cations/anions, ammonia, orthophosphate, TKN and 1,4-dioxane. The containers will be delivered to the laboratory within 24 hours of sample collection.

A Chain of Custody Record will be completed by the sampler in the field after securing analytical samples. The sampler will be responsible for retaining possession of the samples until they are delivered to the laboratory or until they are delivered to a courier or common carrier for shipment to the laboratory. When the samples are released from the custody of the sampling personnel, the Chain of Custody Record will be signed by both relinquishing and receiving parties with the date and time indicated. A copy of the form will be retained by the sampler for inclusion in the project files and the original form will accompany the shipment. The Chain of Custody Record will then be signed by the relinquishing party and receiving laboratory personnel when the samples are ultimately received at the laboratory.

If samples are shipped, a bill of lading or an air bill will be used and retained in the project files as documentation of sample transportation. Prior to shipment, the cooler will be affixed with a custody seal as a check for tampering and the cooler will be securely wrapped with clear tape. A separate additional Chain of Custody Record will be completed for each cooler of samples. This form will be placed in a plastic bag. This form will be used by the laboratory personnel as a check to verify that the containers listed on the form are present in the cooler when they are received at the laboratory. A copy of the signed Chain of Custody Record will accompany the laboratory analysis reports.

9.0 WATER LEVEL MEASUREMENT PROCEDURES

Water levels will be measured in the monitoring wells using a water level indicator probe. The water levels will be measured from the surveyed reference point to the nearest 0.01 foot. Water levels will be measured progressively from upgradient monitoring wells to downgradient monitoring wells, attempting to measure water levels from the cleanest well to the dirtiest well.

To avoid possible cross contamination of the wells, the water level indicator will be decontaminated prior to and following the water measurement of individual wells. The water level indicator will be decontaminated by rinsing it with imported water, vigorously scrubbing with a brush and laboratory-grade standard detergent (e.g., Alconox® or Liquinox®) and imported water, then rinsing it with copious amounts of deionized water and drying with a paper towel.

The water depth levels and reference elevations determined from monitoring well survey(s) will be recorded on a Water Level Record form and the water table elevations calculated. A blank copy of this form is presented in Attachment A.

ATTACHMENT A

QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) FORMS AND FIELD REPORT FORMS

C.T. MALE ASSOCIATES

TEST BORING LOG

BORING NO.:
ELEVATION: **DATUM:**
LATITUDE: **LONGITUDE:**
START DATE: **FINISH DATE:**
SHEET OF

PROJECT: _____ CTM PROJECT NO.: _____

LOCATION: _____ CTM OBSERVER: _____

DEPTH (FT.)	SAMPLE TYPE	SAMPLE NO.	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	N	RECOVERY	SAMPLE CLASSIFICATION	NOTES
5										
10										
15										
20										
25										
30										

N = NO. OF BLOWS TO DRIVE 2" SAMPLER 12" WITH A 140 LB. WT. FALLING 30" PER BLOW

DRILLING CONTRACTOR: _____

DRILL RIG TYPE: _____

METHOD OF INVESTIGATION: _____

GROUNDWATER LEVEL

DATE	LEVEL	CASING	STABILIZATION TIME

SAMPLE CLASSIFICATION BY:

THE SUBSURFACE INFORMATION SHOWN HEREON WAS OBTAINED FOR C.T. MALE EVALUATION. IT IS MADE AVAILABLE TO AUTHORIZED USERS ONLY THAT THEY MAY HAVE ACCESS TO THE SAME INFORMATION AVAILABLE TO C.T. MALE. IT IS PRESENTED IN GOOD FAITH, BUT IS NOT INTENDED AS A SUBSTITUTE FOR INVESTIGATIONS, INTERPRETATION OR JUDGMENT OF SUCH AUTHORIZED USERS.

C.T. MALE ASSOCIATES

DIRECT-PUSH EXPLORATION LOG

BORING NO.:
ELEV.: **DATUM:**
START DATE: **FINISH DATE:**
SHEET **1 of 1**

PROJECT: _____ CTM PROJECT NO.: _____
LOCATION: _____ CTM OBSERVER: _____

DEPTH (FT)	SAMPLE INTERVAL	SAMPLE NUMBER	SAMPLE RECOVERY (FT)	SAMPLE CLASSIFICATION	NOTES
2					
4					
6					
8					
10					
12					
14					
16					

DRILLING CONTRACTOR: _____
DIRECT-PUSH TYPE: _____
METHOD OF SAMPLING: _____

GROUNDWATER LEVEL READINGS

DATE	LEVEL	REFERENCE MEASURING POINT

THE SUBSURFACE INFORMATION SHOWN HEREON WAS OBTAINED FOR C.T. MALE EVALUATION. IT IS MADE AVAILABLE TO AUTHORIZED USERS ONLY THAT THEY MAY HAVE ACCESS TO THE SAME INFORMATION AVAILABLE TO C.T. MALE. IT IS PRESENTED IN GOOD FAITH, BUT IS NOT INTENDED AS A SUBSTITUTE FOR INVESTIGATIONS, INTERPRETATION OR JUDGMENT OF SUCH AUTHORIZED USERS.

SAMPLE CLASSIFICATION BY:

ORGANIC VAPOR HEADSPACE ANALYSIS LOG

PROJECT:	**PROJECT #:**	**PAGE OF**
CLIENT:		**DATE COLLECTED:**
LOCATION:		
INSTRUMENT USED: MiniRae 3000 **LAMP** 10.6 **eV**		**DATE ANALYZED:**
DATE INSTRUMENT CALIBRATED:	**BY:**	
TEMPERATURE OF SOIL: ambient		**ANALYST:**

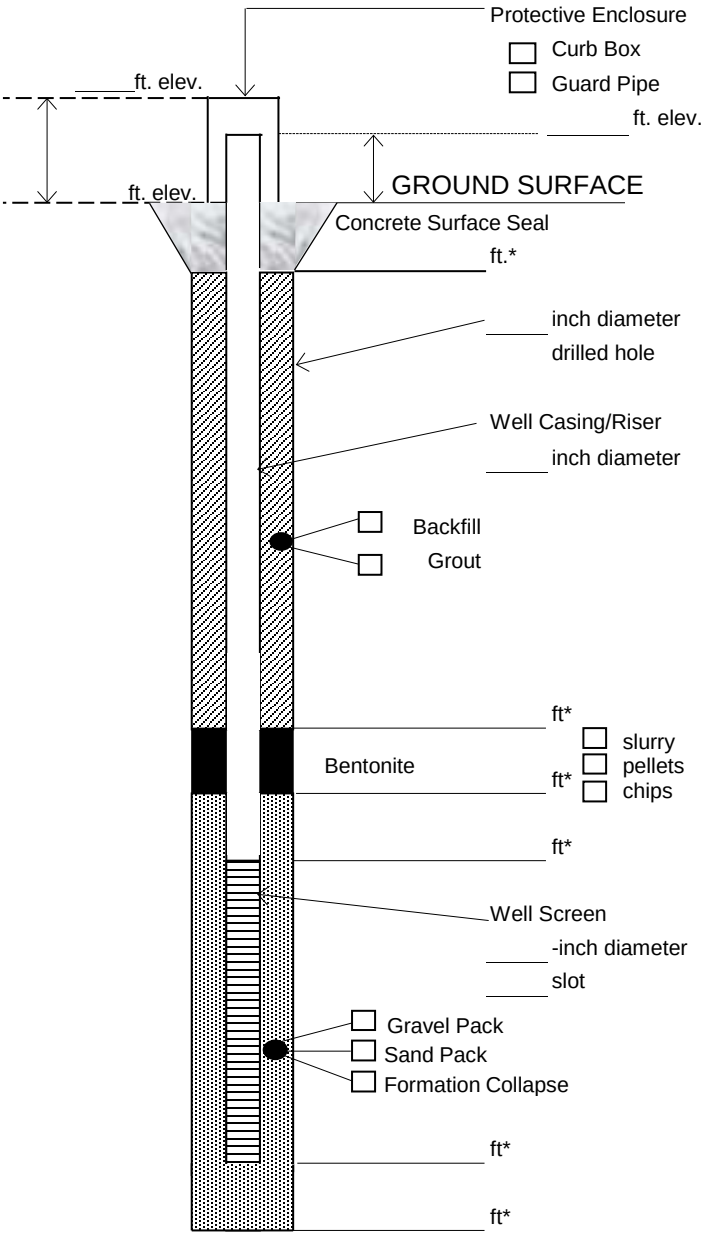
EXPLORATION NUMBER	SAMPLE NUMBER	DEPTH (FT.)***	SAMPLE TYPE	SAMPLE READING (PPM)**	BACKGROUND READING (PPM)**	REMARKS

*Instrument was calibrated in accordance with manufacturer's recommended procedure using a calibration gas supplied by the manufacturer.
**PPM represents concentration of detectable volatile and gaseous compounds in parts per million of air.
*** represents feet below the ground surface

Well No. _____

MONITORING WELL CONSTRUCTION LOG

C.T. MALE ASSOCIATES



* Depth below ground surface.

Project Name: _____

_____

Project Number: _____

Well No.: _____ Boring No.: _____

Town/City: _____

County: _____ State: _____

Installation Date(s): _____

Drilling Contractor: _____

Drilling Method: _____

Water Depth From Top of Riser: _____ ft _____ Date

C.T. Male Observer: _____

Materials Used:

_____ Bags of Sand (_____ lb. bags)
Sand Size: _____ Brand: _____
_____ Bags of Bentonite (_____ lb. bags)
Brand: _____
_____ ft. of _____ well screen
_____ ft. of _____ well riser
_____ Bags of Cement/Concrete (_____ lb. bags)
Brand: _____

Grout Mixture:

_____ Bags of Cement (_____ lb. bags)
_____ Lbs. of Bentonite
_____ Gallons of Water
_____ Grout Batches

Notes:

WELL DEVEOPMENT LOG

Project Name: ______________________ Date Started: __________

Project Number: _____________ Date Finished: _________

Field Parameters		Well Volumes and Corresponding Field Parameters Value									
	Intitial	1	2	3	4	5	6	7	8	9	10
pH											
Conductivity											
EH											
Temperature (C)											
Turbidity											

Monitoring Well: Notes:
Water Level:
Total Depth:
Water Column:
One Well Volume:

Field Parameters		Well Volumes and Corresponding Field Parameters Value									
	Intitial	1	2	3	4	5	6	7	8	9	10
pH											
Conductivity											
EH											
Temperature (C)											
Turbidity											

Monitoring Well: Notes:
Water Level:
Total Depth:
Water Column:
One Well Volume:

Field Parameters		Well Volumes and Corresponding Field Parameters Value									
	Intitial	1	2	3	4	5	6	7	8	9	10
pH											
Conductivity											
EH											
Temperature (C)											
Turbidity											

Monitoring Well: Notes:
Water Level:
Total Depth:
Water Column:
One Well Volume:

Field Parameters		Well Volumes and Corresponding Field Parameters Value									
	Intitial	1	2	3	4	5	6	7	8	9	10
pH											
Conductivity											
EH											
Temperature (C)											
Turbidity											

Monitoring Well: Notes:
Water Level:
Total Depth:
Water Column:
One Well Volume:

C.T. MALE ASSOCIATES, P.C.

WATER LEVEL RECORD

Project Name _____ Project Number _____
Location _____ Measurement Taken By _____
Method or Reading_____ Datum_____

		Date _____		Date_____		Date_____	
Well No.	Ref. Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.

Measuring Point(s) _____

_____

Groundwater Services Field Log

DATE: _____ PROJECT NAME: _____

PROJECT NO.: _____ PROJECT LOCATION: _____

SAMPLING PERSONNEL: _____

MONITORING WELL ID#: _____ NOTES TAKEN BY: _____

DEPTH TO WATER: _____ FROM: _____ BAILER ID: _____

DEPTH TO BOTTOM: _____ FROM: _____ BAILER: LAB CLEANED / FIELD CLEANED

WATER COLUMN HEIGHT: _____ BAILER: STAINLESS STEEL _____

OTHER _____

CONVERSION FACTORS LINEAR FEET TO GALLONS

WELL CASING DIAMETER

1″ = 0.041 GALLONS 3" = 0.38 GALLONS

1.25" = 0.064 GALLONS 4" = 0.66 GALLONS

WELL VOLUME: _____ GALLONS 2" = 0.16 GALLONS 6" = 1.47 GALLONS

VOLUMES PURGED: _____ GALLONS PURGE METHOD: _____

TIME STARTED: _____ ; TIME FINISHED: _____

OBSERVATIONS: COLOR _____ ; ODOR _____

SHEEN _____ ; TURBIDITY _____

OTHER _____ _____

WATER RECOVERY HEIGHT: _____ ; RECOVERY TIME IN MINUTES: _____

FIELD PARAMETERS: pH _____ , TEMPERATURE _____

CONDUCTIVITY _____ UMHO/CM, OTHER _____

SAMPLE COLLECTION TIME: _____

NOTES: _____

Environmental Services Field Log

Date: Time On-Site: Time Off-Site:

Project Name: Project No.:

Purpose: Field Report No:

Weather Conditions:

Present at Site:

Observations:

Items to Verify:

List of Attachments:

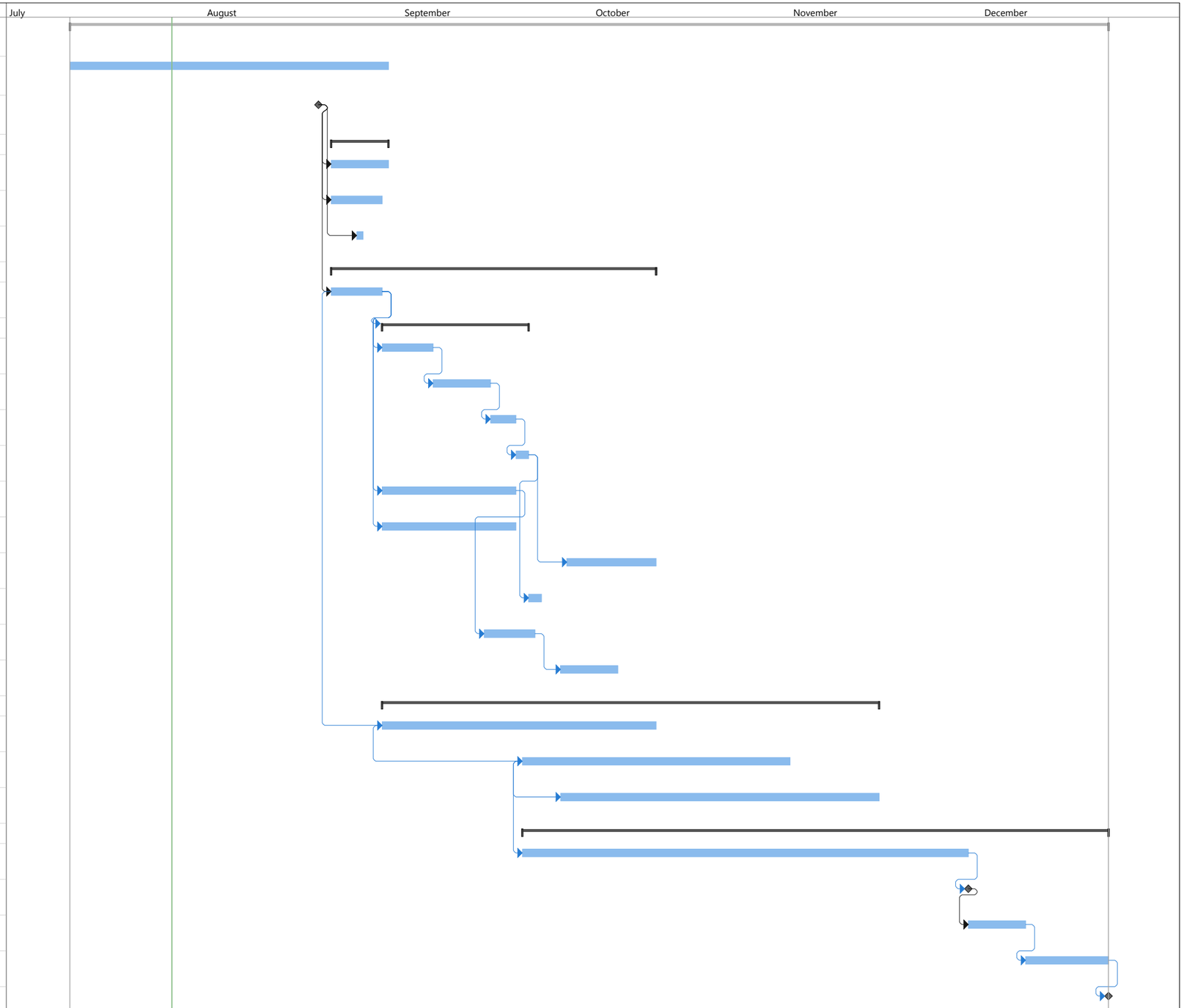
Field Log Prepared by:

Copies to:

Appendix C

CSM Site Investigation Implementation Schedule

ID	Task Name	Duration
0	**CSM Work Plan Implementation Schedule**	**117 days**
1	Facilitate access agreements	36 days
2	Receive CSM Work Plan approval	0 days
3	**Bedrock Study**	**7 days**
4	Conduct desktop study	7 days
5	Completed bedrock outcrop study	6 days
6	Install pressure transducers	1 day
7	**Field Investigation**	**37 days**
8	Prepare, coordinate, and initial mobilization for field investigation	6 days
9	**Install bedrock monitoring wells (2 rotasonic drill rigs)**	**17 days**
10	Advance borings	6 days
11	Conduct geophysical and flow logging	7 days
12	Collect discrete bedrock groundwater samples	2 days
13	Construct monitoring wells	2 days
14	Advance deep soil profile and install monitoring wells (1 rotasonic rig)	15 days
15	Advance shallow soil profile (1 direct-push rig)	15 days
16	Advance deep soil profile (1 rotasonic rig)	10 days
17	Survey monitoring wells	2 days
18	Develop deep profile and bedrock monitoring wells	6 days
19	Collect groundwater samples	7 days
20	**Laboratory Analysis and Review**	**56 days**
21	Submit soil and groundwater samples for laboratory analysis	31 days
22	Receive analytical results (15 day turnaround time)	30 days
23	Complete data validation	36 days
24	**Prepare draft SI report**	**66 days**
25	Draft SI report	50 days
26	Submit draft report for internal and legal review	0 days
27	Review internal draft	7 days
28	Receive and incorporate internal and legal comments	9 days
29	Submit draft SI report for VTDEC review	0 days



Project: CSM Work Plan Implementation Schedule
Date: Thu 7/27/17

Task
Summary
Milestone