

Groundwater and PFAS: State of Knowledge and Practice

Field Sampling and Analyses Section 5

One of eight sections prepared by National Ground Water Association volunteers. Each section was prepared to stand independently, or to be integrated with the other seven sections.

Field Sampling and Analyses

INTRODUCTION AND SCOPE

This section presents and discusses the current best practices for the collection and analysis of environmental samples for PFAS. Emphasis is placed on water samples (e.g., drinking water, groundwater, and surface water); other media [soil, sediment, biota (e.g., fish tissue), and waste] are not discussed. Emphasis is also placed on laboratory analysis using USEPA Method 537 Revision 1.1, referred to as US EPA Method 537 in this section (USEPA 2009); other laboratory analytical methods and field screening methods are briefly discussed to the extent they are commercially available in the U.S.

Some sources of PFAS, such as aqueous film-forming foams (AFFFs), include many fluorinated compounds, many of which are difficult to quantitate using promulgated analytical methods and commercial laboratories. However, some polyfluorinated compounds can degrade in the environment to perfluorinated compounds that are of regulatory interest. It is for this reason that some specialty analytical methods are briefly discussed in this section.

USEPA Method 537 is a laboratory analytical method that was promulgated in September 2009 for the quantification of 14 PFAS. In May 2012, USEPA promulgated the third Unregulated Contaminant Monitoring Rule (UCMR3), which required all large public water suppliers and a subset of smaller water suppliers to test for the following six PFAS (USEPA 2012):

- Perfluorobutanesulfonic acid (PFBS)
- Perfluorohexanesulfonic acid (PFHxS)

- Perfluoroheptanoic acid (PFHpA)
- Perfluorooctanoic acid (PFOA)
- Perfluorononanoic acid (PFNA)
- Perfluorooctanesulfonic acid (PFOS).

This discussion is generally focused on the six UCMR3 PFAS.

Sampling and Analysis Program Considerations

When formulating a sampling and analysis program, it is important to develop appropriate data quality objectives (DQOs) that consider how the resultant data will be used and by whom. For example, if sampling a public water supply, USEPA Method 537 should be used for analysis since the method is specific to drinking water samples. When conducting a site investigation, such as a remedial investigation at a Superfund site, a different method might be more appropriate. The level of rigor required for the sampling and analysis, such as the collection of quality assurance/quality control (QA/QC) samples and validation of analytical data packages may also vary depending on the project objectives and the potential consequences of the results.

Although this document is focused on the six UCMR3 PFAS, some sampling and analysis programs may only need to focus on PFOA and PFOS, for which USEPA or state agencies has issued lifetime health advisories for drinking water. For other programs, it may be prudent to analyze more than the six UCMR3 PFAS. USEPA Method 537 was promulgated for 14 PFAS, and some commercial laboratories have modified the method to analyze additional PFAS.

The matrix(ces) to be analyzed can impact many aspects of the sampling and analysis program, including the analytical method and choice of laboratory.

Any sampling and analysis program for PFAS must also consider the potential for sample contamination due to well materials; sampling equipment; and the

Disclaimer: This publication is a collaborative effort to try to set forth best suggested practices on this topic but science is always evolving, and individual situations and local conditions may vary, so members and others utilizing this publication are free to adopt differing standards and approaches as they see fit based on an independent analysis of such factors. This publication is provided for informational purposes only, so members and others utilizing this publication are encouraged, as appropriate, to conduct an independent analysis of these issues. The NGWA does not purport to have conducted a definitive analysis on the topic described in this publication, and it assumes no duty, liability or responsibility for the contents or use of the publication.

clothing, personal protective equipment (PPE), and/or personal care products in use by the field personnel at the time of sample collection. This is important due to the pervasive use of PFAS in commercial products, the single-digit parts per trillion (ppt) detection limits, and the ppt concentrations of regulatory interest. The potential for cross contamination is discussed later in this section.

LABORATORY ANALYSES AND FIELD SCREENING METHODS

Standard Laboratory Analytical Methods

USEPA Method 537 (USEPA 2009)

USEPA Method 537 is currently the only promulgated method for the analysis of PFAS. It is a liquid chromatography/tandem mass spectrometry (LC/MS/MS) method. There are laboratories that follow this method as written, especially for the six UCMR3 PFAS in drinking water. However, most laboratories have their own modified version of Method 537 based on their expertise and improvements in available equipment/calibration standards, to analyze for selected PFAS in additional matrices (groundwater, surface water, soil, sediment, tissue, etc.), and to achieve lower method detection and reporting limits than presented in the published method. In addition, there are linear and branched isomers of some PFAS that Method 537 specifically addresses, including the branched isomers when quantitating for PFOS and PFHxS. In September 2016, USEPA issued a Technical Advisory recommending that laboratories also quantify linear and branched isomers for PFOA. Since the Technical Advisory is a recommendation, it is important to discuss the project objectives with the laboratory when setting up the analytical program, particularly with regards to quantitating for linear and branched isomers.

The typical turnaround times for data from the laboratories using USEPA Method 537 (with or without modification) range from two to six weeks depending on the sample matrix, the requested PFAS analyte list, number of samples submitted, and the data deliverables requested [e.g., results only data package; sample results with QA/QC results (USEPA Level II); sample results with QA/QC results and raw data (USEPA Level IV); and/or an electronic data deliverable (EDD)].

NGWA does not endorse or recommend vendors, and it is up to the user to select a laboratory based on the specific needs of a project. In response to increased market demand, there are now many commercial laboratories providing Method 537 analyses throughout the U.S. Information about these laboratories is available online.

Although not comprehensive, useful starting points include the following:

- The list of laboratories provided by USEPA in conjunction with UCMR3 (<https://www.epa.gov/dwucmr/list-laboratories-approved-epa-third-unregulated-contaminant-monitoring-rule-ucmr-3> or <https://www.epa.gov/sites/production/files/2016-10/documents/ucmr3-lab-approval.pdf>).
- The searchable database of laboratories accredited by the U.S. Department of Defense (DOD) to perform Method 537 analyses for its projects (<http://denix.osd.mil/edqw/accreditation/accreditedlabs/>). Note, however, that only a few of the laboratories that perform these analyses are currently accredited by U.S. DOD.
- The environmental, health, and/or laboratory-certification agency for the state in which the sampling is being performed. In addition to USEPA requirements and approvals, individual state certifications and approvals should be considered when selecting a laboratory.

ASTM D7979-16 (ASTM, D7979-16)

While less common than USEPA Method 537, which can be modified for the analysis of liquid samples apart from drinking water, ASTM Method D7979-16 can be used for a wide variety of matrices including groundwater, surface water, wastewater, and sludge. Concentrations are determined through a combination of liquid chromatography followed by tandem mass spectrometry (LC/MS/MS).

USEPA SW-846 Method 8321B (SW-846, 2007)

USEPA SW-846 Method 8321B was a precursor to USEPA Method 537, but is still available as a means for analyzing nonvolatile compounds such as PFAS. Concentrations are determined through a combination of high performance liquid chromatography and thermospray mass spectrometry (HPLC-TS-MS).

Specialty Analytical Methods

As discussed earlier in this section, some sources of PFAS (e.g., AFFFs) include many fluorinated com-

pounds, many of which are difficult to quantitate using promulgated analytical methods and commercial laboratories. Moreover, some of the polyfluorinated compounds that may be present are precursors, meaning they can transform in the environment to the perfluorinated compounds which are currently of regulatory interest. Three specialty analytical methods are briefly discussed below that can be used to evaluate the importance of polyfluorinated compounds to the fate and transport of perfluorinated compounds.

Particle Induced Gamma-Ray Emission (PIGE) Analysis (Schaidler 2017)

The PIGE spectroscopy method was developed by Dr. Graham Peaslee and his research group at the University of Notre Dame to screen groundwater and soil samples for total fluorine [similar to how total petroleum hydrocarbons (TPH) can be analyzed at hydrocarbon-impacted sites]. This method can reportedly be performed at a much lower cost compared to standard LC/MS/MS, and can achieve detection limits in the single- to low double-digit parts per billion (ppb) range as fluorine. The resulting total fluorine results can be used to guide characterization locations and delineate the footprint of PFAS-contaminat-

ed sites before more extensive analysis for individual PFAS.

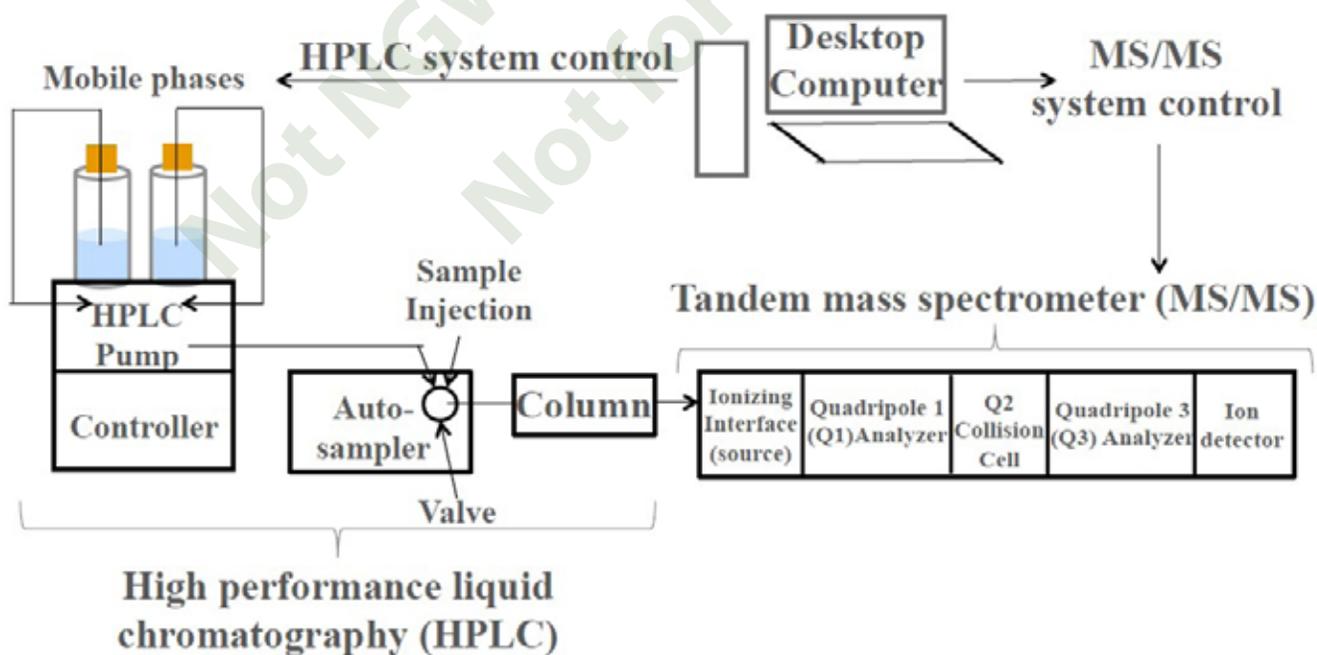
Total Oxidizable Precursor (TOP) Assay

TOP assay involves the use of USEPA Method 537 twice on two identical samples (the second collected similar to a duplicate sample). One sample is analyzed by USEPA Method 537. The other sample is heated and chemically oxidized and then analyzed using USEPA Method 537. The results for the various PFAS are then compared and the difference represents that portion of the precursor pool that can degrade to the perfluorinated compounds that are quantitated by EPA Method 537 (Houtz and Sedlak 2012). It is important to note, however, that the chemical oxidation of the sample is unlikely to completely transform all the fluorinated compounds that may be present in the sample to the perfluorinated compounds being analyzed.

Adsorbable Organic Fluorine (AOF) Analysis

AOF analysis uses combustion ion chromatography (CIC) to provide a total fluorine value [similar to how TPH can be analyzed at hydrocarbon-impacted sites]. PFAS and other organic constituents are sorbed to an activated carbon matrix. The matrix is then com-

Liquid chromatography tandem mass spectrometry LC/MS/MS



Source: Guelfo, Jennifer. Analysis of Per and PolyFluoroalkyl Substances (PFAS), Brown University Superfund Research Program, August 2016.

busted, and the resultant fluoride is measured via ion chromatography (Wagner et al. 2013), with fluorine detection limits in the single-digit ppb range.

Advances in Mobile Laboratory Technology

Site characterization programs for PFAS often involve well drilling, borehole geophysical logging, packer testing, groundwater sampling, and multi-level monitoring well completions. The time-critical nature of these integrated field activities has resulted in the development of at least one mobile laboratory that utilizes LC/MS/MS to provide scientifically defensible water quality analyses (using modified EPA Method 537) in the field, at single-digit ppt detection levels. Another mobile laboratory is reportedly being developed that uses a different analytical method to provide field screening capabilities at the ppb level. The availability of these and possibly other real-time field screening and analysis methods is expected to grow significantly over time. State agency regulatory acceptability and certification of mobile laboratories should also be considered.

Other Considerations for Laboratory Analyses

Components of Analytical Equipment

While there are several laboratory analytical methods as described above, the standard methods each analyze a water matrix using liquid chromatography (LC) to separate the various compounds and tandem mass spectrometry (MS/MS) to detect and quantify. As PFAS can be present in materials used to store, filter, and prepare samples for analysis, some laboratories have modified their methodology to reduce the potential for laboratory-related cross contamination that could appear in the sample results.

Cost

The cost to analyze a sample for PFAS varies quite widely due to a number of factors, including the analytical method; number of PFAS to be quantified; required turnaround time; requested deliverable(s); number and timing of samples (volume discount, available capacity); and the laboratory. However, PFAS analyses are generally more expensive than routine organic analyses, such as volatiles, semi-volatiles, and pesticides/PCBs.

Analytical Expectations and Data Validation

The method detection limits for laboratory PFAS analyses are currently in the single-digit ppt range.

Moreover, PFAS have been used for many purposes for several decades and are environmentally persistent. As a result, there is a likelihood that some PFAS will be reported as being present in environmental samples regardless of where the samples are collected or the analytical method employed. This potential for PFAS to be reported in samples should be expected, and communicated to stakeholders, before the sampling is performed. It is important that the project team understand the analytical acceptance criteria and evaluate whether those are acceptable for the project DQOs. It is also important to discuss with the laboratory and understand the potential effects of the presence of analytes in sample matrix, and if so, are there corrective measures or alternative analytical techniques that may be used.

The lack of standards, guidance values, or health advisories for many PFAS is an additional complication which must be considered. The consequence of detections should be considered in advance and data assessment should include explanations for low-level PFAS concentrations reported in samples. This can include discussion of the QA/QC process and results to evaluate whether the reported concentrations are a potential artifact of field or laboratory sample handling, and discussion of the concentrations with regards to what might be expected given the persistent nature of PFAS, concentrations in the source zone, and the sample location relative to the source zone.

Data validation may be especially important for PFAS sample analysis, due to the low concentration of regulatory interest and the potential for cross contamination, as discussed previously. Although it increases the cost of the project, data validation should also be considered. Validation consists of the detailed review of the analytical results and the supporting QA/QC information to help determine if the data are of sufficient quality to meet the project's data quality objectives and to identify potential issues with the analyses and/or the results. To support data validation, the required QA/QC samples must be collected for analysis, and a complete Level IV analytical package must be obtained from the laboratory. If data validation will be performed, it is important to coordinate with the laboratory and ensure the laboratory is aware and can meet any project-specific analysis requirements that the data validator will be using.

USEPA does not currently have data validation guidelines specific to PFAS. As a result, data validators

are using USEPA's general guidelines for validating organic data (*USEPA National Functional Guidelines for Superfund Organic Methods Data Review*, EPA-540-R-2016-002, September 2016 along with the method description/requirements (ex. USEPA Method 537) https://www.epa.gov/sites/production/files/2016-09/documents/national_functional_guidelines_for_superfund_organic_methods_data_review_0.pdf). In addition, U.S. DOD provides quality control requirements for PFAS analyses in Table 15 of its Quality Systems Manual (QSM) (version 5.0, July 2013), which may also be useful for data validation.

Field Screening Methods

The development of field tests for PFAS is currently in a relatively immature phase. There are currently no commercially available field screening methods that are capable of detecting PFAS at concentrations less than 50 ppb; therefore, the field tests that are currently available are mainly for use in source areas with concentrations that are orders of magnitude higher than drinking water criteria (DiGuseppi 2017). Field screening methods described include:

- Foam height analysis in which a water sample is placed in a small bottle, shaken, and the presence and height of any resulting foam is measured (NEWMOA 2016). This method is useful for determining the potential presence of PFAS only at parts per million (ppm) levels, and is not specific to PFAS (i.e., many surfactants do not contain PFAS).
- Methylene blue active substance (MBAS) measurement kits are commercially available (Chemetrics 2016). This method detects surfactant concentrations to the range of 50 ppb, and is not specific to PFAS. The detection level can be decreased by concentrating the samples, but that process is more difficult to perform in the field.
- An anionic surfactant detection kit (astkCARE™) was commercially available from CRC Care (<http://www.crccare.com/products-and-services/technologies/astkcare>). However, this has reportedly been taken off the North American market recently for product improvements and may be reintroduced (DiGuseppi 2017).
- Ion-Selective Electrodes (ISEs) with fluorine anion-exchanger membranes have been developed for the detection of perfluorooctanoate (PFO-)

and perfluorooctanesulfonate (PFOS-). Detection limits of PFO- and PFOS- are approximately 1.0 ppb and 0.43 ppb, respectively. Measurements with ISEs can be performed in situ, is less costly, and avoids lengthy sample preconcentration. Though not commercially available currently, the research team has demonstrated a real-life application of these electrodes, with results that were consistent with those from an earlier LC-MS study (Chen et al. 2013).

FIELD SAMPLING PROCEDURES

Sample Containers and Preservatives

It is recommended that the user verify the current sampling container requirements with the selected laboratory prior to sampling for PFAS, and ensure that the sample containers do not contain the analytes of interest. The current standard is for samples to be submitted in containers (including caps/liners) made of polypropylene or high-density polyethylene (HDPE). Glass sample containers should be avoided due to potential loss of analyte through adsorption to glass. Field filtering of samples should also be avoided to minimize the potential for cross contamination. The laboratory generally needs a minimum volume of 250 milliliters (mL) to perform analysis. Check with the laboratory regarding sample containers for other environmental media (e.g., soil, sediment).

For drinking water that has free/residual chlorine, Trizma® (or similar) may need to be used as a sample preservative. Consult with the laboratory and, if needed, have the laboratory add the appropriate amount of Trizma (or similar) to the sample container(s) that are shipped to the site.

Samples for PFAS analysis should be chilled to <6°C (4+2°C) using ice that is double-bagged in polyethylene plastic; chemical or gel-based cooling products should not be used. Samples should be transported to the laboratory, or shipped overnight, to ensure delivery of the samples at the sample preservative temperature of <6°C.

Quality Assurance/Quality Control (QA/QC) Samples

Although the collection and analysis of QA/QC samples adds cost to the sampling and analysis program, these additional samples are used to provide information on the quality of the laboratory results for the samples collected at the site, namely

the potential for contamination of those samples by other factors (e.g., false positives resulting from field or laboratory sample collection or handling procedures). QA/QC samples can be especially important for PFAS analyses because of the widespread use of these compounds and the very low (single-digit ppt) concentrations being analyzed. Field-related quality control samples should be included in a project specific Sampling and Analysis Plan (SAP). At a minimum, the following should be considered in the SAP.

Field Reagent Blanks

A field reagent blank (FRB) should be collected during the sampling event to evaluate potential contamination from the overall sample collection and handling process—such as the water used by the laboratory for its method blanks, the sample containers, and exposure of the samples to the environment at the sampling locations including the air, PPE, and the clothing and personal care products of the sampling personnel.

For FRBs, two appropriate containers (one containing PFAS-free water and the other empty) are supplied by the laboratory. During the sampling event, field staff transfer the preserved PFAS-free water from one container into the other container, screw on the laboratory-supplied caps, and place the sample containers into the cooler for submittal with the day's sampling set (typically one per day).

Equipment Blanks

Equipment blanks (EBs) are used to assess the potential contamination of samples by the equipment used at the site to collect those samples. To collect an EB, PFAS-free water provided by the laboratory is poured over, in, or through a particular piece of sampling equipment (for example, a new, disposable bailer, or a pump that has been decontaminated after its prior use) and collected in a sample container. An equipment blank should be collected for each piece of equipment of interest for each sampling event.

Field Duplicate Samples

Field duplicates are recommended at a rate of 1 per 20 samples. A second "blind" field sample is collected at the same location as the primary sample and often has a generic naming convention not known by the laboratory (i.e., avoid using a name like "Dup"). The results are used to check the repeatability of the laboratory analytical results; the documen-

tation for the analytical method that is employed should be consulted for the appropriate relative percent difference (RPD) criteria (e.g., 30% for USEPA Method 537).

Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are field-collected samples into which the laboratory adds known amounts of specific PFAS after receipt, but prior to analysis. Essentially, collecting a MS/MSD sample pair is the same as collecting two field duplicate samples at a certain sampling location; these containers are identified as MS and MSD samples and are not "blind." Laboratories add known amounts of analytes (typically concentrations at/near the middle of the calibration range) when they perform MS/MSD analyses, so it is beneficial to use locations that are known or believed to be clean or have relatively low concentrations for collecting the MS/MSD samples.

Chain of Custody and Sample Shipment

Chain-of-custody (COC) procedures should generally be used to document possession of the samples from collection at the site to receipt by the laboratory. Standard COC procedures are appropriate/adequate for PFAS samples. Make sure that packing and shipping materials do not present the potential for cross contamination during shipment.

It is important to coordinate with the laboratory regarding receipt of the samples. Generally, sampling on the day before the weekend (Friday) or before a holiday should be avoided unless the samples are being transported to the laboratory on the same day, or arrangements have been made with the laboratory to receive the samples and then place in a secure, refrigerated space.

Holding Times

Aqueous samples, if preserved properly (i.e., stored at <6°C without being frozen), must be extracted within 14 days of sample collection and the extracts must be held at room temperature, and analyzed within 28 days of extraction. There is no specific information for holding times for other matrices, but some laboratories recommend 28 days for soil samples. Until studies are performed on holding times for other matrices, it may be prudent to use the more stringent aqueous sample holding time criteria suggested in USEPA Method 537.

General Field Sampling Considerations

As for any sampling program, best practices should be employed in the field to maintain sample integrity and minimize data variability and cross contamination while providing the highest level of data quality and defensibility. This includes maintaining consistency of approach during sample collection.

Regulatory agencies are currently interested in PFAS at ppt levels (e.g., USEPA issued a lifetime health advisory for drinking water at 70 ppt for PFOA and PFOS, individually and combined). In conjunction, given the widespread use of PFAS in many consumer, commercial, and industrial products and processes, and very low concentrations to which PFAS are reported, it is critical that the sampling program consider as many sources of PFAS contamination as practicable. This includes the following:

- To minimize cross contamination during a sampling event, it is recommended that the sampling be performed during any specific event/day from the anticipated “cleanest” (or lowest concentration) to “dirtiest” (or highest concentration) sample locations. If no PFAS data are currently available, then this order should be based on the conceptual model of the site/contamination [e.g., source(s), environmental media, migration pathways/directions, receptor locations].
- Laboratory-supplied water that has been determined to be PFAS-free should be used to prepare all FRBs and EBs.
- The quality of the water used for any other purposes (e.g., equipment decontamination) should be scrutinized, including public water supplies. Many public water supplies have been analyzed for PFAS pursuant to UCMR3, and those results are available from USEPA’s database (<https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule#3>) or from the water provider. Even if data are available from the public water supply, sampling the water used during a PFAS investigation should be considered. If data are not available, the water supply should be analyzed for the PFAS of interest prior to use, and the results should be reviewed to determine if the water quality is suitable based on the objectives of the specific sampling program.
- The materials of construction of all downhole and surface sampling and monitoring equipment—including pumps, packers, transducers, tubing,

liners, valves, and wiring—should be free from polytetrafluorethylene (PTFE) or ethylene tetrafluoroethylene (ETFE) to the maximum extent practicable. In addition, well drilling procedures and completion materials should avoid the use of fluorocarbon-based lubricants, O-rings and pipe thread pastes, tapes and sealants. If possible, a confirmation letter with analytical testing results should be obtained from a manufacturer or service provider certifying that the equipment (or supplies) are free of any PFAS.

- Reusable sampling equipment should be properly decontaminated. New and disposable equipment can also be decontaminated if any materials of construction are not known to be PFAS-free. EBs can be collected and analyzed to obtain the data needed to evaluate the potential for cross contamination of the samples by field equipment.

Sources of Potential Sample Bias and Contamination

A wide range of products commonly used in site investigations are known or suspected to contain PFAS. Due to the combination of low detection limits and potential contamination from PFAS source in sampling equipment and materials such as pumps and tubing (DiGuseppi et al. 2014), field sampling for PFAS requires special precautions be taken to minimize the potential for sample contamination from materials used by samplers. Field sampling procedures from a variety of sources (AMEC 2016; Western Australia DER 2016; U.S. Navy 2015a; U.S. Navy 2015b; USACE 2016) generally indicate that extensive precautions should be followed to limit the potential for sample bias. Therefore, the precautions in Table 5.1 (personal protective equipment, clothing, and hygiene products) and Table 5.2 (sampling equipment) are intended to provide a conservative approach to sample bias prevention. However, the risk of sample bias due to PFAS-containing materials is the subject of ongoing research. A large study is currently underway by Dr. Graham Peaslee of the University of Notre Dame and Dr. Jennifer Field of Oregon State University to determine potential sample bias from 169 common sampling materials and objects; the results of this study are anticipated to be published in spring or summer 2017 (DiGuseppi 2017).

Table 5.1. Personal Protective Equipment, Clothing, and Hygiene Products

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

Table 5.2. General Sampling Equipment and Field Supplies

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

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