Per- and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate

Selected Landfills in Washington State

By

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For the

Solid Waste Management program

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- The Quality Assurance Project Plan (QAPP) that preceded this report has been distributed separately as Ecology publication 22-07-023 and can be found at Publications & Forms.
- Landfill names, Facility site IDs, and Clean-up site IDs are listed in Table 13 in the Additional Tables section.
- Data for this project is available in Ecology's EIM Database,
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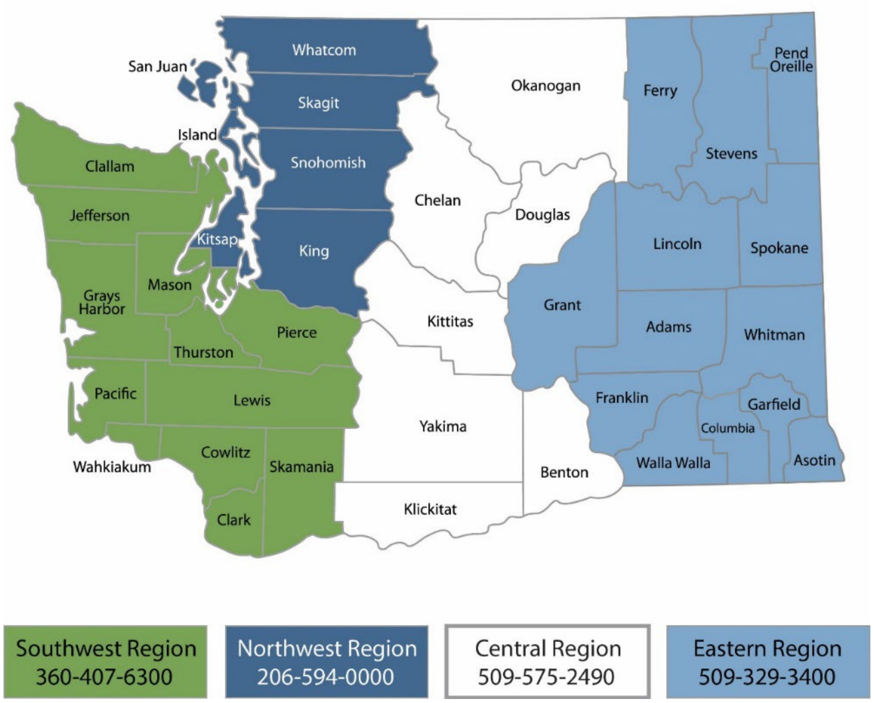

Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	P.O. Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	P.O. Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 West Alder Street Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 North Monroe Spokane, WA 99205	509-329-3400
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Solid Waste Management Program

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Washington State Department of Ecology

Lacey, WA

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Executive Summary

Per- and polyfluoroalkyl substances (PFAS) are a class of thousands of man-made chemicals that have known health risks and are a global contaminant of concern. These chemicals have unique properties that are useful in a variety of commercial and consumer products. Their persistence has contributed to their wide distribution in the environment and living organisms throughout the world. One pathway for PFAS to enter the human body is through the intake of drinking water.

Leachate from landfills contains a variety of chemicals and are a source of contamination of aquifers. In many states, PFAS from landfills is a contributor to this pollution. Several landfills in Washington State are undergoing cleanup because of groundwater pollution, but state regulations do not require landfills to test for PFAS. There are no known previous studies of PFAS associated with landfills in Washington State. This project is the first step to determine the potential for significant PFAS contamination of aquifers from state landfills.

Leachate samples were collected from 19 landfills. Most of the samples are from municipal solid waste landfills, but a few samples were collected from limited purpose and woodwaste landfills. A total of 29 samples were analyzed for PFAS. This total includes field duplicates and multiple samples at some landfills. All samples were tested for either 40 or 32 analytes, depending on which commercial laboratory performed the analysis. Sixteen samples were also tested for 32 analytes with the total oxidizable precursor (TOP) analyses.

The highest sum of PFAS is 173,029 ng/liter for sample CEDAR_LF01, and the average sum is 32,220 ng/liter. The lowest sum of PFAS is at AIRPORT_LF01 which is a wood-waste landfill. Analyte concentrations after Total Oxidizable Precursors (TOP) analyses (post-TOP) generally showed a decrease in precursor chemicals with increases in perfluorocarboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs), compared to pre-TOP analyses. However, for individual samples, there is a wide variation in magnitude and direction of change between pre- and post-TOP analyses values.

For samples from 16 landfills, fluorotelomer carboxylic acids (FTCAs) are the most abundant PFAS group, followed by PFCAs, and then PFSAs. For eight landfills, PFCAs are the most abundant followed by PFSAs. FTCAs are common in carpets, but many products contribute to PFAS in landfills.

SGS AXYS, the lab that did most of the analyses for this study, noted that these are some of the highest municipal landfill leachate PFAS values observed by the laboratory. At least five landfills sampled in this study have undertaken cleanup for groundwater contamination, though PFAS is not a constituent landfills must currently sample.

Per- and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate – Selected Landfills in Washington State

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals that manufacturers use in commercial products and are major chemicals of concern on a global scale. Exposure to PFAS is associated with a range of harmful health effects. One of the most common exposure pathways to humans is through ingestion of drinking water. Landfills are a source of PFAS contamination in groundwater and wells in other states, despite design and operation regulations. Regulations in Washington State require landfills to monitor groundwater for a variety of chemicals, however, PFAS testing is not required. If leachate from a landfill contains PFAS chemicals, there is the potential for contamination of the underlying aquifer. Sampling leachate is a less expensive option in the initial investigation than sampling numerous monitoring wells.

This project fulfills a recommendation identified in the PFAS Chemical Action Plan (CAP), developed jointly by Ecology and the Washington State Department of Health (Ecology, 2021). The CAP reviews many facets of PFAS, including chemistry, analytical methods, sources and uses, fate and transport, environmental occurrence, ecotoxicology, human health, biosolids, regulations, and economic analysis. The mission of the Department of Ecology is to protect human health and the environment. As such, this project is a first step to understanding the magnitude of PFAS at landfills in Washington State and making recommendations for future actions.

PFAS

PFAS are man-made substances. The term PFAS is used for this entire class of synthetic chemicals and is plural so there is no need to follow it with a small "s." The National Institute of Environmental Health Sciences states that there are 4,700 different PFAS substances (NIH, 2022). Some estimates put the number of PFAS chemicals at over 9,000 (Ecology, 2021). New PFAS chemicals are continually developed, as regulations and health concerns limit the usage of older PFAS chemicals.

History and uses

PFAS chemicals do not occur naturally in nature. The first PFAS chemical was produced in the 1930s, and since the 1940s, PFAS have been used in a variety of manufacturing and commercial products. PFAS are added to these products to reduce friction, repel oil and water, protect against high temperatures, and provide surfactant properties. Because of these unique properties, new PFAS usages are continuing to evolve. Consumer products containing PFAS include non-stick coatings, fabric protectors, fire-fighting foam, Gore-Tex, cosmetics, and other household items.

Chemistry

Many acronyms and abbreviations are used in PFAS terminology. For example, PFAS refers to the entire family of per- and polyfluoroalkyl substances, while perfluorinated sulfonates (PFSAs) are a subgroup of PFAS, and perfluorooctane sulfonate (PFOS) is an individual chemical in the PFSA subgroup. It is important to use the terms correctly to avoid confusion, and not use a term like “PFOS” when one means “PFAS”.

Perfluorinated chemicals have carbon chain atoms that are completely fluorinated, whereas polyfluorinated chemicals will have at least one carbon atom chain that is not fully fluorinated. In addition, PFAS chemicals consist of chains of fluorinated carbons that may be linear or branched. PFAS substances occur as acids or in various ionic states: anions, cations, and zwitterions. Most PFAS exist in the environment in the anionic form, however, they are often reported in the acidic form. Reporting may depend on the standards used in the analysis. The samples for this report were analyzed by two different laboratories. SGS AXYS listed the analytes mostly as the anion, while Eurofins listed them as the acid. The different chemical forms have different Chemical Abstracts Service (CAS) numbers assigned but have the same abbreviation. For example, the CAS numbers for perfluorodecanoate and perfluorodecanoic acid are 73829-36-4 and 335-76-2, respectively, but both are abbreviated as PFDA. Some PFAS do not have assigned CAS numbers.

PFAS can be classified in several ways, depending on chemical structure. One scheme divides PFAS into non-polymers and polymers. The non-polymer family has been the focus of regulatory efforts because they are more abundant and more common at PFAS investigation sites (ITRC, 2017). The non-polymer family is further subdivided into perfluorinated and polyfluorinated compounds.

PFAS are also identified as long-chain or short-chain. Replacement chemistry refers to the replacement of longer-chained chemicals with newer, shorter-chained chemicals.

The following table describes the classification of PFAS by chain length.

Table 1. Classification of PFAS by Chain Length.

Chain Length	***PFCAs: Number of carbons***	***PFSAs: Number of carbons***	***Examples***
Long-chain	8 or more	6 or more	PFOA, PFOS, PFNA, PFUnA, PFHXS, PFDS, and precursors capable of forming long-chain PFAAs
Short-Chain	7 or fewer	5 or fewer	PFBA, PFPeA, PHxA, PFHpA, PFBS, PFPeS

PFAS in the environment

The persistence of PFAS in the environment has given them the moniker, “forever chemicals.” The carbon-fluorine bond is one of the strongest in nature, so PFAS do not readily degrade into non-PFAS compounds in the environment (NIH, 2022).

ITRC (2019) states that some PFAS can degrade into perfluoroalkyl acids (PFAAs). The carbon-hydrogen and carbon-oxygen bonds in precursor PFAS are changed at variable rates to PFAAs by biotic and abiotic processes (ITRC, 2018) (Hamid et. al., 2018). For example, firefighting foam eventually breaks down in the environment to form PFAAs. Fluorotelomers may degrade to perfluoroalkyl carboxylic acids (PFCAs) or perfluorosulfonic acids (PFSAs). Cousins et. al. (2020) note that the vast majority of PFAS are either non-degradable or degrade to form terminal products which are still PFAS.

Concerns about the older PFAS materials prompted industry to develop shorter-chained PFAS chemicals. Studies show that these substitute PFAS compounds are also toxic chemicals (Wang et. al. 2017) and can be more mobile in the environment than the older, longer-chained PFAS (ITRC, 2018).

PFAS in groundwater moves through the process of advection, dispersion, and diffusion. Dispersion is limited relative to solvents and other contaminants, so PFAS plumes are generally narrower. Contaminant velocity in a plume is generally reduced compared to the velocity of groundwater due to the effect of sorption, with long-chain having higher sorption than short-chain PFAS.

Health Effects

The chemical properties that make PFAS attractive for industrial and commercial products increase the likelihood of exposure and possible adverse health effects. Properties of PFAS include the following:

- Widespread occurrence. Blood testing shows that nearly every human being, including newborns, has some PFAS in their body (ITRC, 2017). Studies have even identified 22 PFAS substances in polar bears and their prey in the Arctic (Boisvert et.al., 2019).
- Many opportunities for human exposure. Common in cookware, fast-food packaging (DTSC, 2022), clothing, cosmetics, upholstery, and other items used every day. Also, PFAS can be ingested from contaminated water.
- Persistence in the environment. Can remain in the environment for decades or longer.
- Mobility in the environment.
- Bioaccumulation. PFAS chemicals can enter the food chain in various ways and gradually accumulate as intake exceeds excretion.
- Difficult cleanup.

Health effects may include increased risk of cancer and birth defects, as well as increased cholesterol levels, changes in liver enzymes, decreases in infant birth weights, and other health problems. Studies show that PFAS exposure may affect the immune system and reduce resistance to infectious disease and antibody responses to vaccines (ATSDR, 2022; Grandjean, 2017).

Regulations

PFOS manufacturing was phased out in 2002. From 2002 to 2015 manufacturers phased out production of perfluorohexane sulfonate (PFHxS), perfluorooctanoic acid (PFOA), related precursors, and longer-chain PFCAs which resulted in a greater than 95% reduction decrease in these chemicals. Federal and state governments have adopted regulations in recent years, but the Environmental Protection Agency (EPA) rules allow continued use of some of these phased-out chemicals in specific applications. Production of PFAS has shifted overseas.

Federal actions on PFAS include the following:

- EPA began phasing out PFOA in 2006 and completed a global stewardship program to eliminate it by 2015.
- In 2016, the EPA set a health advisory for PFOA and PFOS at 70 parts per trillion (ppt) in drinking water. For comparison, in 2019 Wisconsin recommended a groundwater standard of 20 ppt for PFOA and PFOS individually or combined. A limit of 1 ppt is more appropriate according to some scientists (EWG, 2022).
- The creation of an updated list of 172 PFAS chemicals subject to Toxics Release Inventory Reporting.
- In 2021 the EPA announced that they will regulate PFAS contamination under the Resource Conservation and Recovery Act. Four PFAS are now considered hazardous chemicals: PFOA, PFOS, PFBS, and GenX.
- In 2022, the EPA issued interim lifetime drinking water health advisories for PFOA, PFOS, GenX (hexafluoropropylene oxide dimer acid and its ammonium salt) and PFBS (perfluorobutane sulfonic acid and its related compound potassium perfluorobutane sulfonate) at 0.004, 0.02, 10, and 2,000 parts per trillion (ppt) respectively. For comparison, in 2016 EPA set drinking water health advisories for PFOA and PFOS at 70 ppt, and in 2019 Wisconsin recommended a groundwater standard of 20 ppt for PFOA and PFOS individually or combined. A limit of 1 ppt is more appropriate according to some scientists (EWG, 2022).
- Exposure assessments are conducted by the Agency for Toxic Substances and Disease Registry and the Centers for Disease Control and Prevention in communities known to have PFAS in drinking water from nearby military bases.

The Washington State Department of Health and the Department of Ecology developed a joint Chemical Action Plan (CAP) (Ecology, 2021) to recommend actions to protect human health and the environment. Preliminary recommendations in the PFAS CAP include the following:

- Ensure safe drinking water,
- Manage environmental contamination,
- Reduce PFAS in products, and
- Research and manage PFAS in waste.

The state legislature named PFAS a priority chemical class in Senate Bill 5135 (also known as the Safer Products for Washington program, RCW 70A.350). Additionally, Ecology is leading an alternatives assessment for PFAS in food packaging (RCW 70A.222). Sale of PFAS-containing firefighting foam and firefighting training using these foams have also been prohibited as of July 1, 2020 (RCW 70A.400).

Landfills and leachate

Landfills are sites where waste material is placed for final disposal. Originally waste from towns and cities was discarded in places like valleys or old gravel pits. These waste piles were sometimes burned to reduce pests, odors, and the volume of material. Before 1969, no state or federal statutes or rules were in place to directly deal with the handling of Washington's solid waste. In 1969, the state legislature passed the first statute specific to solid waste. Three more regulations dealing with waste in the state were adopted in the following years before the introduction of federal regulations.

In 1991 the Environmental Protection Agency established federal requirements for landfills receiving non-hazardous waste under the Resource Conservation and Recovery Act (RCRA), 40 CFR Part 258. In response to the federal requirements, Ecology adopted Chapter 173-351 WAC, Criteria for Municipal Solid Waste Landfills in 1993, and later updated the regulation to receive full adequacy determination from the EPA. Additional regulations were adopted for other types of landfills such as construction and demolition material, incinerator ash, and inert waste. A discussion of landfill regulations in Washington State is included in Department of Ecology publication # 12-07-072 (Ecology, 2018). Hazardous waste is managed under different regulations.

Modern landfills are designed to prevent contamination of the environment from landfill operations. This includes bottom liners and leachate collection systems. Waste is deposited in areas in landfills called cells. After the leachate collection system and the bottom liner are constructed, waste is piled on top in layers. The layers are several feet thick and the accumulated waste in a cell can eventually have a thickness of over 50 feet. After a cell reaches its maximum designed height, landfilling activities move to a new cell. A single cell may have an operational life of several years, so successive cells at landfills contain more recent waste material.

Over time, rainwater and moisture from waste materials mix and filter through the waste. The liquid becomes enriched with dissolved and suspended chemicals. This chemically-enriched liquid is known as "leachate". The leachate eventually reaches the liner where it is directed to pipes, and then it flows or is pumped to a leachate collection point. In older, unlined landfills, leachate was able to flow downward until it encountered an aquifer. This includes most landfills constructed in the state before 1993.

Studies have shown that landfills are a major source of PFAS (ITRC, 2019). Landfill leachate is the major pathway by which PFAS exits landfills (Kremen, 2020). Products containing PFAS often end up in landfills where PFAS will continually release into the leachate at slow but relatively steady rates for decades (ITRC, 2019). In landfills that are unlined, or have damaged liner systems, leachate may contaminate groundwater. Typical wastewater treatment plants do not remove PFAS, so leachate sent to wastewater treatment plants from landfills may be discharged to surface waters. PFAS have also been detected in the air around landfills and wastewater treatment plants. Most of the known PFAS groundwater contamination in the state is due to the use of fire-fighting foam agents termed aqueous film forming foam concentrates (AFFF). However, other possible sources, such as leachate from landfills, have not been previously investigated.

Study Area

The study area includes landfills throughout the state of Washington. Jurisdictional Health Departments (JHDs) regulate these facilities. The Solid Waste Management program (SWM) of the Department of Ecology writes the state landfill regulations and serves as a technical consultant to the JHDs. In Washington State, solid waste landfills are regulated under different administrative codes, depending on the type of landfill. Only Limited Purpose Landfills (Chapter 173-350 WAC) and Municipal Solid Waste Landfills (Chapter 173-351 WAC) are required to have leachate collection systems. This includes most of the active landfills.

Washington State has no regulation that requires PFAS testing at landfills, so landfill owners were contacted and asked to voluntarily allow the Department of Ecology to collect samples from their facilities. The project was budgeted for 20 landfills. During project planning over 30 landfills tentatively agreed to sampling. By the time the sampling took place, some facilities withdrew their permission, and others were not selected for various reasons. Nineteen individual landfills were sampled, and multiple samples were collected at some facilities. Figure 1 shows the location of the sampled landfills.

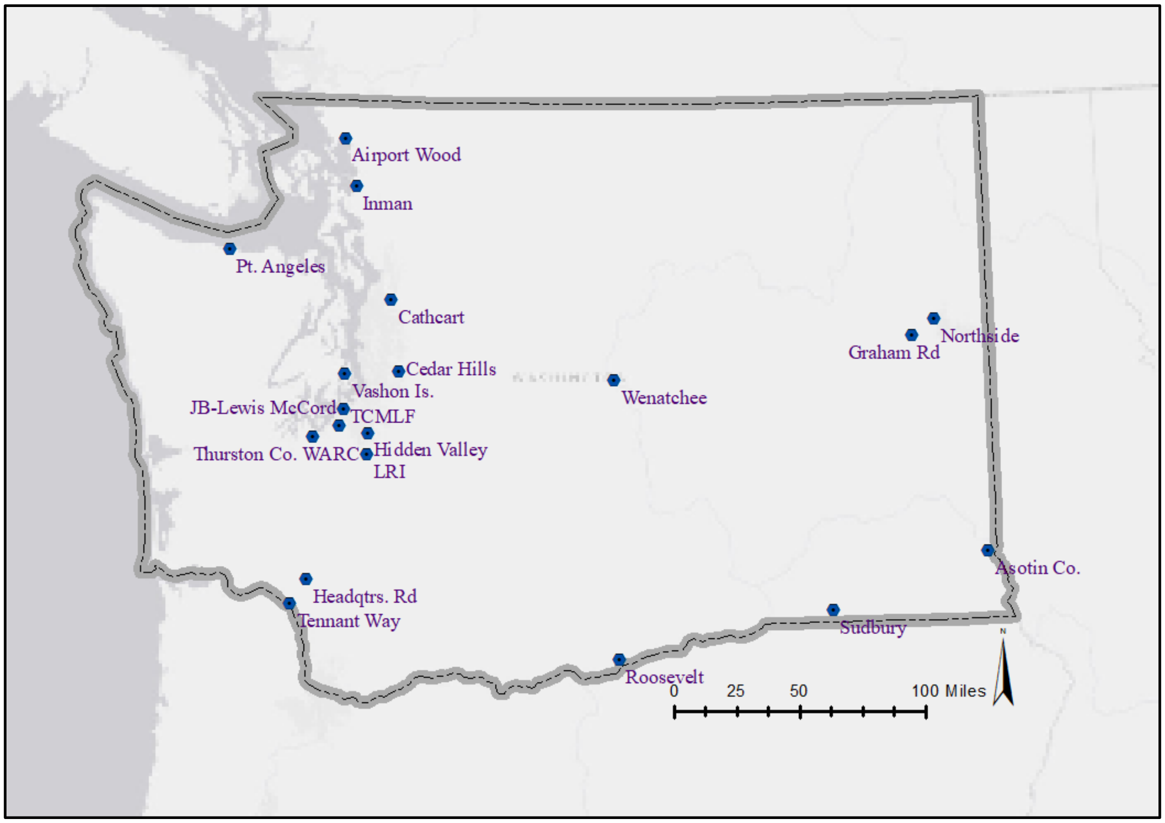


Figure 1. Location of Sampled Landfills in Washington State

Fifteen of the landfills are municipal solid waste (MSW) facilities permitted under Chapter 173-351 WAC, three are permitted under Chapter 173-304 WAC, and one is permitted under Chapter 173-350 WAC and accepts only construction and demolition waste. One of the 173-304 landfills is a wood waste landfill and the others accepted MSW. Seven of the landfills are actively accepting waste, and others are in post-closure care and monitoring. The landfills often contain multiple cells or waste areas. Some of the cells date back to the 1940s, but most of the sampled cells have leachate collection systems consistent with Washington regulation. Leachate from twelve of the landfills is pumped or trucked to wastewater treatment plants, six use evaporation lagoons, and one has a surface discharge permit.

At least five of the landfills have undergone or are currently undergoing cleanup activities. Most of the landfills on the western side of the state are in a wet climate, while those on the eastern side are in temperate climates with one in an arid climate.

Table 2. Landfill names and abbreviations.

Landfill abbreviation	***Landfill Name***	***County***	***Regulation***
AIRPORT	Airport Woodwaste Landfill	Whatcom	Chapter 173-304 WAC
ASOTIN	Asotin County Regional Landfill	Asotin	Chapter 173-351 WAC
CATHCART	Cathcart Landfill	Snohomish	Chapter 173-304 WAC
CEDAR	Cedar Hills Regional Landfill	King	Chapter 173-351 WAC
GRRDF	Graham Road Recycling & Disposal	Spokane	Chapter 173-350 WAC
GWRLRC	Greater Wenatchee Regional Landfill	Douglas	Chapter 173-351 WAC
HEADQUARTERS	Headquarters Landfill	Cowlitz	Chapter 173-351 WAC
HIDDEN	Hidden Valley Landfill	Pierce	Chapter 173-351 WAC
INMAN	Inman Landfill	Skagit	Chapter 173-304 WAC
JBLM	Joint Base Lewis-McChord Landfill 5	Pierce	Chapter 173-351 WAC
LRI	LRI Landfill	Pierce	Chapter 173-351 WAC
NORTHSIDE	Northside Landfill	Spokane	Chapter 173-351 WAC
PT_ANGELES	Port Angeles Landfill	Clallam	Chapter 173-351 WAC
ROOSEVELT	Roosevelt Regional Landfill	Klickitat	Chapter 173-351 WAC
SUDBURY	Sudbury Landfill	Walla Walla	Chapter 173-351 WAC
TCMLF	Tacoma City Municipal Landfill	Pierce	Chapter 173-351 WAC
TENNANT	Tennant Way Landfill, Cowlitz County	Cowlitz	Chapter 173-351 WAC
VASHON	Vashon Island Landfill	King	Chapter 173-351 WAC
WARC	Hawks Prairie Landfill WARC	Thurston	Chapter 173-351 WAC

Project Description

This project was originally planned as Step 1 of Phase 1 of a more extensive program to sample landfills throughout the state for PFAS. Currently, this is the only portion of the investigation that has been funded. During this project, leachate samples were collected from a variety of landfills and analyzed for PFAS. This report discusses activities and results of this project.

Organization and Schedule

This project was conceived and organized by the Senior Hydrogeologist with the Solid Waste Management program (SWM) of the Department of Ecology. Planning began in 2019. Samples from two landfills operated by Waste Management, Inc. were collected by their consultant in December 2019. The other landfills were sampled by Ecology personnel. Due to delays in final approvals and personnel changes, remaining sampling was not completed until November 2020. Samples were collected by the SWM hydrogeologist from the Southwest region with assistance from the hydrogeologists from the Northwest and Central regions.

Sample Collection

The variety of construction methods of leachate systems resulted in a variety of sample collection locations. Samples were collected from spigots, sumps, tanks, pipes, and lagoons. The method of sample collection was site dependent. Field notes from sampling are summarized in Table 19. Poly bottles, beakers, and bailers were used to collect the samples. Sample methods are discussed in the Quality Assurance Project Plan (Department of Ecology Publication #22-07-023).

It was originally planned that at some landfills a series of samples would be collected from separate cells with known operation dates and knowledge of the waste stream in each cell. Unfortunately, most samples were collected at centralized leachate collection systems or lagoons, and the waste material was described simply as municipal solid waste.

Laboratory Analysis and Quality Control

Samples were analyzed at one of two laboratories. The laboratories are accredited by Manchester Environmental Laboratory (Manchester), the Washington State government laboratory.

Analyses

As noted earlier, there are several thousand PFAS chemicals and more are being developed regularly. Commercial laboratories use EPA approved methods for PFAS analyses. Leachate is typically analyzed for 30 to 40 of the most common PFAS analytes. Analytes, abbreviations, and CAS numbers for the PFAS identified in this study are listed in Table 13 in the Additional Tables section.

Two commercial laboratories were used for analysis of samples for this project. Waste Management, Inc. agreed to collect PFAS samples from their landfills in Wenatchee and Spokane provided that their consultants collected the samples and the samples were analyzed at the lab of their choice. Eurofins TestAmerica in West Sacramento CA was selected. Manchester usually does analyses for the Department of Ecology, however, they were unable to do the analyses for the PFAS chemicals needed for this study. The analytical work was put out for bid by Manchester and SGS AXYS in Sidney, BC, Canada was selected. The analytes for each method are listed in Table 14 in the Additional Tables section. PFAS analytes were measured in nanograms per liter. One nanogram (ng) per liter equals one part per trillion (ppt). Analyses reports from the labs include a discussion of their procedures. Due to the size of the lab reports, some are over 1000 pages, they are not included as appendices. They are available from the Department of Ecology by a public records request.

SGS AXYS

SGS AXYS (AXYS) analyzed samples collected by the Department of Ecology using two different methods. Descriptions of the analytical methods are included in the lab reports. All of the samples collected by Ecology were analyzed by AXYS Method MLA 110, which measures 40 PFAS analytes.

Less than 1% of PFAS chemicals are analyzed by standard laboratory methods. An analytical method known as Total Oxidizable Precursors (TOP) was developed to convert oxidizable precursors, such as PFOA, into end product PFAAs (perfluoroalkyl acids) like PFCAs and PFSAs. This conversion is made by using a hydroxyl radical based oxidation reaction of the original sample (Buechler, 2017). Evaluation of pre- and post-TOP analysis data may be useful in obtaining a better understanding of the PFAS chemicals that are not detected by regular analytical methods. AXYS Method MLA 111, which measures 32 analytes, was used for the TOP analyses. The twelve sample locations for TOP analysis were randomly selected.

Eurofins TestAmerica

Samples sent to Eurofins TestAmerica (Eurofins) by Waste Management were analyzed by EPA Method 537M for 32 analytes. No TOP analyses were done on these samples.

Quality control

Quality Control/Quality Assurance (QA/QC) was a fundamental part of this program. Three steps of quality control were incorporated – duplicate field samples, laboratory QC/QA, and third party EPA Level 4 quality control.

Field quality control samples

Five duplicate field samples were collected and submitted to AXYS. The duplicates were blind duplicates and submitted with different sample IDs. Duplicate pairs were collected for both the PFAS samples and the TOP samples at Roosevelt and Vashon. As shown in Table 3, difference in the sums of the total analytes for the regular PFAS analysis (Method 110) is less than one percent, with the exception of the pair from CEDAR. The difference for the TOP analysis (Method 111) pairs is less than five percent. Statistical analyses, t-Tests, for field duplicate pairs are in Table 16 in the Additional Tables section.

Table 3. Field sample comparison. Percent difference of sum of analytes.

Sample Pair	***Method 110 analyses***	***Method 111 (TOP) analyses***
CEDAR_LF02 and CEDAR_LF04	12.1%	N/A
ROOSEVELT_LF01 and ROOSEVELT_LF03	0.8%	1.8%
VASHON_LF02 and VASHON_LF04B	0.26%	3.9%

Figure 2 shows the difference of the duplicate sample pairs for each analyte. Two of the analytes with the largest difference in the pairs are 6:2 FTCA and NFDHA, The difference for 6:2 FTCS was largely due to the VASHON pair, where the value of the original sample was 0.34 ng/l compared to 7.16 ng/l for the duplicate. For NFDHA from the CEDAR pair, the original value was 3.4 ng/l compared to 1.2 ng/l for the duplicate.

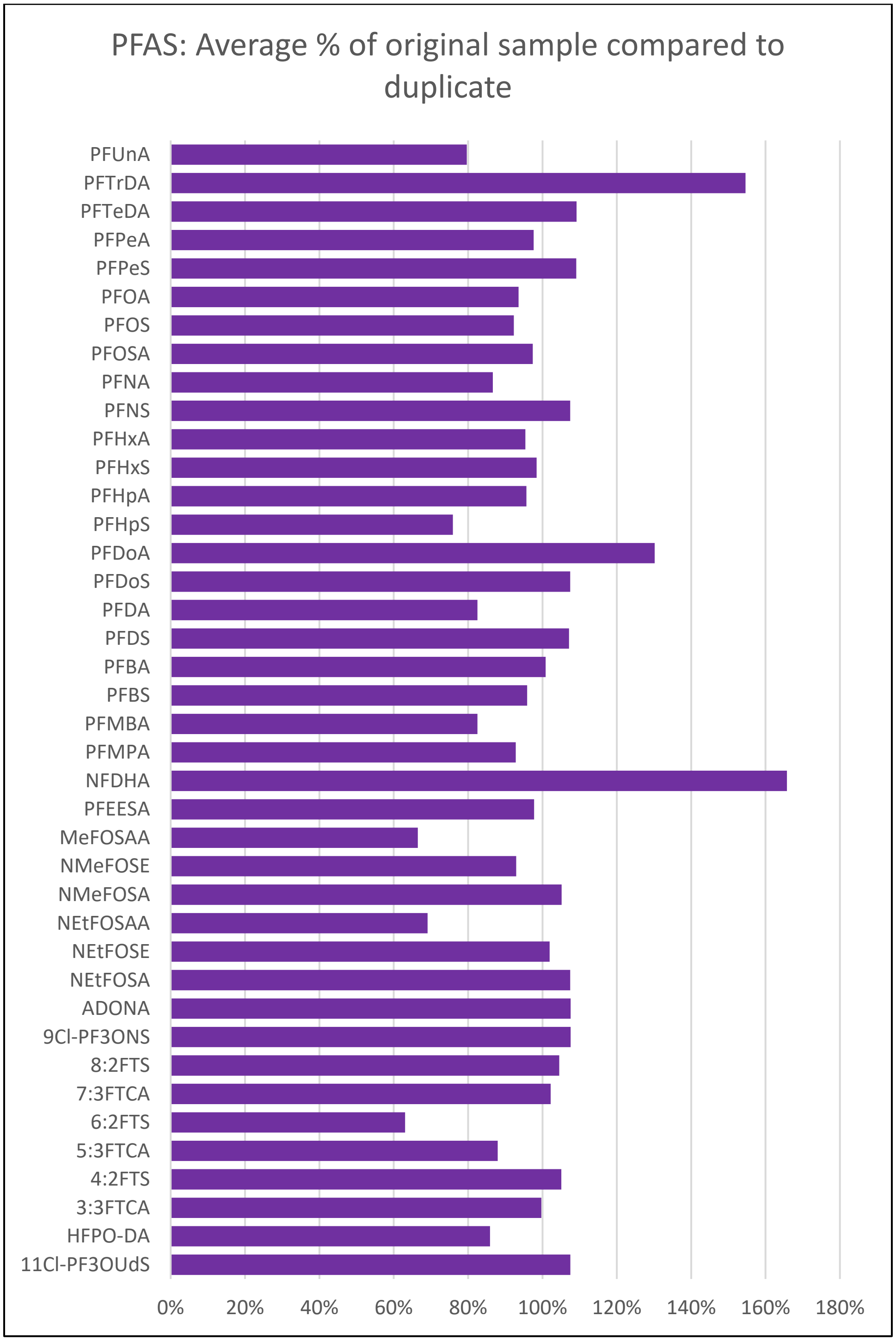


Figure 2. PFAS sample average percent of original compared to duplicate.

As Figure 3 illustrates, there is significantly better correlation for the TOP sample duplicate averages than for the regular PFAS duplicates. Some of this variation may be due to which samples were selected for duplicates and the differences in the magnitude of the analyte values.

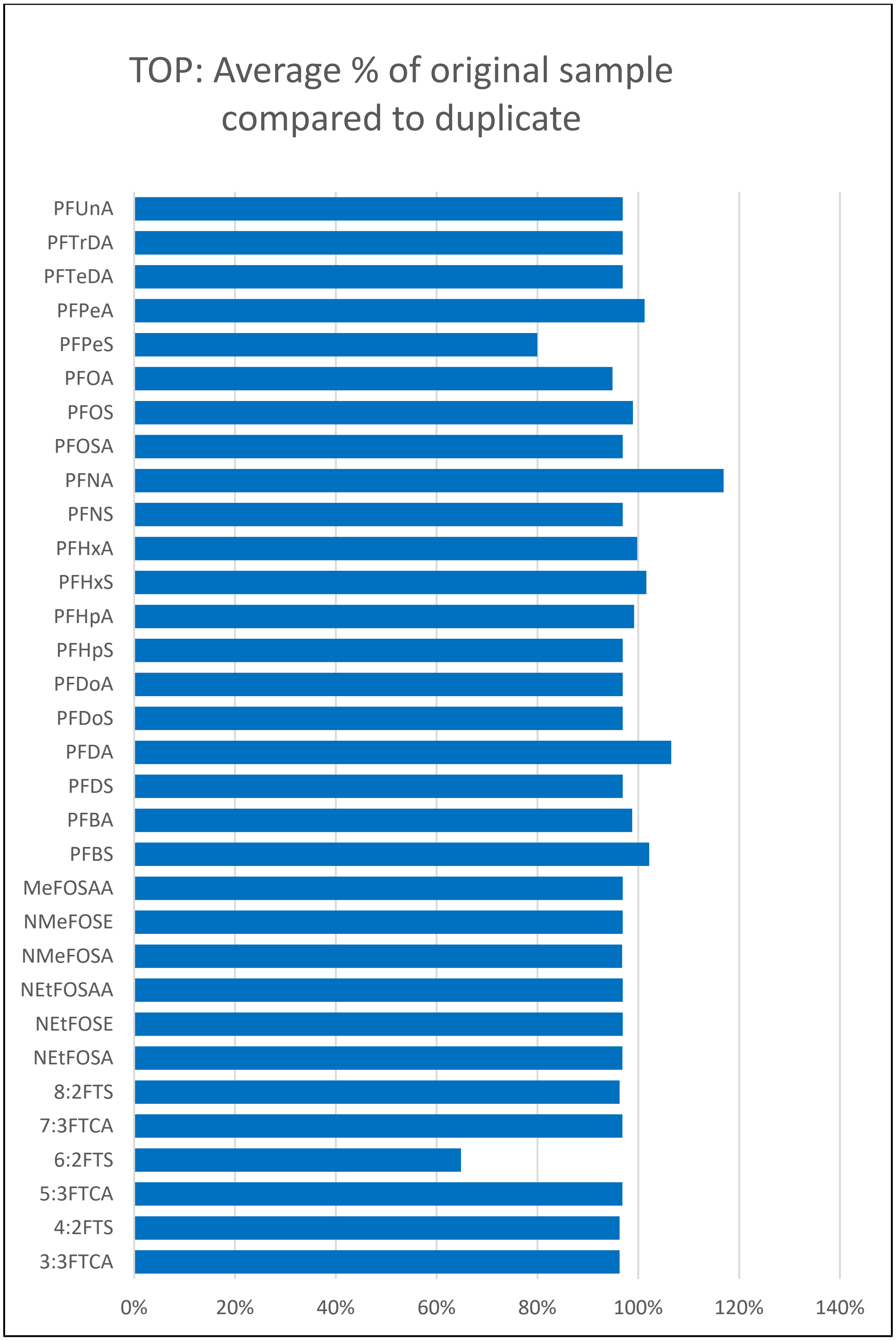


Figure 3. TOP sample average percent of original compared to duplicate.

In addition to the field duplicate samples, one rinsate sample was collected while at ROOSEVELT. No PFAS chemicals were detected in the sample.

Lab quality control

Both analysis laboratories did their own internal Quality Assurance/Quality Control tests. AXYS notes that the field samples and associated QC samples were analyzed in one analysis batch and carried intact through the entire analytical process. AXYS measured 1,424 sample analytes, and the data package spreadsheet included 768 lines of QC data. Sample data were reviewed and evaluated with the batch QC samples. They noted a few minor variations in linearity, calibration verification, OPR, precision, and labeled compound recovery specifications. Sample data and quantification of the associated analytes was not believed to be affected. Overall there was good agreement between the duplicate samples.

Eurofins notes that method blanks and laboratory control samples are within limits or above the requested reporting limits. Tables of QC sample results and QC association summary are included in the lab report. Lab reports with additional QC information are available from the Department of Ecology through a public records request.

EPA Level 4 quality control

EcoChem, Inc. was contracted to conduct a data validation on the AXIS analyses and quality control. The data received a full EPA Stage 4 validation. EcoChem's Data Validation Report is included in Appendix A.

Results

The data for this report is from 41 samples that were collected at 19 landfills during December 2019 and October – November 2020. Table 4 shows the sample and analyte numbers.

Table 4. Project sample totals.

Type of Sample	***Number***	***Number of Analytes***	***Totals***
PFAS - AXYS	22	40	880
PFAS - Eurofins	3	32	96
TOP - AXYS	12	32	384
Field Duplicates	3	40	120
Rinsate	1	40	40
TOTAL	41		1520

PFAS Analyses

The sums of the PFAS analytes for each sample are shown in Figure 4. Samples shown in blue in the graph were analyzed by SGS AXYS for 40 analytes. The three shown in orange were analyzed by Eurofins TestAmerica (Eurofins) for 32 analytes. Analyses per laboratory are listed in Table 14 in the Additional Tables section.

The highest PFAS sum is 173,029 ng/liter for CEDAR_LF01, followed by ROOSEVELT_LF02 with 144,066 ng/liter. The mean is 32,220 ng/liter, and the lowest is 224.5 ng/l for AIRPORT_LF01.

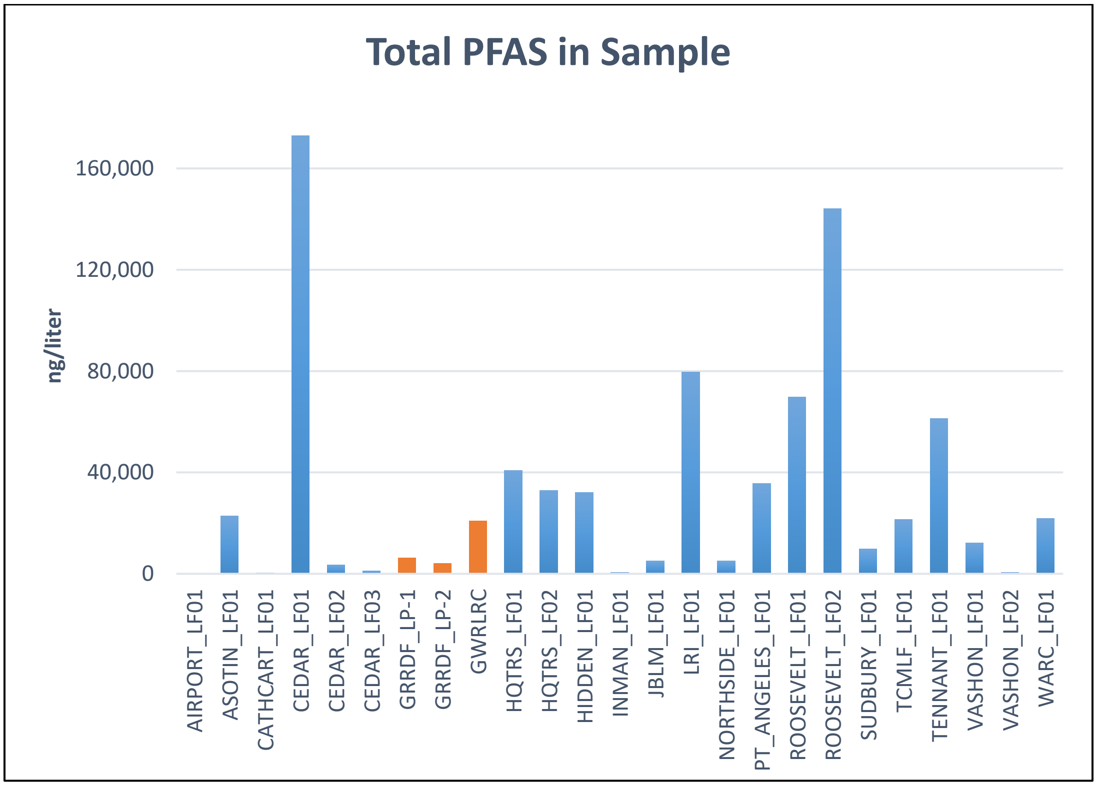


Figure 4. Total PFAS per sample.

PFAS can be divided into groups with similar chemical properties. Table 5 lists the chemical groups used in Table 6.

Table 5. PFAS chemical groups.

Group	**Chemicals**
Ether sulfonic acids	11Cl-PF3OUdS, 9Cl-PF3ONS, PFEESA
Fluorotelomer carboxylic acids	3:3FTCA, 5:3FTCA, 6:2FTS, 7:3FTCA
Fluorotelomer sulfonic acids	10:2FTS, 4:2FTS, 8:2FTS
Per- and polyfluoroalkylether carboxylic acids	ADONA, HFPO-DA, NFDHA, PFMBA, PFMPA
Perfluoroalkane sulfonamides	NEtFOSA, NMeFOSA, PFOSA
Perfluoroalkyl carboxylic acids (PFCAs)	PFBA, PFBS, PFDA, PFDoA, PFHpA, PFHxA, PFHxDA, PFNA, PFOA, PFPeA, PFTeDA, PFTrDA, PFUnA
Perfluoroalkyl sulfonic acids (PFSAs)	PFBS, PFDA, PFDoS, PFDS, PFHpS, PFHxA, PFHxS, PFNS, PFODA, PFOS, PFPeS
Perfluorooctane sulfonamidoacetic acids	NEtFOSAA, NMeFOSAA
Perfluorooctanesulfonamide ethanols	NEtFOSE, NMeFOSE

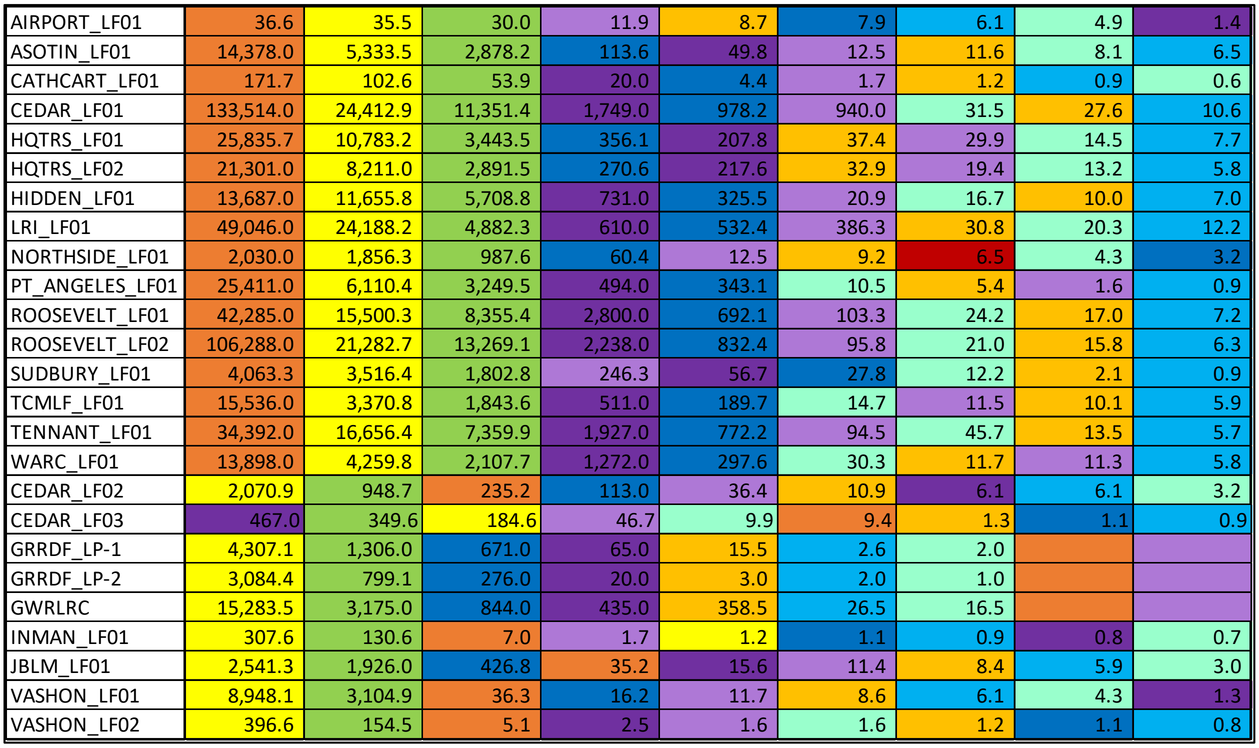
Figure 5 shows the sum of the above PFAS groups for each sample. Samples are arranged in decreasing abundance. This information is also shown as percentages in pie charts in Figure 16 in the Additional Figures section.

Two distinct groups of dominant PFAS chemistry are apparent.

1. Sixteen of the samples have fluorotelomer carboxylic acids as the dominant group, followed by PFCAs, and then PFSAs.
2. Eight of the samples have PFCAs as the dominant group, followed by PFSAs.

CEDAR_LF03 stands out with a different dominant chemistry and is discussed in the Landfill Cell Comparisons below.

Table 6. Sum of PFAS per chemical group for each sample. Values in nanograms per liter.



AIRPORT_LF01	36.6	35.5	30.0	11.9	8.7	7.9	6.1	4.9	1.4
ASOTIN_LF01	14,378.0	5,333.5	2,878.2	113.6	49.8	12.5	11.6	8.1	6.5
CATHCART_LF01	171.7	102.6	53.9	20.0	4.4	1.7	1.2	0.9	0.6
CEDAR_LF01	133,514.0	24,412.9	11,351.4	1,749.0	978.2	940.0	31.5	27.6	10.6
HQTRS_LF01	25,835.7	10,783.2	3,443.5	356.1	207.8	37.4	29.9	14.5	7.7
HQTRS_LF02	21,301.0	8,211.0	2,891.5	270.6	217.6	32.9	19.4	13.2	5.8
HIDDEN_LF01	13,687.0	11,655.8	5,708.8	731.0	325.5	20.9	16.7	10.0	7.0
LRI_LF01	49,046.0	24,188.2	4,882.3	610.0	532.4	386.3	30.8	20.3	12.2
NORTHSIDE_LF01	2,030.0	1,856.3	987.6	60.4	12.5	9.2	6.5	4.3	3.2
PT_ANGELES_LF01	25,411.0	6,110.4	3,249.5	494.0	343.1	10.5	5.4	1.6	0.9
ROOSEVELT_LF01	42,285.0	15,500.3	8,355.4	2,800.0	692.1	103.3	24.2	17.0	7.2
ROOSEVELT_LF02	106,288.0	21,282.7	13,269.1	2,238.0	832.4	95.8	21.0	15.8	6.3
SUDBURY_LF01	4,063.3	3,516.4	1,802.8	246.3	56.7	27.8	12.2	2.1	0.9
TCMLF_LF01	15,536.0	3,370.8	1,843.6	511.0	189.7	14.7	11.5	10.1	5.9
TENNANT_LF01	34,392.0	16,656.4	7,359.9	1,927.0	772.2	94.5	45.7	13.5	5.7
WARC_LF01	13,898.0	4,259.8	2,107.7	1,272.0	297.6	30.3	11.7	11.3	5.8
CEDAR_LF02	2,070.9	948.7	235.2	113.0	36.4	10.9	6.1	6.1	3.2
CEDAR_LF03	467.0	349.6	184.6	46.7	9.9	9.4	1.3	1.1	0.9
GRRDF_LP-1	4,307.1	1,306.0	671.0	65.0	15.5	2.6	2.0		
GRRDF_LP-2	3,084.4	799.1	276.0	20.0	3.0	2.0	1.0		
GWRLRC	15,283.5	3,175.0	844.0	435.0	358.5	26.5	16.5		
INMAN_LF01	307.6	130.6	7.0	1.7	1.2	1.1	0.9	0.8	0.7
JBLM_LF01	2,541.3	1,926.0	426.8	35.2	15.6	11.4	8.4	5.9	3.0
VASHON_LF01	8,948.1	3,104.9	36.3	16.2	11.7	8.6	6.1	4.3	1.3
VASHON_LF02	396.6	154.5	5.1	2.5	1.6	1.6	1.2	1.1	0.8

Explanation

🟧	Fluorotelomer carboxylic acids		▧	Perfluoroalkane sulfonamides
🟨	Perfluoroalkyl carboxylic acids (PFCAs)		▤	Per- and polyfluoroalkylether carboxylic acids
🟩	Perfluoroalkyl sulfonic acids (PFSAs)		▦	Ether sulfonic acids
🟪	Perfluorooctane sulfonamidoacetic acids		▥	Perfluorooctanesulfonamide ethanols
🟦	Fluorotelomer sulfonic acids			

Total Oxidized Precursors (TOP) analyses

Twelve samples were analyzed for total oxidized precursors (TOP). As discussed in the analysis section, TOP analyses may give a better indication of the total PFAS in a sample. Figures 5 – 7 show the percent change of the sum of the analytes for the 12 samples detected after TOP analysis compared to pre-TOP analysis. Table 17 in the Additional Tables section lists the PFAS pre-TOP and post-TOP analyte values for the precursor, PFCA, and PFSA groups.

Seven of the precursors show the expected decreases, however, five analytes increased. For PFCAs, all of the analytes show an increase post-TOP as expected. All but two of the PFSAs have increased post-TOP. PFBS and PFOS have slight decreases. Interpretation of these post-TOP analyses has proven to be problematic, and the authors look forward to seeing other investigations and conclusions from this data set.

Figure 5. Post-TOP % change of analytes for Precursors.

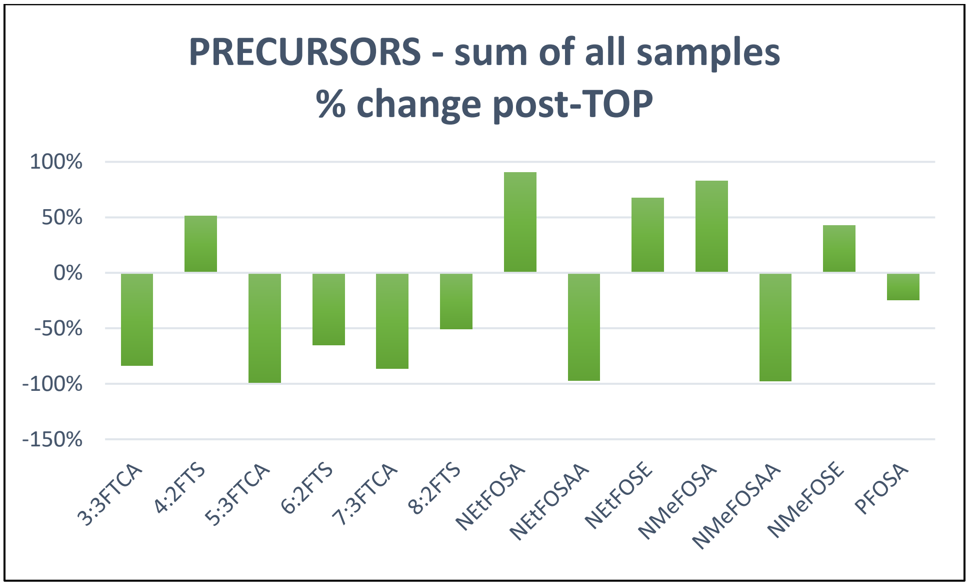


Figure 6. Post-TOP % change of analytes for PFCAs.

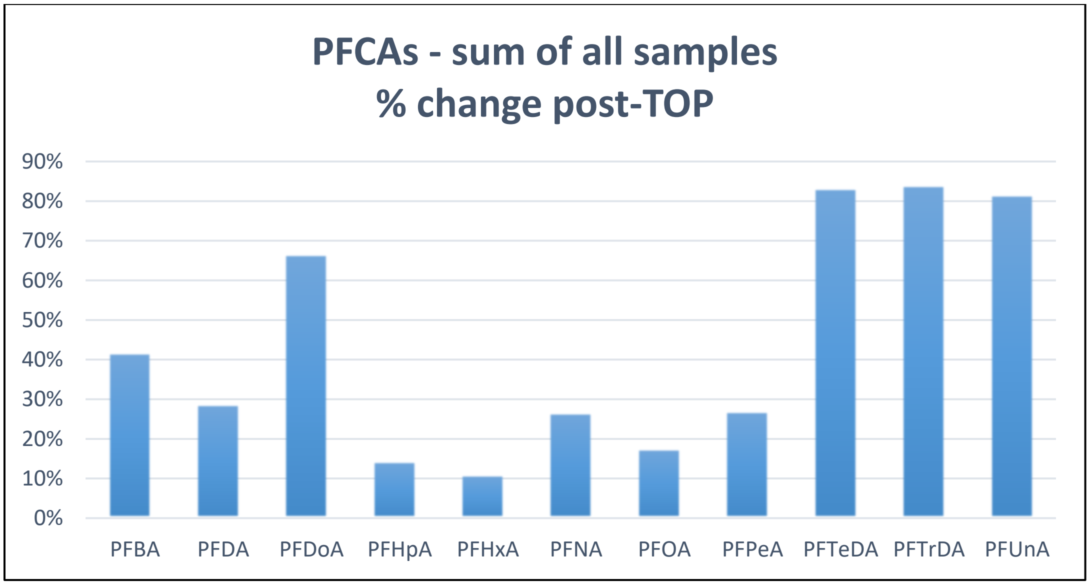
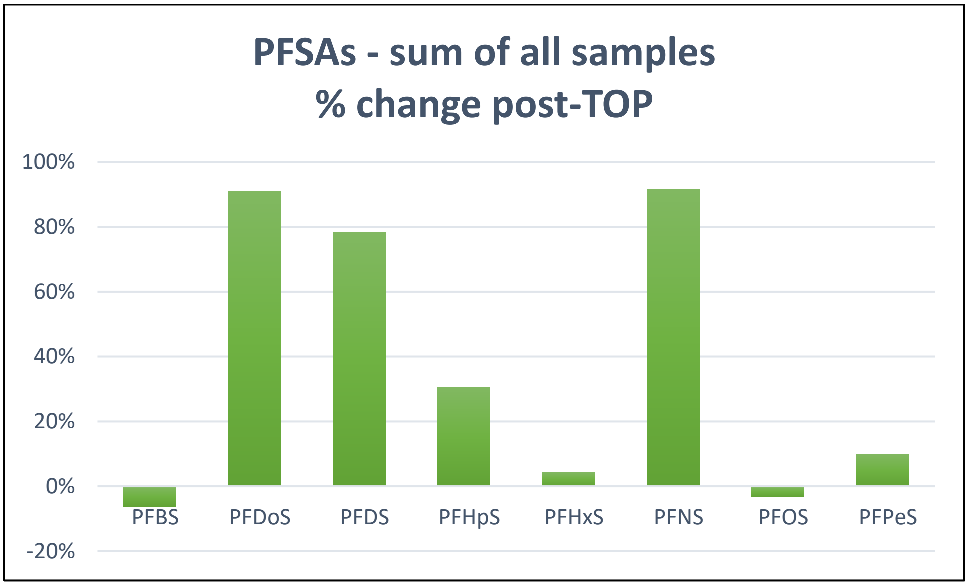


Figure 7. Post-TOP % of change of analytes for PFSAs.



The changes from pre-TOP to post-TOP are generally as expected for the sums of all samples in Figures 5, 6, and 7, but individual samples have wider variations. Figures 8, 9, and 10 show the changes in precursors, PFCAs, and PFSAs for the WARC_LF01 sample pair.

Figure 8. Post-TOP changes for WARC_LF01 precursors.

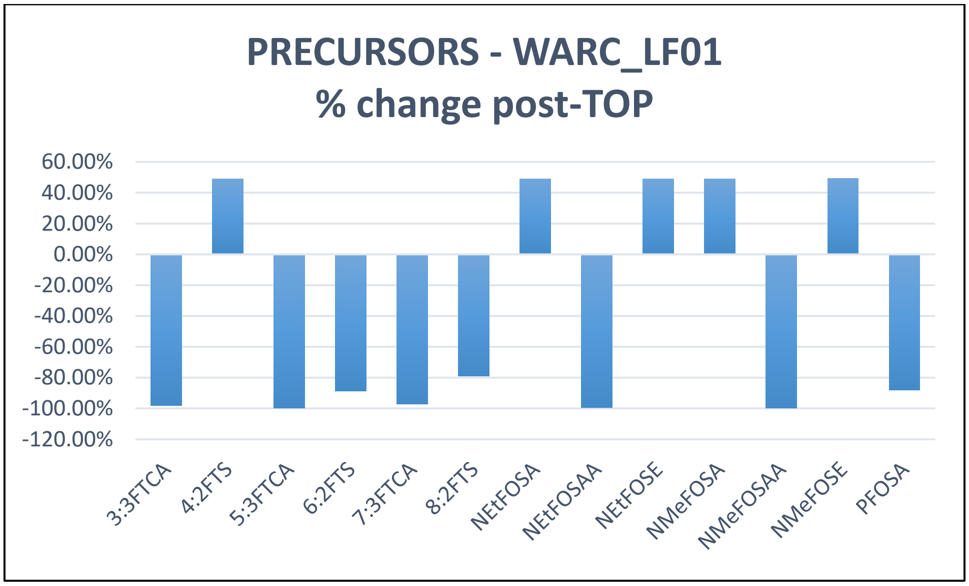


Figure 9. Post-TOP changes for WARC_LF_01 PFCAs.

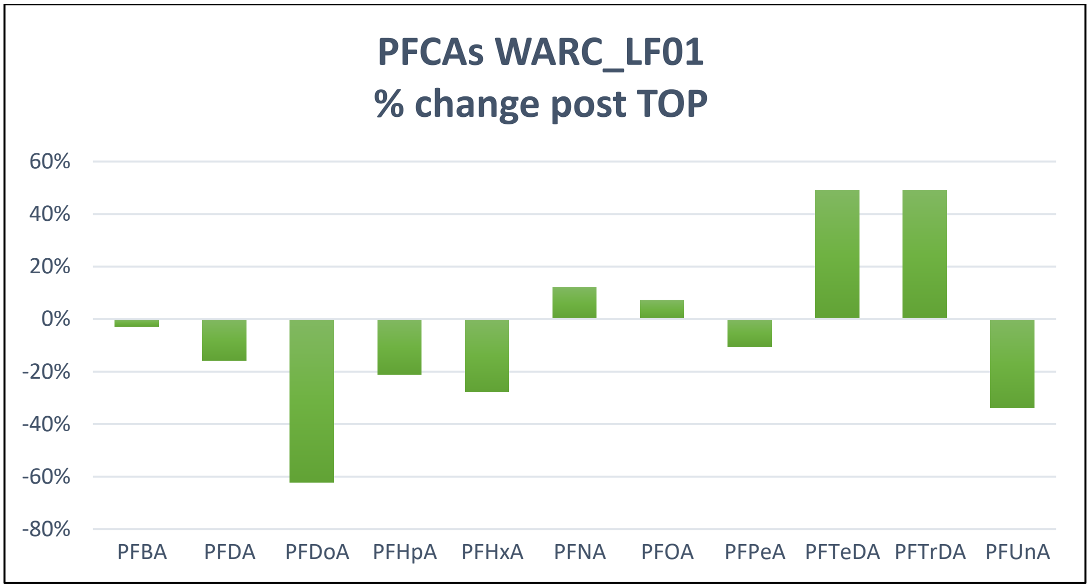
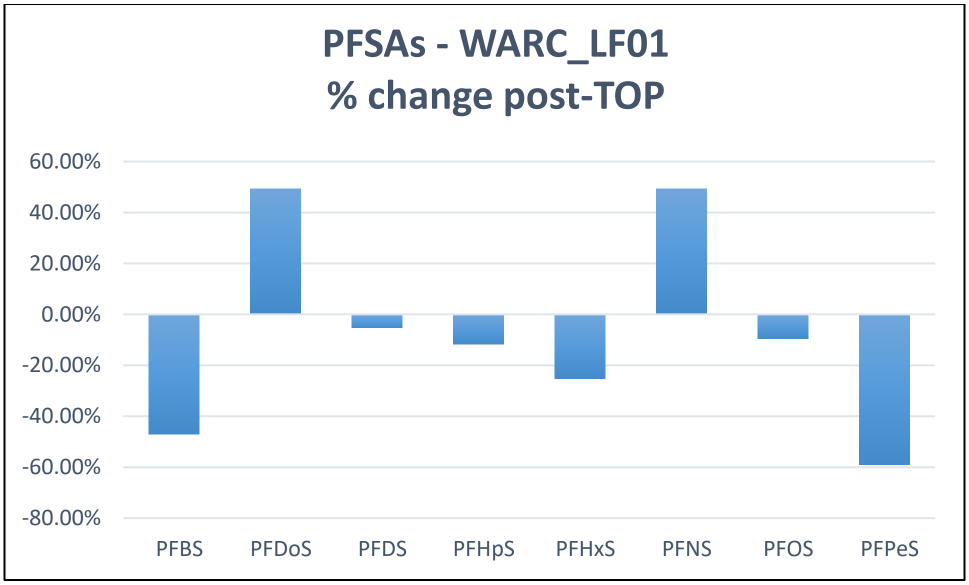


Figure 10. Post-TOP changes for WARC_LF01 PFSAs.



Discussion

Landfill cell comparisons

Multiple samples were collected from five landfills. These samples were collected from different spigots, lagoons, or manholes that were centralized leachate collection stations. As discussed earlier, the samplers were unable to obtain distinct samples from different cells within a landfill. Figures 13 through 17 show the percent of each sample that each group in Table 7 contributes. Amounts shown as zero indicate that the value is less than one.

Sample pairs from GRRDR, HEADQTRS, ROOSEVELT, and VASHON have similar chemistry. The three samples from CEDAR, however, have significant chemical differences.

CEDAR samples LF01 and LF02 were collected from spigots and have similar chemistry except for minor amounts of perfluorooctane sulfonamidoacetic acids in LF01 and fluorotelomer carboxylic acids in LF02. CEDAR_LF03 however, is mostly perfluorooctane sulfonamidoacetic acids followed in abundance by PFSAs and then PFCAs. CEDAR_LF03 was collected from a pump station that pumps into the lagoons.

Table 7. Explanation for Figures 11 through 15.

🟧	Fluorotelomer carboxylic acids		🟩	Perfluoroalkane sulfonamides
🟨	Perfluoroalkyl carboxylic acids (PFCAs)		🟧	Per- and polyfluoroalkylether carboxylic acids
🟩	Perfluoroalkyl sulfonic acids (PFSAs)		🟦	Ether sulfonic acids
🟪	Perfluorooctane sulfonamidoacetic acids		🟪	Perfluorooctanesulfonamide ethanols
🟦	Fluorotelomer sulfonic acids			

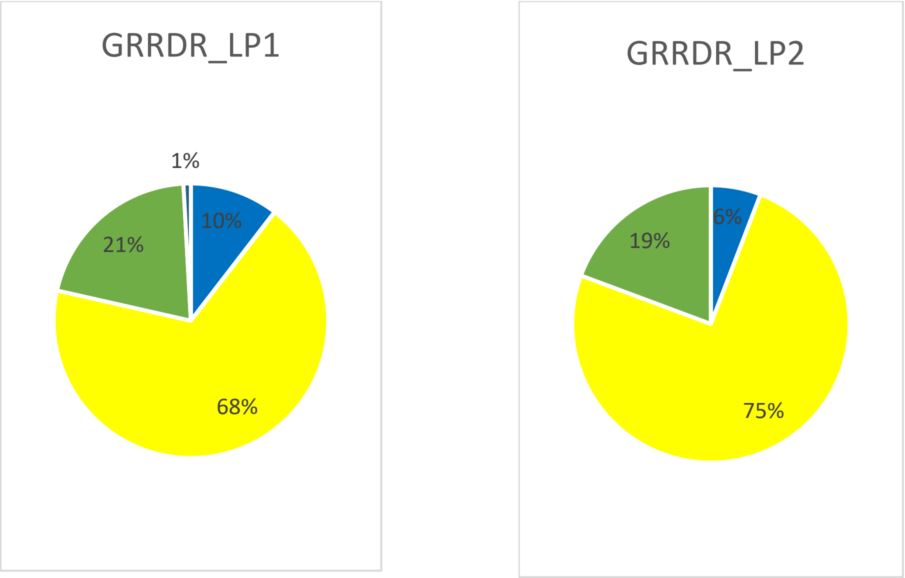


Figure 11. Chemistry of samples from GRDDR.

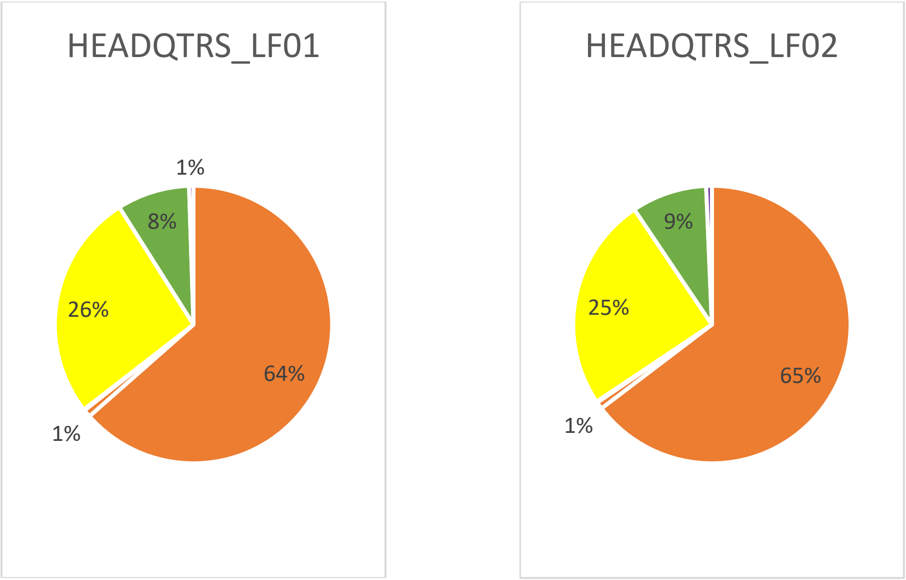


Figure 12. Chemistry of samples from HEADQTRS.

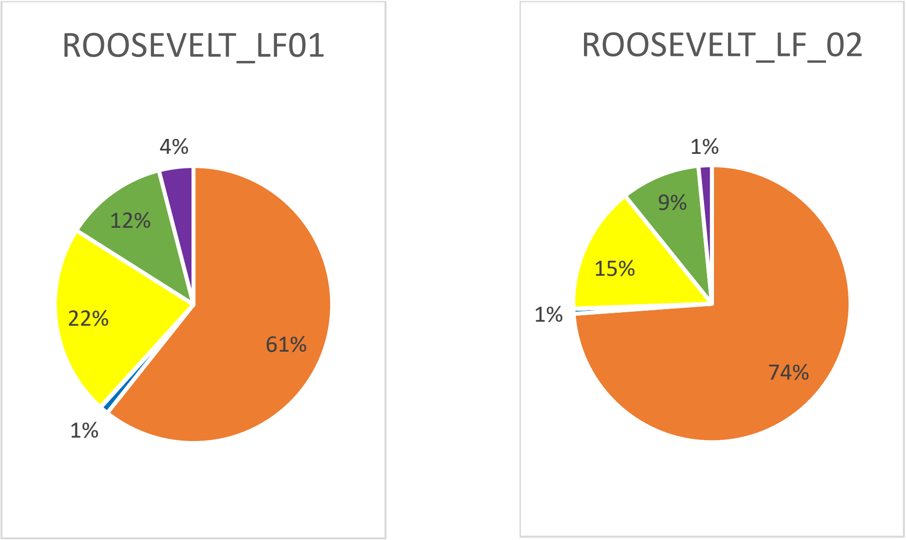


Figure 13. Chemistry of samples from ROOSEVELT.

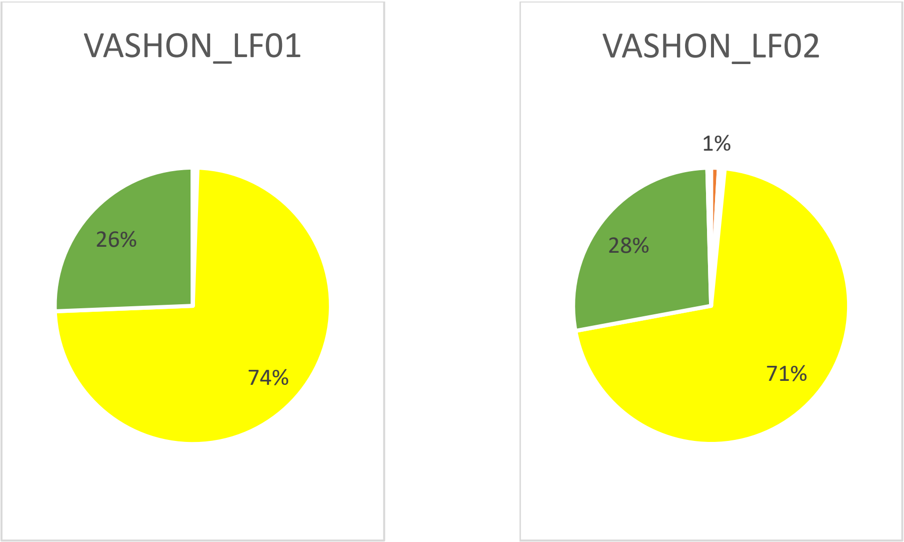


Figure 14. Chemistry of samples from VASHON.

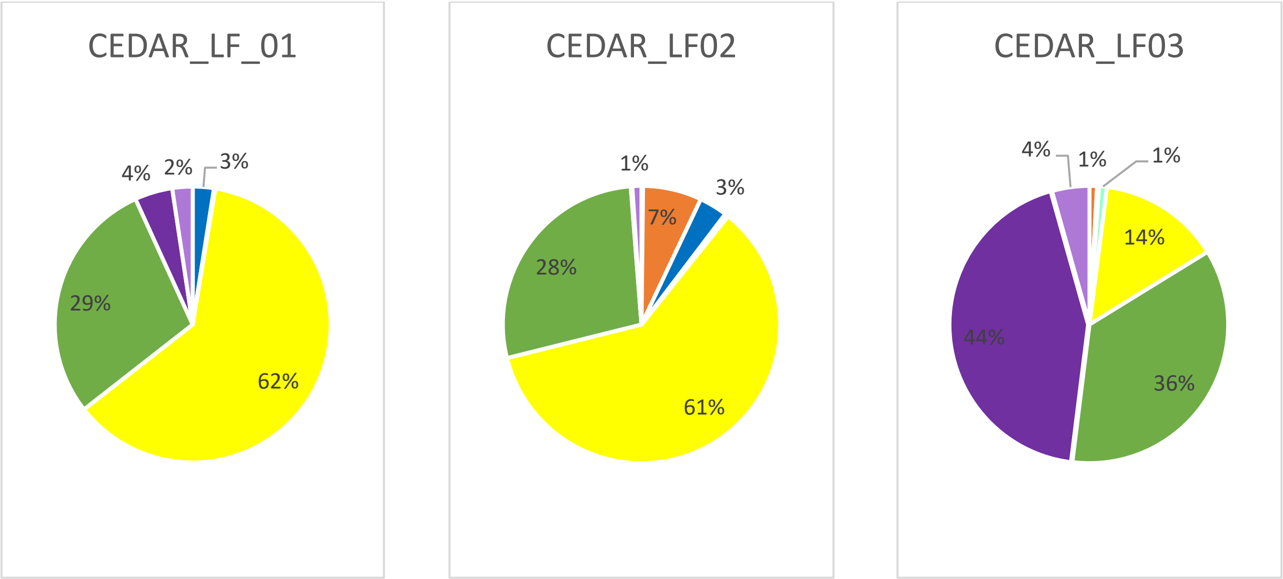


Figure 15. Chemistry of samples from CEDAR.

Other Parameters

Several factors, such as the amount of rainfall, age of waste material, conductivity, and pH have been shown to contribute to the amount of PFAS chemicals in landfill leachate (TURI, 2020). Conductance, pH, and temperature information was recorded during collection of some of the samples for this study (Table 18 in Additional Tables section).

The age of waste in the landfill was estimated as the midpoint year of when the first cell received waste to the time the last cell stopped receiving waste subtracted from the year the leachate PFAS samples were collected. These numbers are rough calculations based on estimated timeframes for receiving waste.

Correlations were calculated between the ∑PFAS and five parameters. Spearman correlations were used because they are non-parametric and less sensitive to outliers than other correlation methods. A summary is shown in the following table.

Table 8. Spearman correlation of ∑PFAS with five parameters.

Spearman Correlations with ∑PFAS (ND=DL/2)					
	Temperature	Conductivity	pH	Waste Age	Rainfall
Correlation coefficient	0.4571	0.6781	0.1250	-0.4683	0.1834
Sample Size	24	24	24	23	24
P-Value	0.0284	0.0011	0.5489	0.0280	0.3791

P-values below 0.05 indicate statistically significant non-zero correlations at the 95% confidence level. Parameters with significant correlations are temperature, conductivity, and waste age. Scatter plots of this data are included in figures 18-22 in the Additional Figures section.

Comparisons with Landfills in Other Places

Leachate samples from 19 landfills in Washington State (WA) were analyzed for PFAS. Analysis of samples from 16 of the landfills was for 40 PFAS chemicals, and samples from three landfills were analyzed for 32 analytes. ∑PFAS concentrations range from 173,029 ng/liter to 224.5 ng/liter. The mean is 32,220 ng/liter. It is difficult to compare these ∑PFAS concentrations with other landfills because previous publications usually focus on just two chemicals, PFOA and PFOS.

PFOA and PFOS values from WA are compared with values from other states and countries in the following table (MWRA, 2019) (Hart and Hickman, 2020) (Lang et al., 2017).

Table 9. PFOA and PFOS values in landfill leachate.

		PFOA			PFOS		
Location	Sample size	Detection %	Range	Median	Detection %	Range	Median
USA	5	100	380 - 1,000	490	100	56 -160	97
USA	6	100	150 - 5,000	1,055	100	25 - 590	155
USA	87	100	30 - 5,000	590	96	3-800	99
Canada	5	100	210 - 1,500	520	100	80 - 4,400	390
Nordic Countries	NA	NA	90-501	230	NA	30 - 190	80
Denmark	NA	NA	0 - 6	3	NA	0 - 4	NA
Sweden	NA	NA	40 - 1,000	540	NA	30 - 1,500	550
Germany	20	95	0 - 926	57	100	0 - 235	3
Spain	6	100	200 - 585	437	17	0 - 44	NA
Australia	17	100	19 - 2,100	450	89	0 - 100	31
Australia	97	64	17 - 7,500	600	65	13 - 2,700	220
China	6	100	281 - 214,000	2260	100	1,150 - 6,020	1740
WA	19	100	6 - 5,150	668	100	10 - 1,080	157
MI	NA	100	16 - 3,200	881	100	9 - 960	222
NC	NA	100	108 - 3,690	1005	100	82 - 402	199

A study in Australia evaluated PFAS samples from 27 landfills for nine analytes (Gallen et al., 2017). PFSAs have the highest values, followed by PFCAs. As shown in Table 10, fluorotelomer carboxylic acids have the highest values in the WA landfills.

Table 10. Comparison of Washington State and Australia maximum sum PFAS concentrations in landfill leachate.

	Maximum value (ng/liter)	
Analyte	***Washington***	***Australia***
5:3FTCA	94,100	
7:3FTCA	38,900	
PFBS	15,200	
PFHxA	10,400	25,000
PFBA	5,600	
PFOA	5,150	7,500
PFPeA	4400	
PFHpA	2250	4,400
MeFOSAA	1930	
PFHxS	1900	16,000
NEtFOSAA	1440	
3:3FTCA	1090	
PFOS	1080	2,700

In North America, Europe, China, and Australia PFCAs are generally the dominant PFAS in landfill leachate (Hamid et. al., 2018). In WA, fluorotelomer carboxylic acids are dominant, followed by PFAAs (PFCAs + PFSAs).

Conclusions and Recommendations

Although the dataset for this project represents only a portion of landfills in the state, there is enough data to draw some conclusions:

- Quality control and quality assurance procedures indicate that the samples collected for this project were reliably handled and analyzed with proper methods.
- There are relatively high PFAS concentrations in some samples. Dr. Bharat Chandramouli, a senior scientist with SGS AXYS Laboratory, noted that "these are some of the highest municipal landfill leachate PFAS values observed by the laboratory" (personal communication, 2021).
- Fluorotelomer carboxylic acids (FTCAs) are the dominant PFAS in leachate from the majority of the 19 sampled landfills. Perfluoroalkyl carboxylic acids (PFCAs) are the next most abundant, followed by perfluoroalkyl sulfonic acids (PFSAs). The most common analytes are, in decreasing order: 5:3 FTCA, 7:3 FTCA, PFHxA, and PFBA. PFOA, one of the few PFAS with a proposed drinking water standard, is the seventh most common. The sum of PFOA is less than 5% of the sum of the six most abundant PFAS.
- It is difficult to confirm what sources have contributed to PFAS in landfill leachate due to many factors, including complex reactions over time and environmental conditions that are unique to each landfill. FTCAs are commonly derived from carpets. Other sources, such as food packaging, are also known contributors to PFAS in landfills.
- The sum of PFAS in leachate samples have significant correlations with conductivity, temperature, and waste age. The correlations are positive for conductivity and temperature; as they increase the sum of the PFAS increases. The correlations are negative for waste age; as waste gets older the sum of PFAS decreases. No significant correlations were found for the sum of PFAS vs. pH or rainfall.
- At least five of the landfills sampled have undergone or are currently undergoing cleanup for groundwater contamination, indicating that an unknown amount of PFAS is likely impacting groundwater at some of the sampled facilities.

Recommendations include the following:

- Encourage statewide adoption of groundwater and cleanup standards for specific analytes and for PFAS totals.
- When cleanup standards for PFAS are established, conduct at least one round of PFAS sampling in monitoring wells at landfill cleanup sites.
- Consider one round of leachate sampling at all MSW landfills and any other landfills that may serve as a reservoir for PFAS-containing substances.
- Consider at least one round of PFAS sampling in monitoring wells at landfills that have high PFAS values in leachate and indications of potential impacts to groundwater. This can be done through Jurisdictional Health Departments through solid waste permits.

Additional Tables

Table 11. Acronyms and Abbreviations.

Abbreviations for sample locations are listed in Table 12.

Abbreviations for individual PFAS chemicals are listed in Table 13.

AFFF	aqueous film forming foam
AXYS	SGS AXYS analytical laboratory
CAP	Chemical Action Plan
CAS	Chemical Abstract Service
EAP	Environmental Assessment Program
Ecology	Department of Ecology (Washington State)
EPA	Environmental Protection Agency
Eurofins	Eurofins TestAmerica analytical laboratory
FTAs	fluorotelomer carboxylic acids
JHD	jurisdictional health department
MSW	municipal solid waste
ng/liter	nanograms per liter
PFAAs	perfluoroalkyl acids
PFAS	per- and polyfluoroalkyl substances
PFCAs	perfluorocaarboxylic acids
PFSAs	perfluorosulfonic acids
QA/QC	quality control/quality assurance
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
∑PFAS	sum of the PFAS
SWM	Solid Waste Management Program
TOP	Total Oxidizable Precursor analysis
WA	Washington State
WAC	Washington Administrative Code
WQ	Water Quality Program

Table 12. Landfill Facility site IDs and Clean-up Site IDs.

Landfill Name	***Abbreviation***	***Facility site ID***	***Clean-up site ID***
Airport Woodwaste Landfill	AIRPORT	2898	
Asotin County Regional Landfill	AOSTIN	572	1942
Cathcart Landfill	CATHCART	2694	
Cedar Hills Regional Landfill	CEDAR	2020	7027
Headquarters Landfill	HEADQTRS	46954465	
Hidden Valley Landfill	HIDDEN	1272	3649
Inman Landfill	INMAN	88413934	3153
Joint Base Lewis-McChord Landfill 5	JBLM		
LRI Landfill	LRI	4441	
Northside Landfill	NORTHSIDE	111	2500
Port Angeles Landfill	PT_ANGELES	6433299	
Roosevelt Regional Landfill	ROOSEVELT	12862377	11543
Sudbury Road Landfill	SUDBURY	4446540	2485
Tacoma Municipal Landfill	TCMLF	220	654
Tennant Way Landfill, Cowlitz County	TENNANT	1079	
Vashon Island Landfill	VASHON	2192	1146
Thurston County Waste & Recovery Center	WARC	65553894	
Graham Road Recycling & Disposal	GRRDF	46767518	
Greater Wenatchee Regional Landfill	GWRLRC	368	7343

Table 13. PFAS names, abbreviations, and CAS numbers.

Name	***Abbreviation***	***CAS #***
10:2 Fluorotelomer sulfonic acid	10:2FTS	120226-60-0
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate	11Cl-PF3OUdS	2196242-82-5
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9
Perfluoro-2-methyl-3-oxahexanoic acid	HFPO-DA	13252-13-6
3:3 perfluorohexanoate	3:3FTCA	1169706-83-5
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4
4:2 Fluorotelomer sulfonate	4:2FTS	414911-30-1
4:2 Fluorotelomer sulfonic acid	4:2FTS	757124-72-4
5:3 perfluoroctanoate	5:3FTCA	1799325-94-2
6:2 Fluorotelomer sulfonate	6:2FTS	425670-75-3
6:2 Fluorotelomer sulfonic acid	6:2FTS	27619-97-2
7:3 perfluorodecanoate	7:3FTCA	1799325-95-3
8:2 Fluorotelomer sulfonate	8:2FTS	481071-78-7
8:2 Fluorotelomer sulfonic acid	8:2FTS	39108-34-4
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	9Cl-PF3ONS	1621485-21-9
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1
Dodecafluoro-3H-4,8-dioxanonanoate	ADONA	2127366-90-7
N-Ethyl perfluorooctane sulfonamide	NEtFOSA	4151-50-2
N-Ethyl perfluorooctane sulfonamidoethanol	NEtFOSE	1691-99-2
N-Ethylperfluorooctanesulfonamidoacetate	NEtFOSAA	(blank)
N-Ethyl perfluorooctane sulfonamidoacetic acid	NEtFOSAA	2991-50-6
N-Methyl perfluorooctane sulfonamide	NMeFOSA	31506-32-8
N-Methyl perfluorooctane sulfonamidoethanol	NMeFOSE	24448-09-7
N-Methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9
Perfluoro(2-ethoxyethane)sulfonate	PFEESA	220689-13-4
Perfluoro-3,6-dioxaheptanoate	NFDHA	39187-41-2
Perfluoro-3-methoxypropanoate	PFMPA	(blank)
Perfluoro-4-methoxybutanoate	PFMBA	1432017-36-1
Perfluorobutane sulfonate	PFBS	45187-15-3
Perfluorobutane sulfonic acid	PFBS	375-73-5
Perfluorobutanoate	PFBA	45048-62-2
Perfluorobutyric acid	PFBA	375-22-4
Perfluorodecane sulfonate	PFDS	126105-34-8

Name	***Abbreviation***	***CAS #***
Perfluorodecanesulfonic acid	PFDS	335-77-3
Perfluorodecanoate	PFDA	73829-36-4
Perfluorodecanoic acid	PFDA	335-76-2
Perfluorododecane sulfonate	PFDoS	343629-43-6
Perfluorododecanesulfonic acid	PFDoS	79780-39-5
Perfluorododecanoate	PFDoA	171978-95-3
Perfluorododecanoic acid	PFDoA	307-55-1
Perfluoroheptane sulfonate	PFHpS	146689-46-5
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluoroheptanoate	PFHpA	120885-29-2
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorohexadecanoic acid	PFHxDA	67905-19-5
Perfluorohexane sulfonate	PFHxS	108427-53-8
Perfluorohexanesulfonic acid	PFHxS	355-46-4
Perfluorohexanoate	PFHxA	92612-52-7
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoro-n-octadecanoic acid	PFODA	16517-11-6
Perfluorononane sulfonate	PFNS	474511-07-4
Perfluorononane sulfonate acid	PFNS	98789-57-2
Perfluorononanoate	PFNA	72007-68-2
Perfluorononanoic acid	PFNA	375-95-1
Perfluorooctane sulfonamide	PFOSA	754-91-6
Perfluorooctane sulfonate	PFOS	45298-90-6
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorooctanoate	PFOA	45285-51-6
Perfluorooctanoic acid	PFOA	335-67-1
Perfluoropentane sulfonate	PFPeS	175905-36-9
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
Perfluoropentanoate	PFPeA	45167-47-3
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorotetradecanoate	PFTeDA	365971-87-5
Perfluorotetradecanoic acid	PFTeDA	376-06-7
Perfluorotridecanoate	PFTrDA	862374-87-6
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluoroundecanoate	PFUnA	196859-54-8
Perfluoroundecanoic acid	PFUnA	2058-94-8

Table 14. Laboratory methods and analytes.

SGS AXYS		**Eurofins**
Method 110	***Method 111***	***Method 537***
		10:2FTS
11Cl-PF3OUdS		11Cl-PF3OUdS
3:3FTCA	3:3FTCA	
4:2FTS	4:2FTS	4:2FTS
5:3FTCA	5:3FTCA	
6:2FTS	6:2FTS	6:2FTS
7:3FTCA	7:3FTCA	
8:2FTS	8:2FTS	8:2FTS
9Cl-PF3ONS		9Cl-PF3ONS
ADONA		ADONA
HFPO-DA		HFPO-DA
MeFOSAA		
NEtFOSA	NEtFOSA	NEtFOSA
NEtFOSAA	NEtFOSAA	NEtFOSAA
	NMeFOSAA	NMeFOSAA
NEtFOSE	NEtFOSE	
NFDHA		
NMeFOSA	NMeFOSA	
NMeFOSE	NMeFOSE	
PFBA	PFBA	PFBA
PFBS	PFBS	PFBS
PFDA	PFDA	PFDA
PFDoA	PFDoA	PFDoA
PFDoS	PFDoS	PFDoS
PFDS	PFDS	PFDS
PFEESA		
PFHpA	PFHpA	PFHpA
PFHpS	PFHpS	PFHpS
PFHxA	PFHxA	PFHxA
		PFHxDA
PFHxS	PFHxS	PFHxS
PFMBA		
PFMPA		
PFNA	PFNA	PFNA
PFNS	PFNS	PFNS
PFOA	PFOA	PFOA
		PFODA
PFOS	PFOS	PFOS
PFOSA	PFOSA	
PFPeA	PFPeA	PFPeA
PFPeS	PFPeS	PFPeS
PFTeDA	PFTeDA	PFTeDA
PFTrDA	PFTrDA	PFTrDA
PFUnA	PFUnA	PFUnA

Table 15. Field duplicate paired t-Test.

t-Test: Paired Two Sample for Means ***CEDAR***		
	LF_01	***LF_04***
Mean	87.9	98.6
Variance	53,201.5	57,358.2
Observations	39	39
Pearson Correlation	0.993941	
Hypothesized Mean Difference	0	
df	38	
t Stat	-2.44266061	
P(T<=t) one-tail	0.00966995	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.019339899	
t Critical two-tail	2.024394164	

t-Test: Paired Two Sample for Means ***ROOSEVELT***		
	LF_01	***LF_03***
Mean	1,789	1,803
Variance	37,431,309	37,313,380
Observations	39	39
Pearson Correlation	0.999918	
Hypothesized Mean Difference	0	
df	38	
t Stat	-1.1125750	
P(T<=t) one-tail	0.136440001	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.272880002	
t Critical two-tail	2.024394164	

t-Test: Paired Two Sample for Means ***VASHON***		
	LF_02	***LF_04B***
Mean	14.5	14.5
Variance	1,442.4	1,393.3
Observations	39	39
Pearson Correlation	0.999514	
Hypothesized Mean Difference	0	
df	38	
t Stat	0.179486485	
P(T<=t) one-tail	0.429254694	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.858509388	
t Critical two-tail	2.024394164	

Table 16. TOP pairs - analyte values (in ng/liter). Sum of Groups shown in bold.

Groups/Analytes	ASOTIN_LF01	ASOTIN_LF01_TOP	CEDAR_LF02	CEDAR_LF02_TOP
PFCAs	**7628.62**	**10194.32**	**2674.16**	**2464.675**
PFBA	1400	3010	1210	650
PFDA	5.16	8.26	4.27	3.78
PFDoA	0.715	1.515	1.095	1.445
PFHpA	582	599	186	199
PFHxA	2510	2790	781	875
PFNA	16.6	20	38	25.4
PFOA	622	661	142	189
PFPeA	2490	3100	308	516
PFTeDA	0.715	1.515	1.325	1.355
PFTrDA	0.715	1.515	1.72	1.58
PFUnA	0.715	1.515	0.75	2.115
PFSAs	**583.035**	**535.96**	**345.38**	**321.055**
PFBS	220	203	182	147
PFDoS	0.715	1.515	0.68	3.465
PFDS	0.715	1.515	0.68	5.05
PFHpS	2.19	1.515	0.68	9.45
PFHxS	260	261	118	114
PFNS	0.715	1.515	0.68	9.44
PFOS	65.8	37.7	33.7	23.8
PFPeS	32.9	28.2	8.96	8.85
Precursors	**14561.915**	**366.13**	**393.89**	**593.86**
3:3FTCA	712	6.05	28.2	174
4:2FTS	9.86	6.05	4.26	5.4
5:3FTCA	13300	203	190	99.5
6:2FTS	95.7	70.5	106	56.7
7:3FTCA	366	37.9	17	216.5
8:2FTS	8.03	6.05	2.725	5.4
NEtFOSA	1.79	3.79	1.7	3.39
NEtFOSAA	41.4	1.515	2.04	5
NEtFOSE	5.35	11.35	5.1	10.15
NMeFOSA	0.825	1.745	0.785	1.56
NMeFOSAA	8.36	1.515	4.1	1.355
NMeFOSE	7.15	15.15	31.3	13.55
PFOSA	5.45	1.515	0.68	1.355

Groups/Analytes	HEADQTRS_LF01	HEADQTRS_LF01_TOP	JBLM_LF01	JBLM_LF01_TOP
PFCAs	**6624.76**	**11287.3**	**4121.77**	**4552.005**
PFBA	1400	4300	554	659
PFDA	31.6	64.8	13.7	17.8
PFDoA	6.46	16.6	2.25	3.01
PFHpA	354	518	362	377
PFHxA	3020	3420	1630	1790
PFNA	63	115	70	84.4
PFOA	715	859	748	809
PFPeA	1030	1920	733	803
PFTeDA	0.655	16.6	3.62	1.29
PFTrDA	0.655	16.6	1.76	1.285
PFUnA	3.39	40.7	3.44	6.22
PFSAs	**7601.885**	**7858.3**	**345.54**	**396.4**
PFBS	7210	7440	63.2	60.3
PFDoS	0.655	16.6	0.65	1.285
PFDS	0.655	16.6	1.67	2.96
PFHpS	3.92	16.6	4.77	4.57
PFHxS	211	163	125	128
PFNS	0.655	16.6	0.65	1.285
PFOS	157	138	117	167
PFPeS	18	50.9	32.6	31
Precursors	**26444.005**	**1488.8**	**492**	**132.49**
3:3FTCA	75.7	66.5	2.61	5.15
4:2FTS	5.29	66.5	61.8	5.15
5:3FTCA	25000	414.5	16.3	32.1
6:2FTS	336	60	301	10
7:3FTCA	760	414.5	16.3	32.1
8:2FTS	14.8	66.5	64	17
NEtFOSA	1.645	41.45	1.63	3.21
NEtFOSAA	63.8	16.6	13.6	1.285
NEtFOSE	4.915	124	4.88	9.6
NMeFOSA	0.755	19.05	0.75	1.475
NMeFOSAA	144	16.6	1.98	1.285
NMeFOSE	25	166	6.5	12.85
PFOSA	12.1	16.6	0.65	1.285

Groups/Analytes	LRI_LF01	LRI_LF01_TOP	NORTHSIDE_LF01	NORTHSIDE_LF01_TOP
PFCAs	**13391.72**	**21873.4**	**2491.14**	**2823.53**
PFBA	5600	10600	529	728
PFDA	93.5	159	3.68	5.61
PFDoA	11	48.8	0.715	1.48
PFHpA	605	1050	248	250
PFHxA	4310	4820	709	725
PFNA	84	211	12.6	12
PFOA	1380	2000	284	310
PFPeA	1290	2880	702	787
PFTeDA	2.93	16.65	0.715	1.48
PFTrDA	3.79	16.65	0.715	1.48
PFUnA	11.5	71.3	0.715	1.48
PFSAs	**15678.8**	**14068.35**	**352.725**	**363.42**
PFBS	15200	13500	77.8	76
PFDoS	0.72	16.65	0.715	1.48
PFDS	4.16	16.65	0.715	1.48
PFHpS	3.6	16.65	1.68	1.48
PFHxS	304	316	210	220
PFNS	0.72	16.65	0.715	1.48
PFOS	144	169	41.7	41.8
PFPeS	21.6	16.75	19.4	19.7
Precursors	**50595.02**	**1731.25**	**2110.415**	**179.885**
3:3FTCA	116	66.5	122	5.9
4:2FTS	20.7	66.5	2.87	5.9
5:3FTCA	44000	416.5	1890	36.95
6:2FTS	451	297	54.7	52.6
7:3FTCA	4930	416.5	17.95	36.95
8:2FTS	60.7	66.5	2.87	5.9
NEtFOSA	1.8	41.65	1.795	3.695
NEtFOSAA	163	16.65	0.715	1.48
NEtFOSE	74.3	124.5	5.35	11.05
NMeFOSA	4.02	19.15	0.825	1.7
NMeFOSAA	447	16.65	2.5	1.48
NMeFOSE	312	166.5	7.15	14.8
PFOSA	14.5	16.65	1.69	1.48

Groups/Analytes	PT_ANGES_LF01	PT_ANGES_LF01_TOP	RSEVLT_LF01	RSVELT_LF01_TOP
PFCAs	**8323.606**	**11385.55**	**17147.01**	**25724.2**
PFBA	1750	3270	5130	9360
PFDA	26.2	33.8	86.7	107
PFDoA	0.371	1.415	8.89	16.55
PFHpA	741	883	1490	1840
PFHxA	2470	2830	5100	6560
PFNA	55	63	135	161
PFOA	1550	1940	2890	3710
PFPeA	1730	2360	2300	3920
PFTeDA	0.0935	1.415	0.8	16.55
PFTrDA	0.0935	1.505	0.8	16.55
PFUnA	0.848	1.415	4.82	16.55
PFSAs	**1036.317**	**1318.845**	**6708.73**	**6835.2**
PFBS	283	301	3540	3550
PFDoS	0.0935	1.415	0.8	16.55
PFDS	1.53	1.415	5.03	16.55
PFHpS	8	10.9	30.1	16.55
PFHxS	438	626	1900	2020
PFNS	0.0935	1.415	0.8	16.55
PFOS	252	296	1030	965
PFPeS	53.6	80.7	202	234
Precursors	**26260.212**	**268.155**	**45904.565**	**1484.05**
3:3FTCA	231	5.65	655	66
4:2FTS	10.1	5.65	24.1	66
5:3FTCA	21700	72.7	38000	413.5
6:2FTS	207	81.2	453	59.5
7:3FTCA	3480	35.35	3630	413.5
8:2FTS	126	33.5	215	66
NEtFOSA	0.867	3.535	1.995	41.35
NEtFOSAA	265	1.415	1360	16.55
NEtFOSE	0.7	10.55	71.9	124
NMeFOSA	2.54	1.625	2.37	19.05
NMeFOSAA	229	1.415	1440	16.55
NMeFOSE	0.935	14.15	31.4	165.5
PFOSA	7.07	1.415	19.8	16.55

Groups/Analytes	TCMLF_LF01	TCMLF_LF01_TOP	VASHON_LF01	VASHON_LF01_TOP
PFCAs	**4579.92**	**6972.2**	**11143.91**	**11350.54**
PFBA	1300	2790	2700	2870
PFDA	12.1	16.7	5.83	7.42
PFDoA	1.54	16.7	0.67	1.405
PFHpA	421	512	1020	1000
PFHxA	1310	1530	2570	2680
PFNA	35.3	16.7	17.4	21.5
PFOA	883	1020	898	926
PFPeA	615	1020	3930	3840
PFTeDA	0.66	16.7	0.67	1.405
PFTrDA	0.66	16.7	0.67	1.405
PFUnA	0.66	16.7	0.67	1.405
PFSAs	**634.5**	**611.2**	**909.02**	**884.055**
PFBS	113	94.6	380	353
PFDoS	0.66	16.7	0.67	1.405
PFDS	0.66	16.7	0.67	1.405
PFHpS	5.22	16.7	8.01	6.84
PFHxS	287	285	251	241
PFNS	0.66	16.7	0.67	1.405
PFOS	202	148	127	128
PFPeS	25.3	16.8	141	151
Precursors	**16262.92**	**1500.6**	**69.785**	**126.2**
3:3FTCA	713	67	2.685	5.65
4:2FTS	6.3	67	2.685	5.65
5:3FTCA	13900	418	16.8	35.15
6:2FTS	90.1	60.5	10.8	5.05
7:3FTCA	923	418	16.8	35.15
8:2FTS	93.3	67	2.685	5.65
NEtFOSA	1.645	41.8	1.68	3.515
NEtFOSAA	350	16.7	0.67	1.405
NEtFOSE	4.92	125	5	10.5
NMeFOSA	0.755	19.2	0.77	1.62
NMeFOSAA	161	16.7	0.67	1.405
NMeFOSE	6.6	167	6.7	14.05
PFOSA	12.3	16.7	1.84	1.405

Groups/Analytes	VASHON_LF02	VASHON_LF02_TOP	WARC_LF01	WARC_LF01_TOP
PFCAs	**495.0745**	**520.82**	**5367.77**	**4828.58**
PFBA	127	135	1400	1360
PFDA	2.15	3.74	49	41.3
PFDoA	0.0935	1.215	3.36	1.27
PFHpA	38.3	40.2	524	414
PFHxA	115	115	1440	1040
PFNA	2.53	4.42	57.2	65.2
PFOA	36.5	41.6	1150	1240
PFPeA	173	176	741	663
PFTeDA	0.0935	1.215	0.645	1.27
PFTrDA	0.0935	1.215	0.645	1.27
PFUnA	0.314	1.215	1.92	1.27
PFSAs	**56.0435**	**58.1**	**999.72**	**706.28**
PFBS	18.7	18.7	381	202
PFDoS	0.0935	1.215	0.645	1.27
PFDS	0.0935	1.215	1.34	1.27
PFHpS	0.353	1.215	6.99	6.17
PFHxS	11.9	10	280	209
PFNS	0.0935	1.215	0.645	1.27
PFOS	18.4	21.3	304	275
PFPeS	6.41	3.24	25.1	10.3
Precursors	**11.821**	**115.09**	**15509.135**	**160.27**
3:3FTCA	0.3745	4.855	268	5.05
4:2FTS	0.3745	4.855	2.585	5.05
5:3FTCA	2.34	30.35	12500	31.7
6:2FTS	0.3375	10.5	108	12.3
7:3FTCA	2.34	30.35	1130	31.7
8:2FTS	0.3745	4.855	187	39.6
NEtFOSA	0.234	3.035	1.615	3.17
NEtFOSAA	2.37	1.215	773	3.47
NEtFOSE	0.7	9.1	4.84	9.5
NMeFOSA	0.1075	1.395	0.745	1.46
NMeFOSAA	0.0935	1.215	499	1.27
NMeFOSE	0.935	12.15	6.45	12.7
PFOSA	1.24	1.215	27.9	3.3

Table 17. Spearman correlations (all calculations).

Spearman Rank Correlations						
	∑PFAS (ND=DL/2)	Temperature	Conductivity	pH	Waste Age	Rainfall
∑PFAS (ND=DL/2)		0.4571	0.6781	0.125	-0.4683	0.1834
		24	24	24	23	24
		0.0284	0.0011	0.5489	0.028	0.3791
Temp	0.4571		0.5412	-0.4382	-0.044	0.2007
	24		24	24	23	24
	0.0284		0.0094	0.0356	0.8364	0.3358
Conductivity	0.6781	0.5412		-0.1012	-0.0335	0.3254
	24	24		24	23	24
	0.0011	0.0094		0.6274	0.8751	0.1187
pH	0.125	-0.4382	-0.1012		-0.2982	-0.3951
	24	24	24		23	24
	0.5489	0.0356	0.6274		0.162	0.0581
Waste Age	-0.4683	-0.044	-0.0335	-0.2982		0.159
	23	23	23	-3		23
	0.028	0.8364	0.8751	0.162		0.4559
Rainfall	0.1834	0.2007	0.3254	-0.3951	0.159	
	24	24	24	24	23	
	0.3791	0.3358	0.1187	0.0581	0.4559	

Explanation

Correlation
Sample Size
P-Value

Table 18. PFAS and physical parameters.

Sample	∑PFAS (ng/L)	Temp (°C)	Conductivity (µS/cm)	pH	Approx. Median Age (years)	Rain (in.)
AIRPORT_LF01	142.8	15.1	1,812	6.93		36
ASOTIN_LF01	22,791.6	17.9	7,539	6.8	10.25	38
CATHCART_LF01	357.0	19.6	304	6.62	22.5	36
CEDAR_LF01	173,015.2	22.9	30,800	8.13	17.5	57
CEDAR_LF02	3,430.5	22.9	26,118	5.67	17.5	57
CEDAR_LF03	1,070.4	22.9	196	5.88	17.5	57
GRRDF_LP-1	6,321.7	2.65	5,452	8.25	15	17
GRRDF_LP-2	4,114.5	2.65	5,452	8.25	15	17
HEADQUARTERS_LF01	40,715.8	17.6	13,740	9.15	13.5	48
HEADQUARTERS_LF02	32,962.9	17.6	8,726	7.7	13.5	48
HIDDEN_LF01	32,162.7	14.5	13,387	7.26	16.5	40
INMAN_LF01	451.5	14.3	1,199	7.95	17	33
JBLM_LF01	4,973.5	17.2	8,474	5.65	15.25	39
LRI_LF01	79,708.6	24	18,151	7.49	6.1	39
NORTHSIDE_LF01	4,969.9	15.1	5,034	7.3	14	17
PT_ANGELES_LF01	35,626.4	18	6,303	7.4	15	26
ROOSEVELT_LF01	69,784.5	29.4	37,226	7.16	15	17
ROOSEVELT_LF02	144,049.1	29.4	28,229	7.29	15	17
SUDBURY_LF01	9,728.4	24.8	3,188	6.86	7	21
TCMLF_LF01	1,493.4	18.7	10,868	7.52	16.5	39
TENNANT_LF01	61,267.0	18.4	11,638	7	13	59
VASHON_LF01	12,137.4	17.5	3,884	6.93	16	37
VASHON_LF02	565.0	17.5	319	7.51	16	37
WARC_LF01	21,894.2	18.7	5,324	7.02	15	66

Table 19. PFAS Sampling Field Notes

SAMPLE LOCATION	**SAMPLE DATE**	**LEACHATE TEMP**	**BAROMETER**	**CONDUCTIVITY** (µS/cm)	**pH**	**NOTES**
Airport Landfill_LF01	10/13/2020	15.1°C	750.8	1812	6.93	Stormwater and infiltration through wastewater.
Asotin Landfill_LF01	10/20/2020	17.9°C	732.1	7539	6.80	60°F, partly sunny

SAMPLE LOCATION	**SAMPLE DATE**	**LEACHATE TEMP**	**BAROMETER**	**CONDUCTIVITY** (µS/cm)	**pH**	**NOTES**
Cathcart Landfill_LF01 -Pump station	10/12/2020	19.6°C	759.5	304.4	6.62	50°F, overcast Sample taken at Pump Station 4.
Cedar Landfill_LF01 At 567 & 8-1 -Spigot	10/09/2020	34.5°C	743.9	30800	8.13	Sample collected from spigot.
Cedar Landfill_LF02 At 567 & 8-1 -Spigot	10/09/2020	18.8°C	743.7	26118	5.76	Sample collected from spigot.
Cedar Landfill_LF03 -Pump station	10/09/2020	15.3°C	744.3	196	5.88	Sample collected from disposable bailer. Pump Station 2.
Headquarters Landfill_LF01 -Lagoon	10/06/2020	17.6°C	740.3	13740	9.15	52°F, light fog Leachate lagoon was being aerated, took field blank to see if PFAS is aerosoled.
Headquarters Landfill_LF02 -Pump house	10/06/2020	17.6°C	741.1	8726	7.7	52°F, light fog HQ probe YS1 did not record
Hidden Valley Landfill_LF01 -Spigot	10/15/2020	14.5°C	763.9	13387	7.26	53°F, sunny Sample collected from inside of building at spigot.
Inman Landfill_LF01 -Lagoon	10/13/2020	14.3°C	752.8	1199	7.95	50°F, overcast, rainy Sample bottles dipped into lagoon.

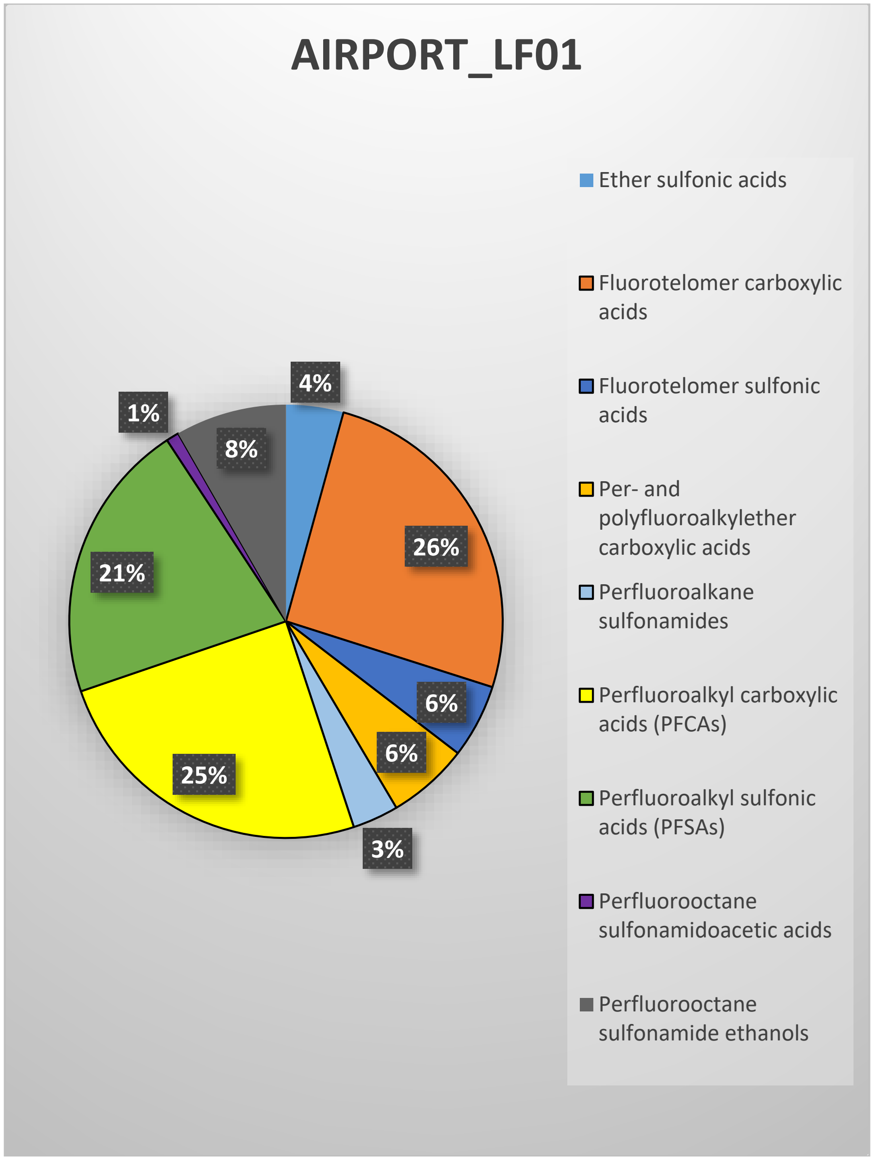
SAMPLE LOCATION	SAMPLE DATE	LEACHATE TEMP	BAROMETER	CONDUCTIVITY (µS/cm)	pH	NOTES
JBLM Landfill_LF01 -Sump	10/08/2020	17.2°C	753.8	8474	5.65	First leachate sump dry, second leachate sump draws from Cell 5. JBLM is sampling groundwater for PFAS. PFAS has been found at McChord and Ft. Lewis. See if solo point has reported PFAS.
LR1_LF01 -Tank	10/15/2020	24.0°C	758.3	18151	7.49	43°F, sunny, clear. Sample taken from truck. Driver added 500 ml of ‘anti-foam’. Sample collected by dipping sample bottles into leachate tank opening on top of truck. ORP= -38.7 MV
Northside Landfill_LF01 -Manhole	10/21/2020	15.1°C	709.7	5034	7.3	39°F, overcast Sample taken at sewer manhole.
Port Angeles Landfill_LF01 -Sump	11/01/2020	18°C	753.9	6303	7.4	47°F, overcast, drizzle Sample taken from sump using facility pump.

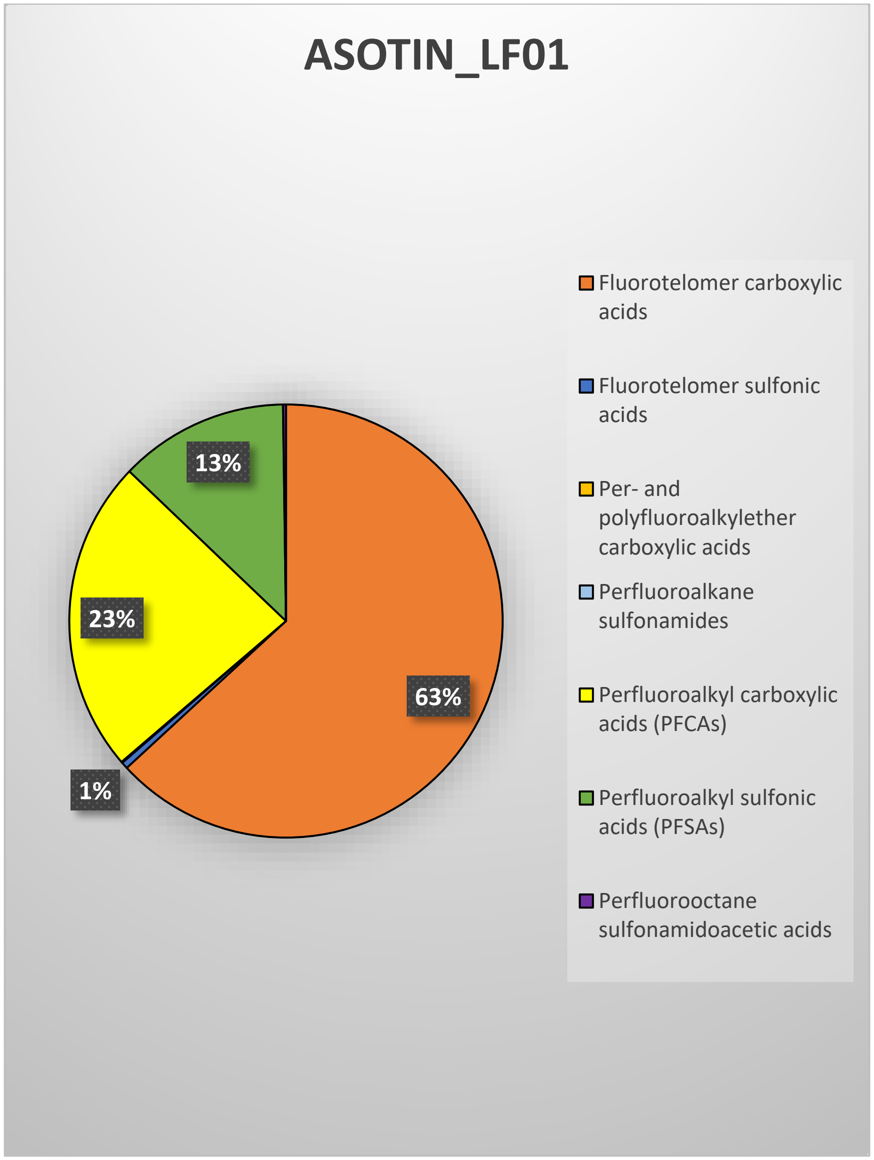
SAMPLE LOCATION	**SAMPLE DATE**	**LEACHATE TEMP**	**BAROMETER**	**CONDUCTIVITY** (µS/cm)	**pH**	**NOTES**
Roosevelt Regional Landfill_LF01 -Leachate pipe	10/29/2020	30.9°C	725.5	37226	7.16	Outlet Pipe 1, 11 gpm
Roosevelt Regional Landfill_LF02 -Leachate pipe	10/29/2020	27.8°C	725.8	28299	7.29	Outlet Pipe 2, 6.6 gpm
Sudbury Landfill_LF01 -Leachate pipe	10/22/2020	24.8°C	749.6	3188	6.86	Sample taken at leachate pipe.
Tacoma City Municipal Landfill_LF01	10/08/2020	18.7°C	752.1	10868	7.52	60°F, slightly overcast. Dip sample using stainless steel cup, then poured in bottles.
Tennant Way Landfill_LF01	10/06/2020	18.4°C	763.0	11638	7.0	65°F, Sunny
Vashon Island Landfill_LF01	10/07/2020	18°C	750.3	3884	6.93	Sample taken using peristaltic pump & silicon tubing. Landfill has waste from K2 ski manufacturing. Ski waxes contain PFAS.
Vashon Island Landfill_LF02	10/07/2020	16.9°C	750.2	318.5	7.51	Collected blind duplicate at Vashon Island Landfill_LF04B
WARC Landfill_LF01 -Tank	10/07/2020	18.7°C	753.9	5324	7.02	Sample was drawn from

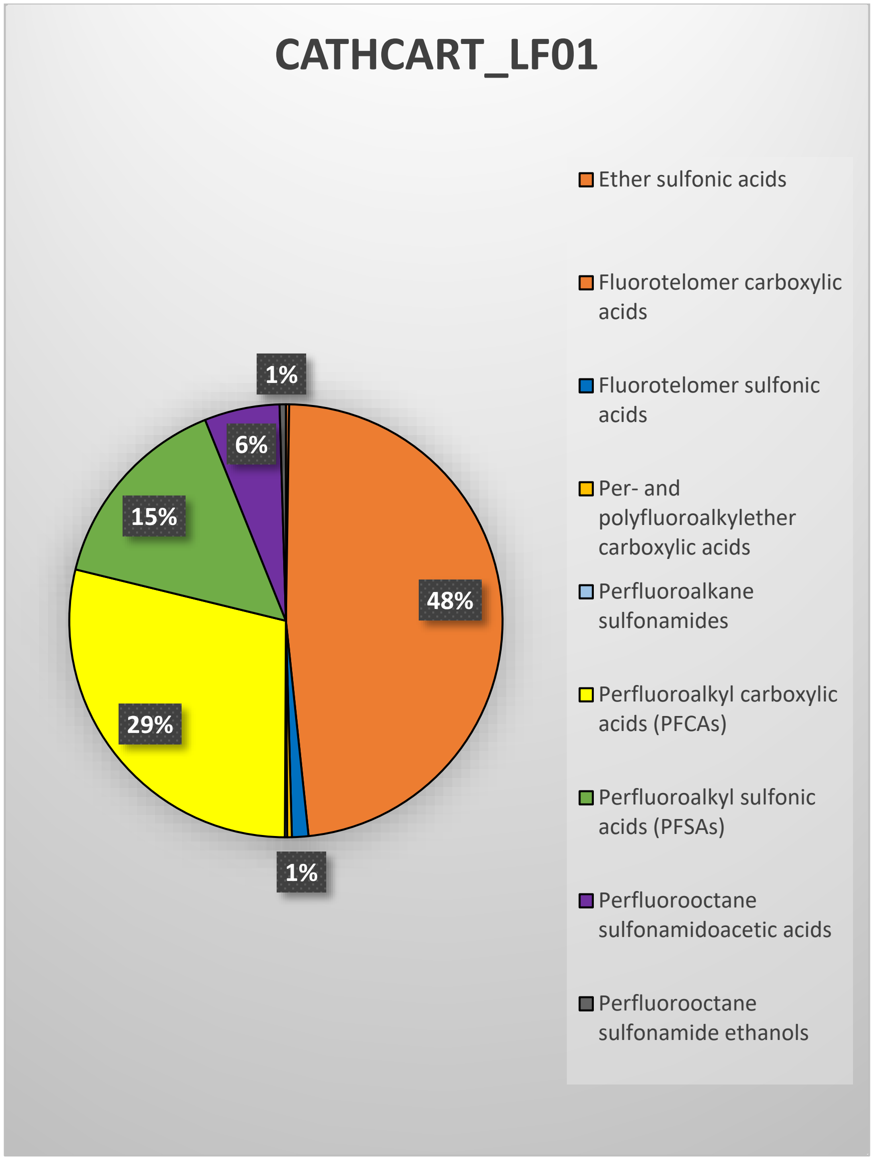
SAMPLE LOCATION	**SAMPLE DATE**	**LEACHATE TEMP**	**BAROMETER**	**CONDUCTIVITY** (µS/cm)	**pH**	**NOTES**
						200 gallon poly tank.

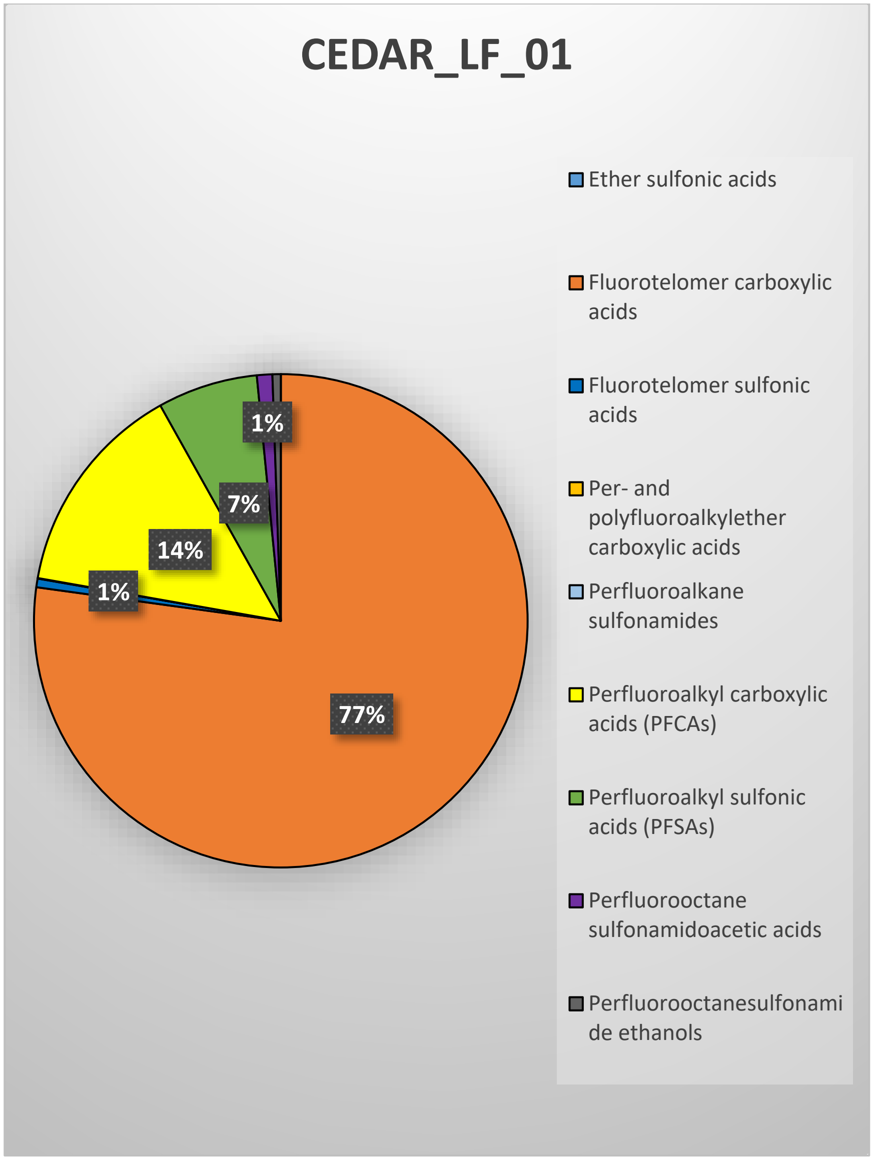
Additional Figures

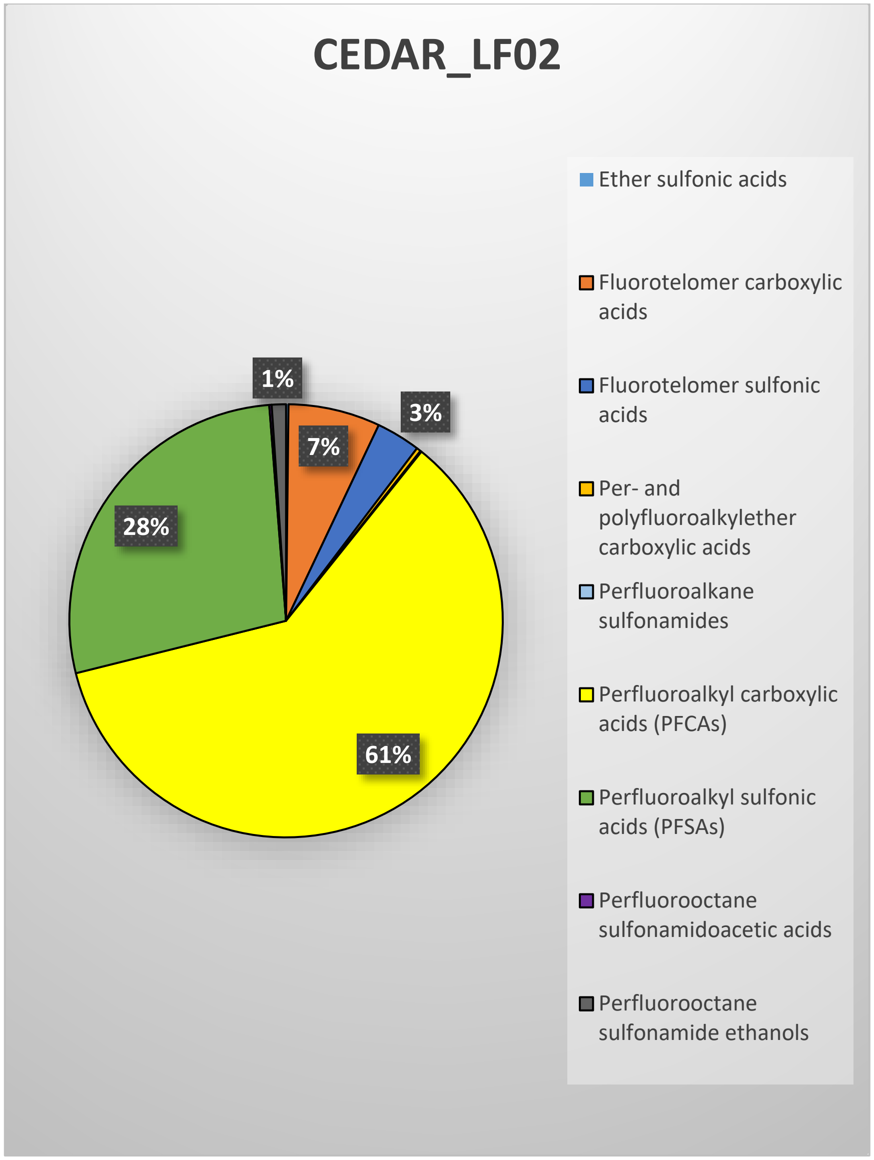
Figure 16.Percent of PFAS groups per sample.

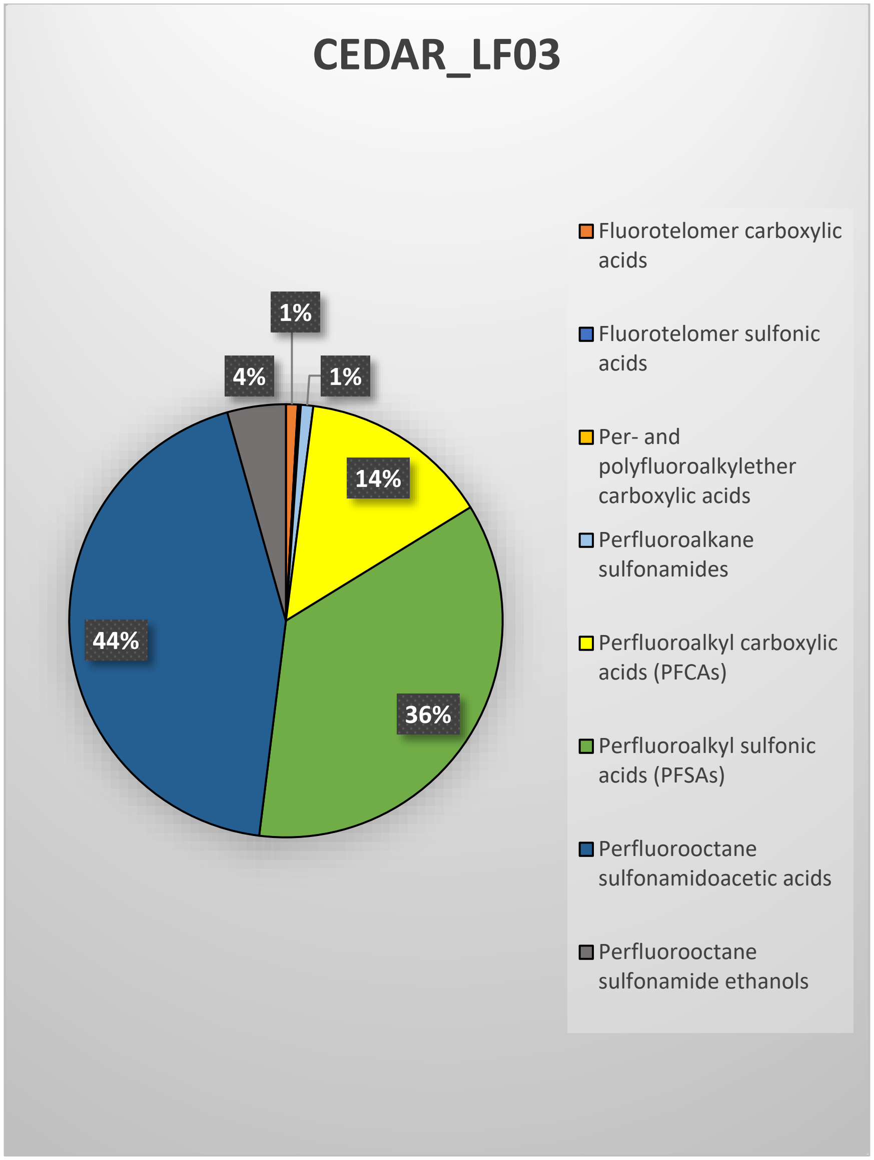


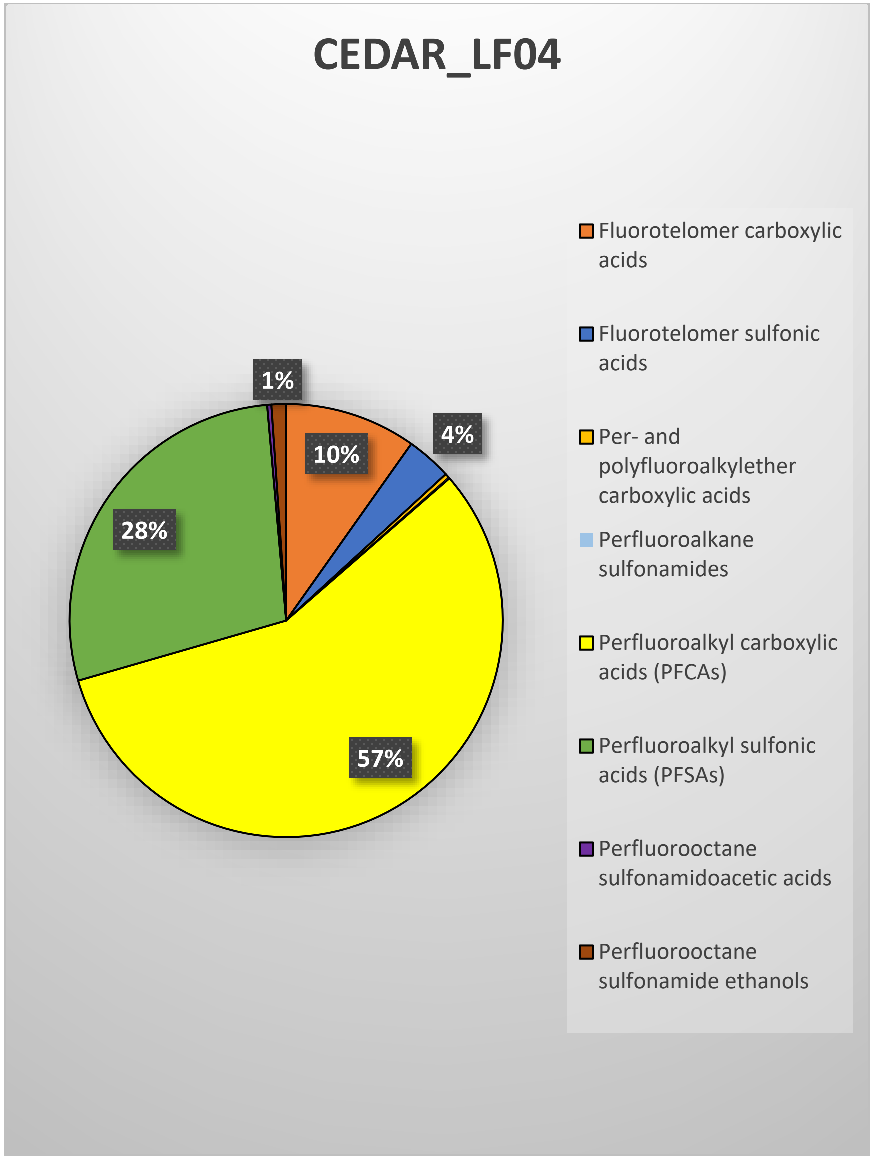


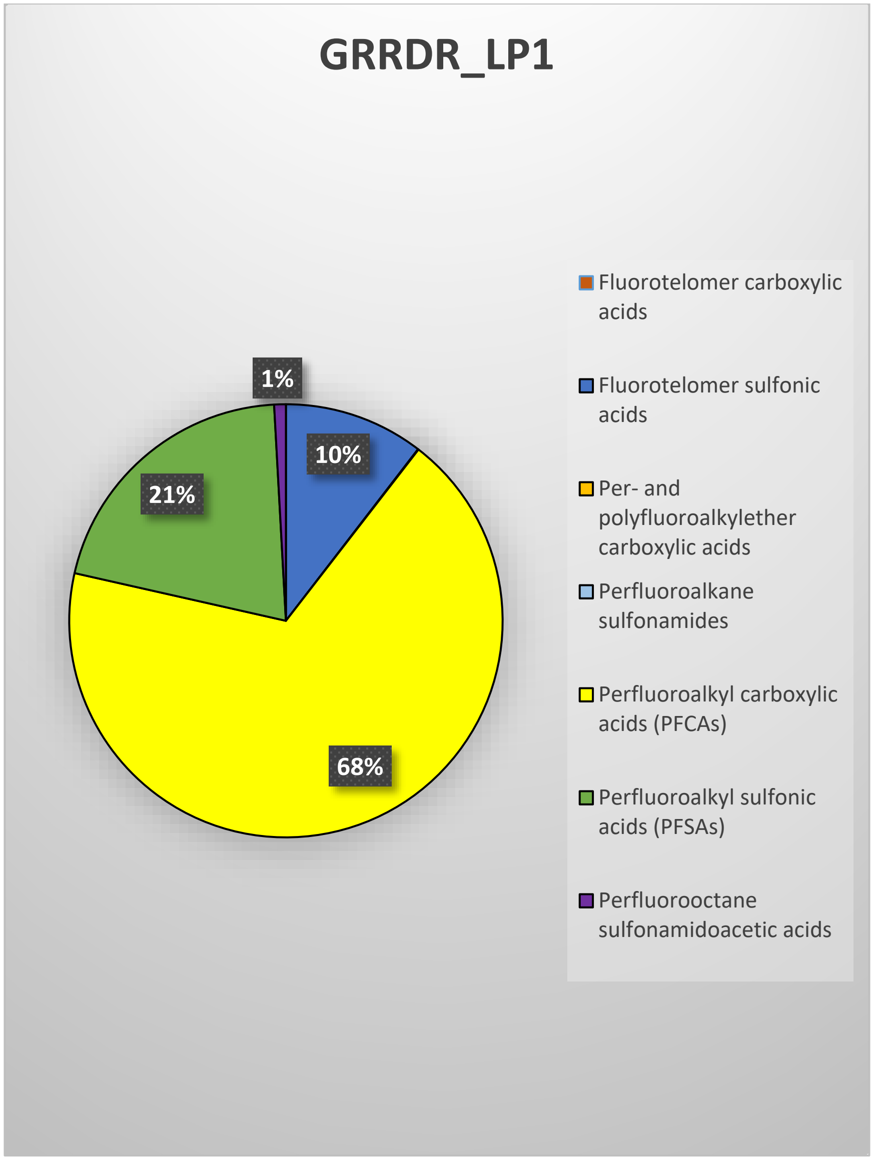

CATHCART_LF01
1%
6%
15%
48%
29%
1%
Ether sulfonic acids
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids
Perfluorooctane sulfonamide ethanols

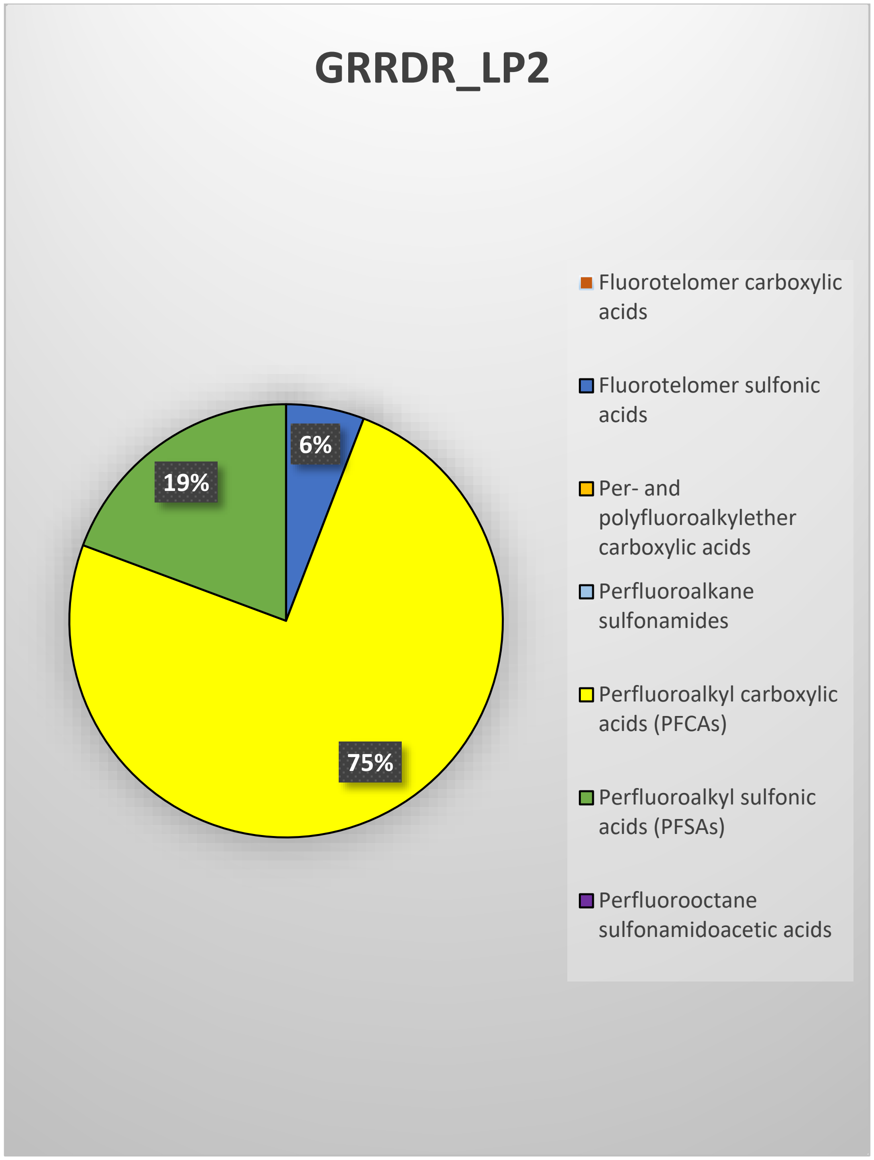

CEDAR_LF_01
1%
7%
14%
1%
77%
Ether sulfonic acids
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids
Perfluorooctanesulfonamide ethanols

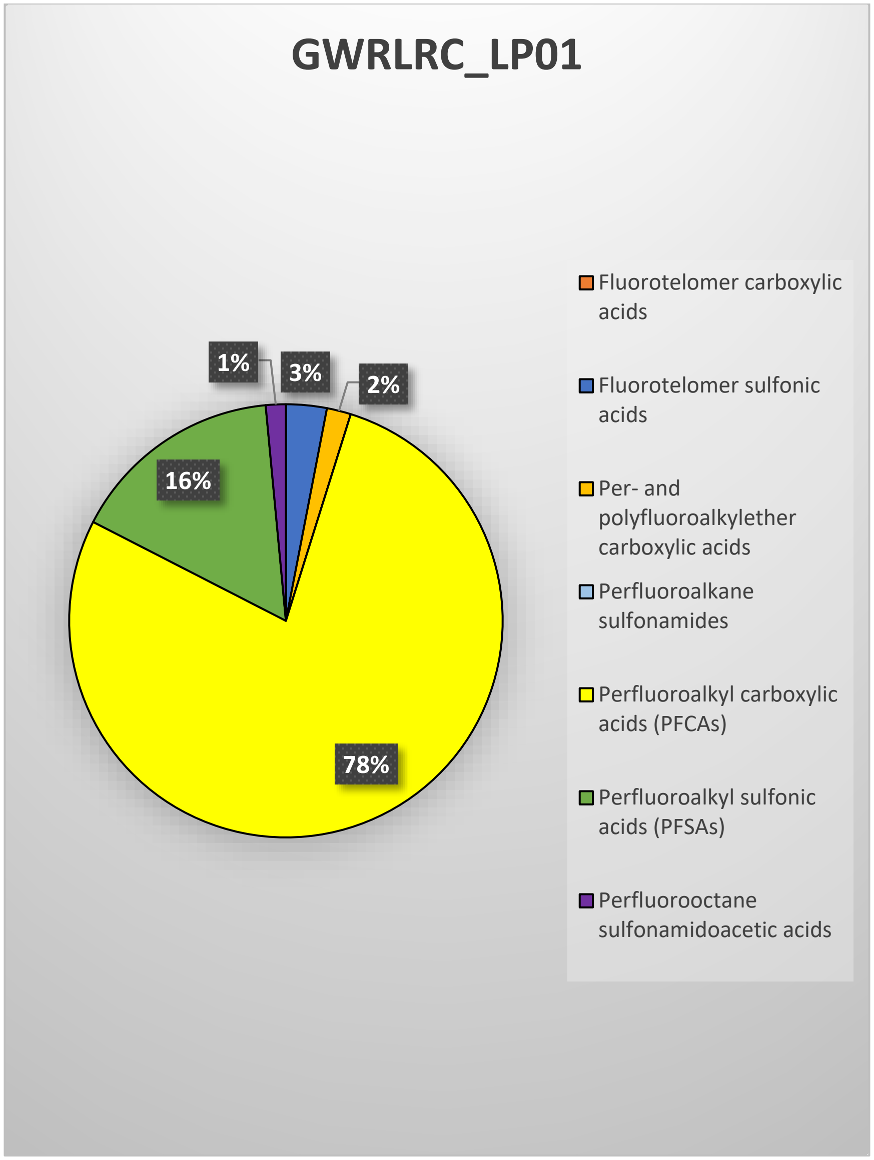

CEDAR_LF02
1%
3%
7%
28%
61%
Ether sulfonic acids
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids
Perfluorooctane sulfonamide ethanols

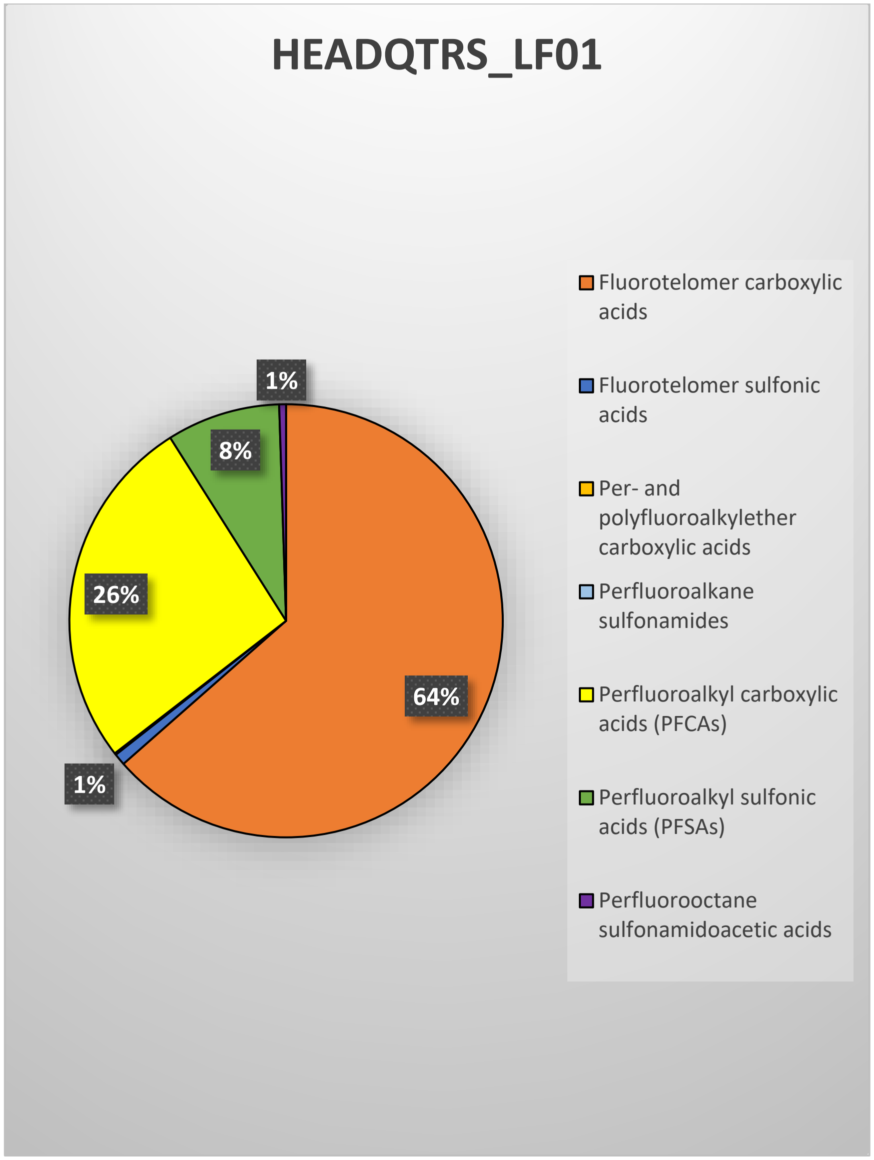

CEDAR_LF03
1%
4%
1%
14%
44%
36%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids
Perfluorooctane sulfonamide ethanols

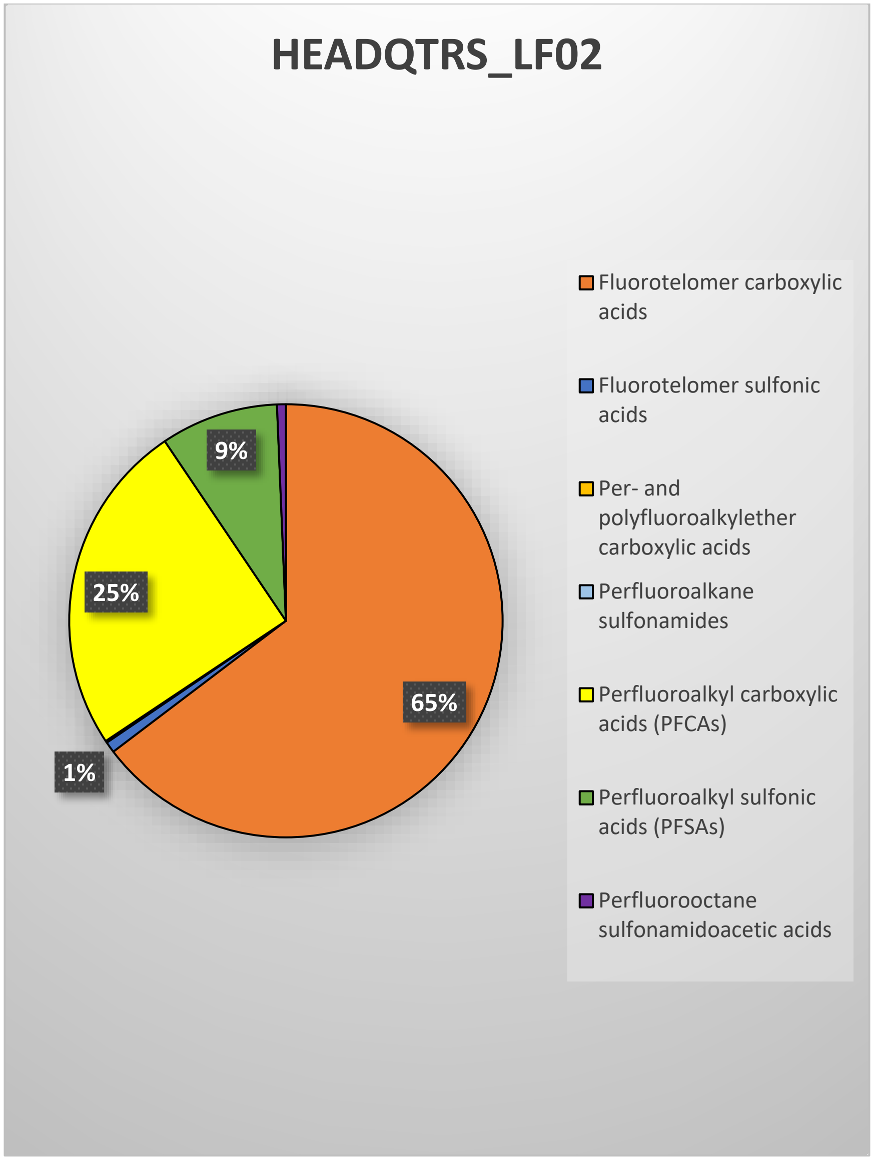

CEDAR_LF04
1%
10%
4%
28%
57%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids
Perfluorooctane sulfonamide ethanols

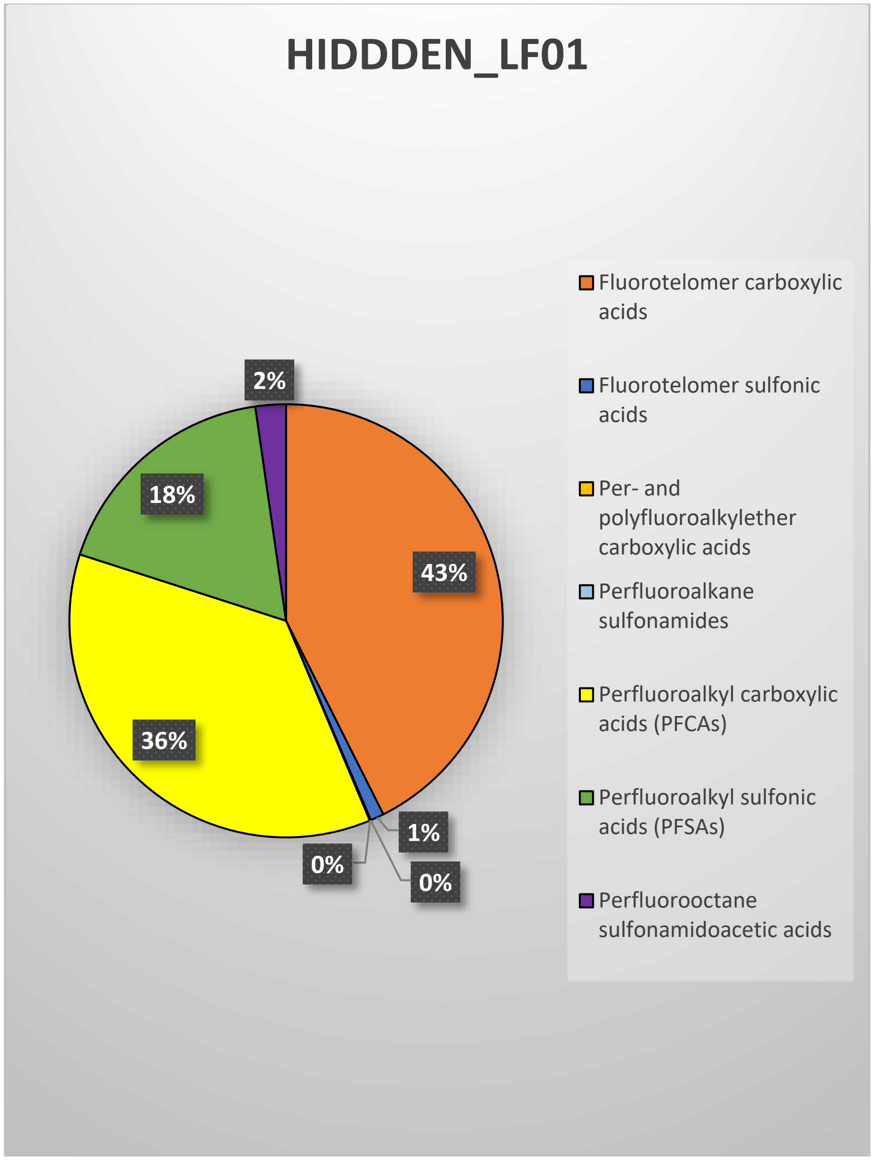

GRRDR_LP1
1%
10%
21%
68%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

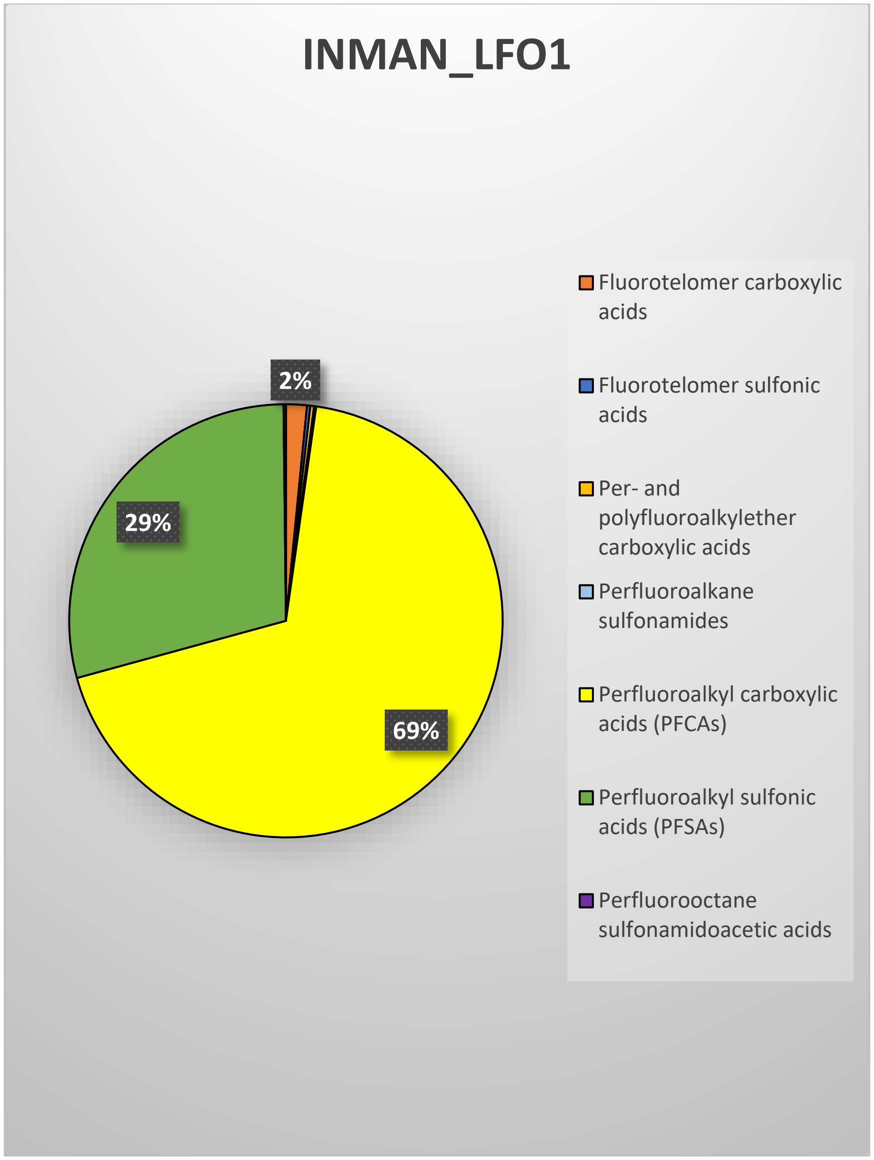

GRRDR_LP2
6%
19%
75%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

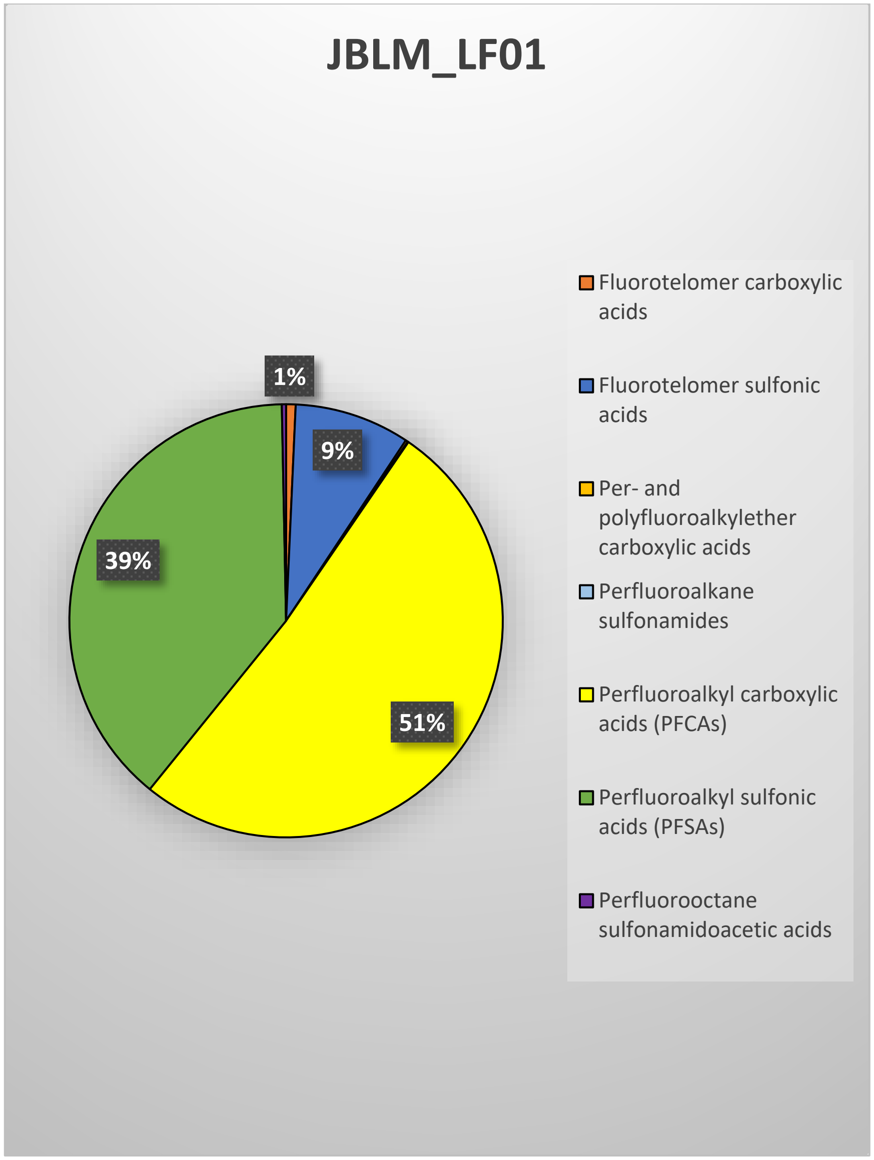

GWRLRC_LP01
1%
3%
2%
16%
78%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

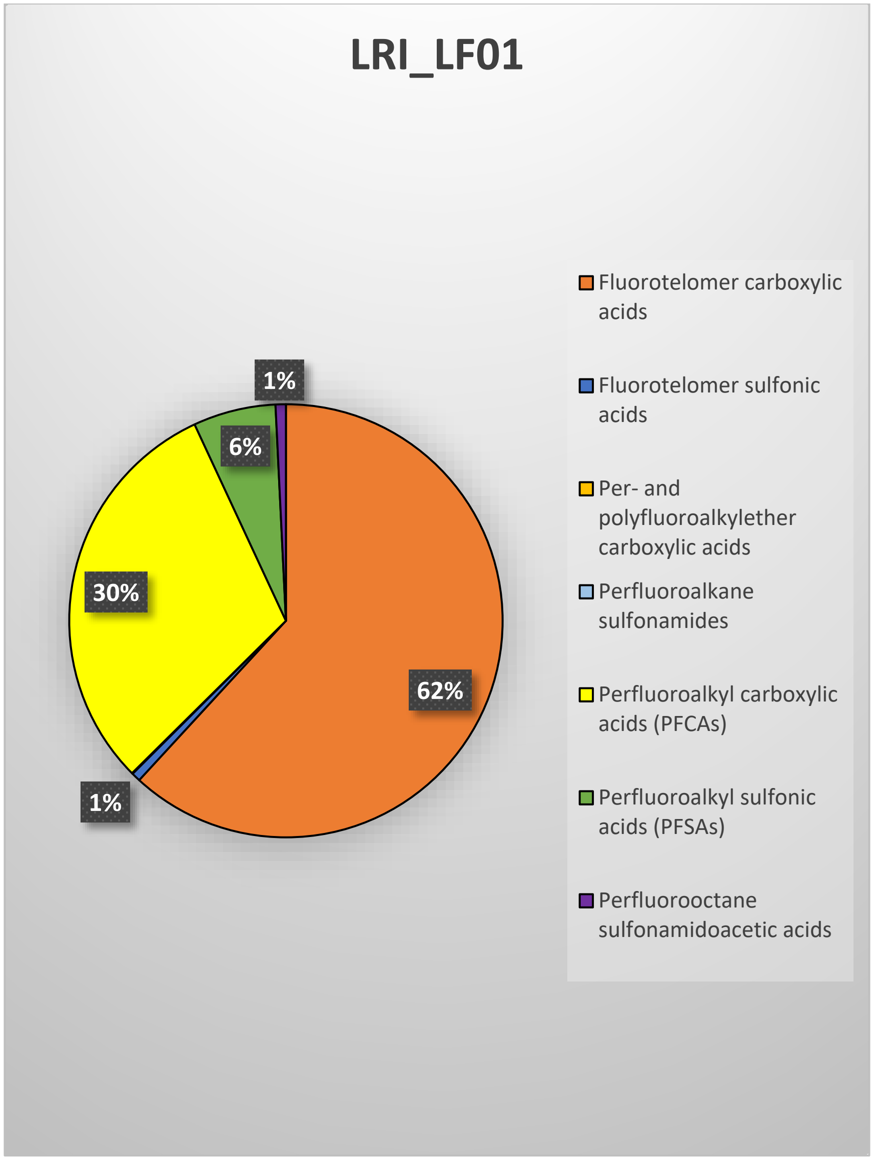

HEADQTRS_LF01
1%
8%
26%
64%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

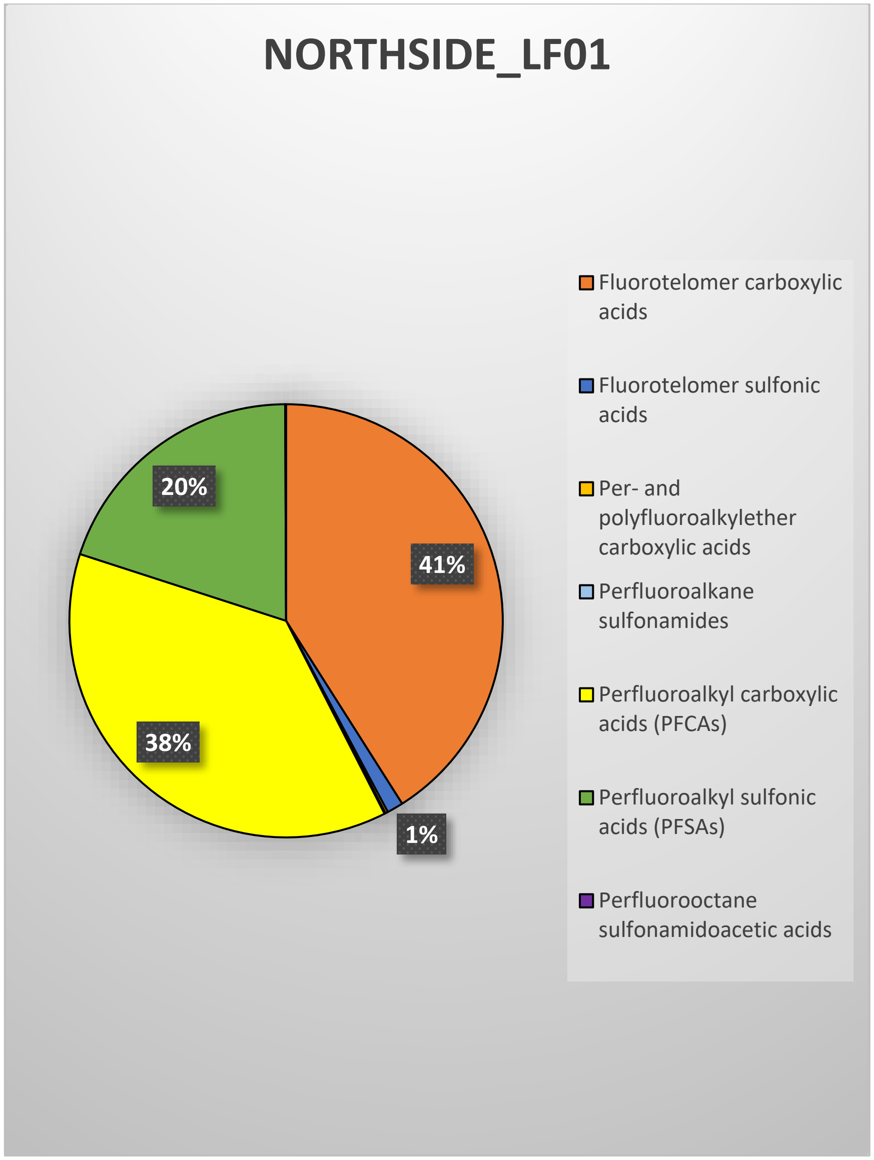

HEADQTRS_LF02
9%
25%
65%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

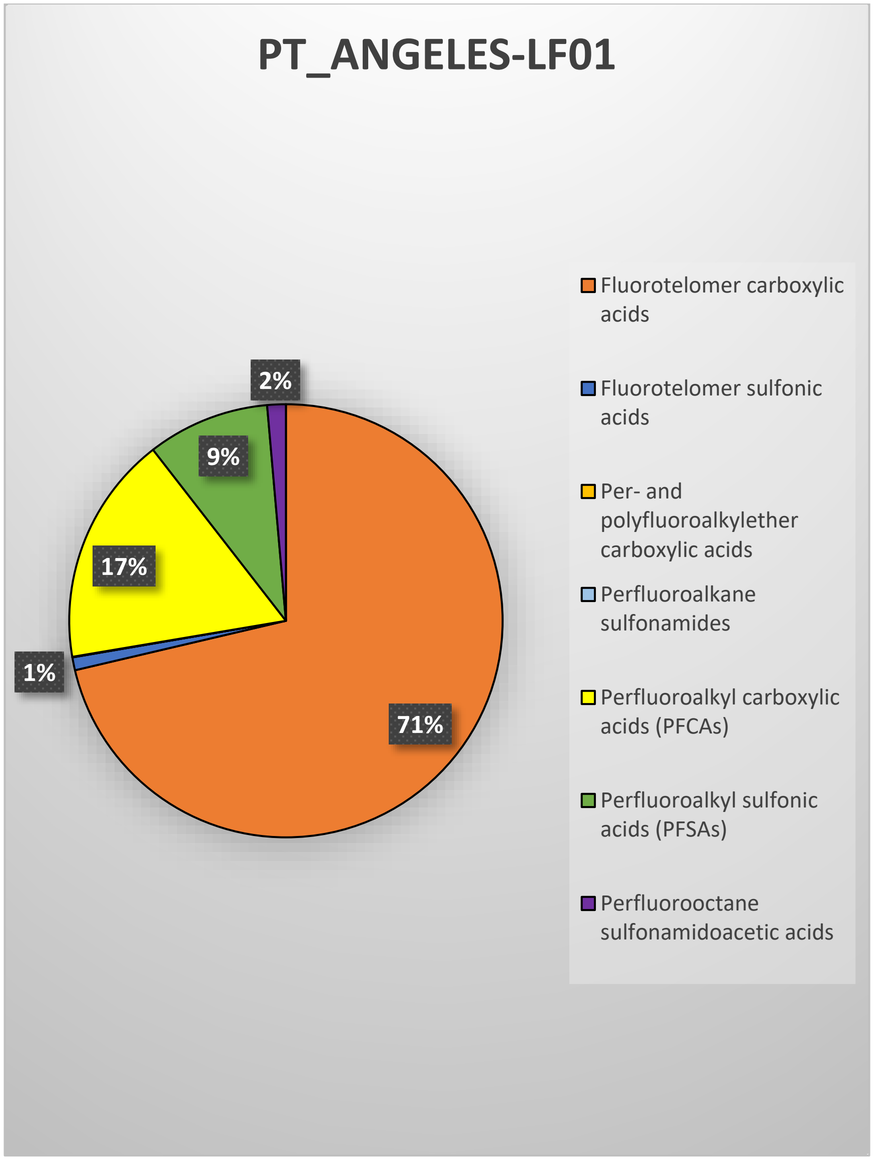

HIDDDEN_LF01
2%
18%
43%
36%
1%
0%
0%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

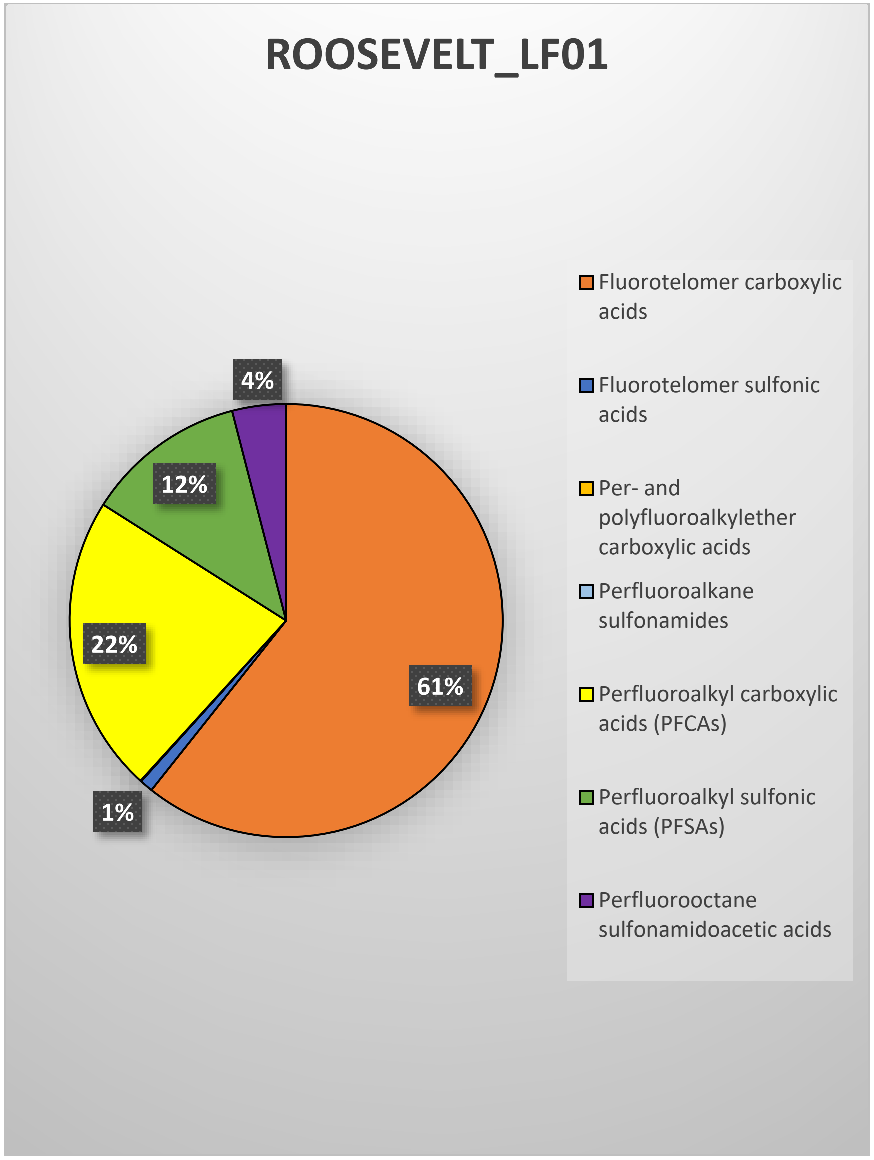

INMAN_LFO1
2%
29%
69%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

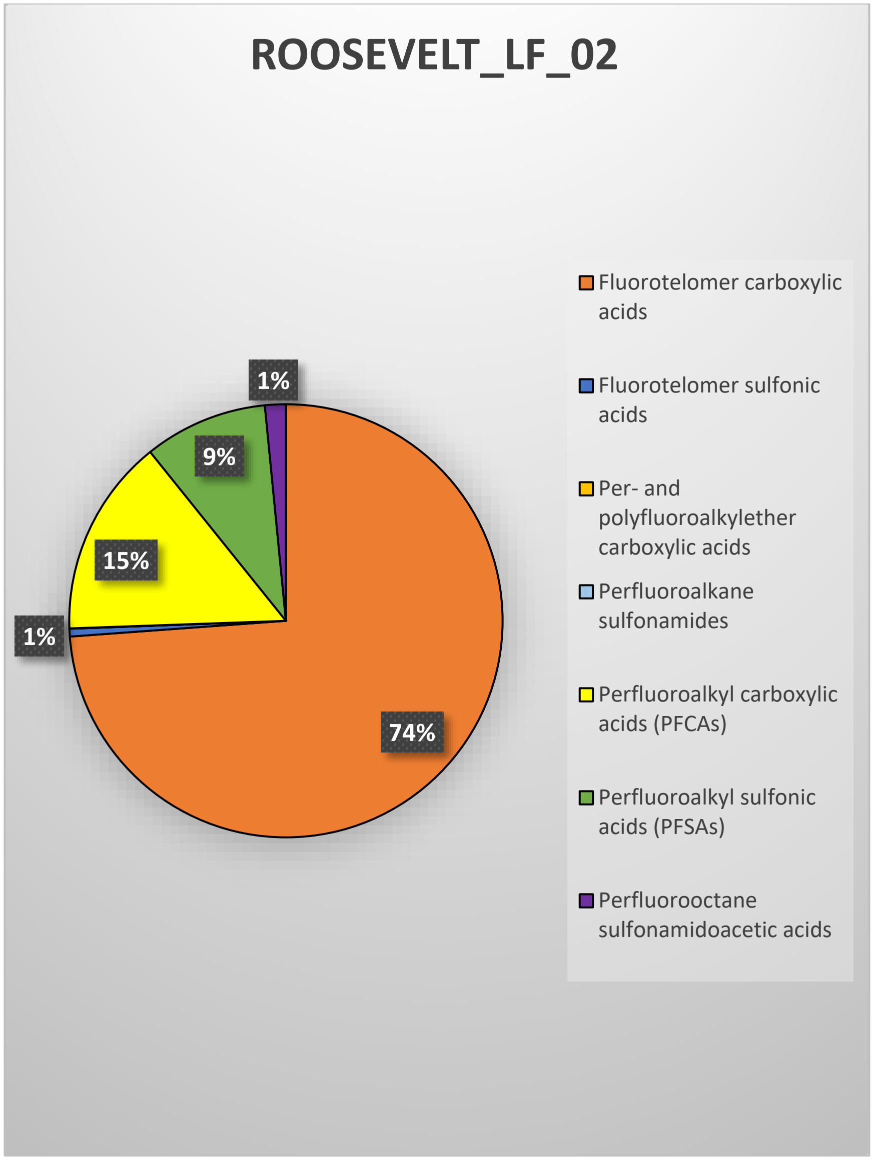

JBLM_LF01
1%
9%
39%
51%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

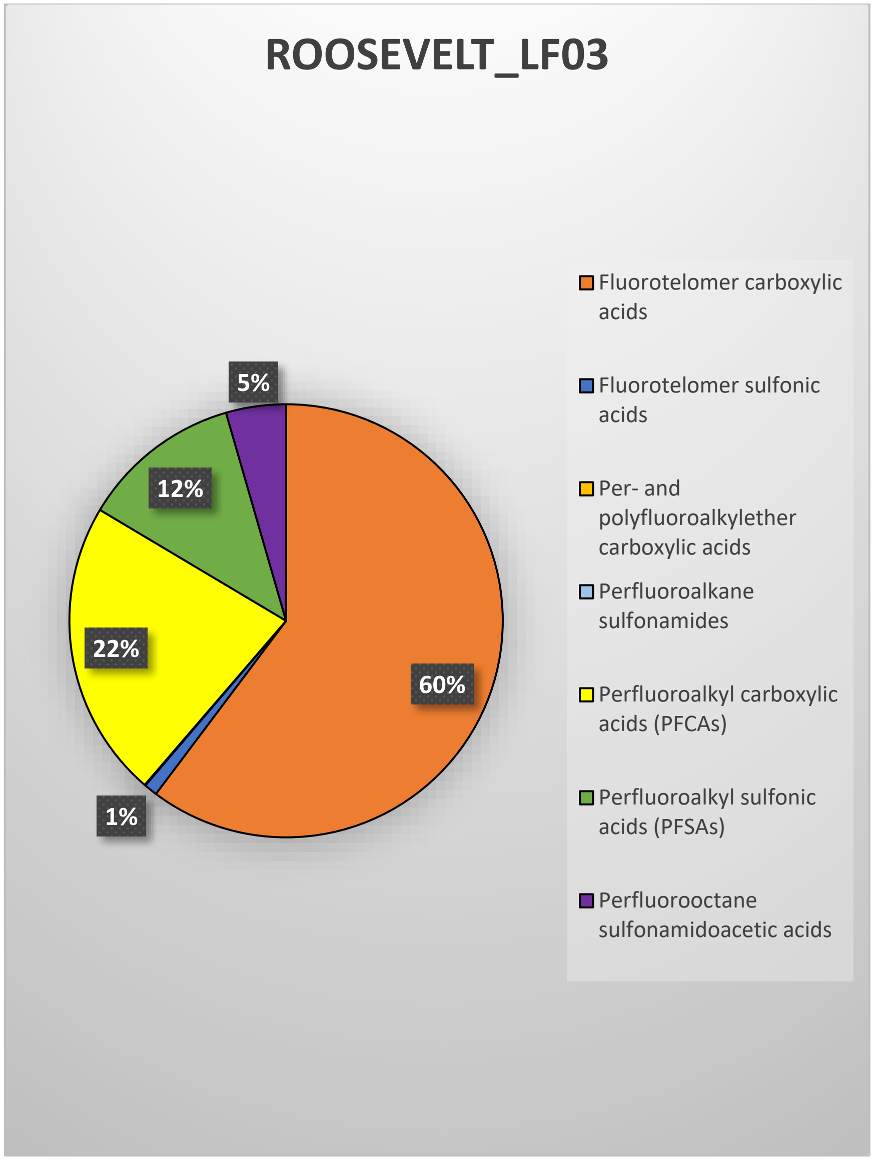

LRI_LF01
1%
6%
30%
62%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

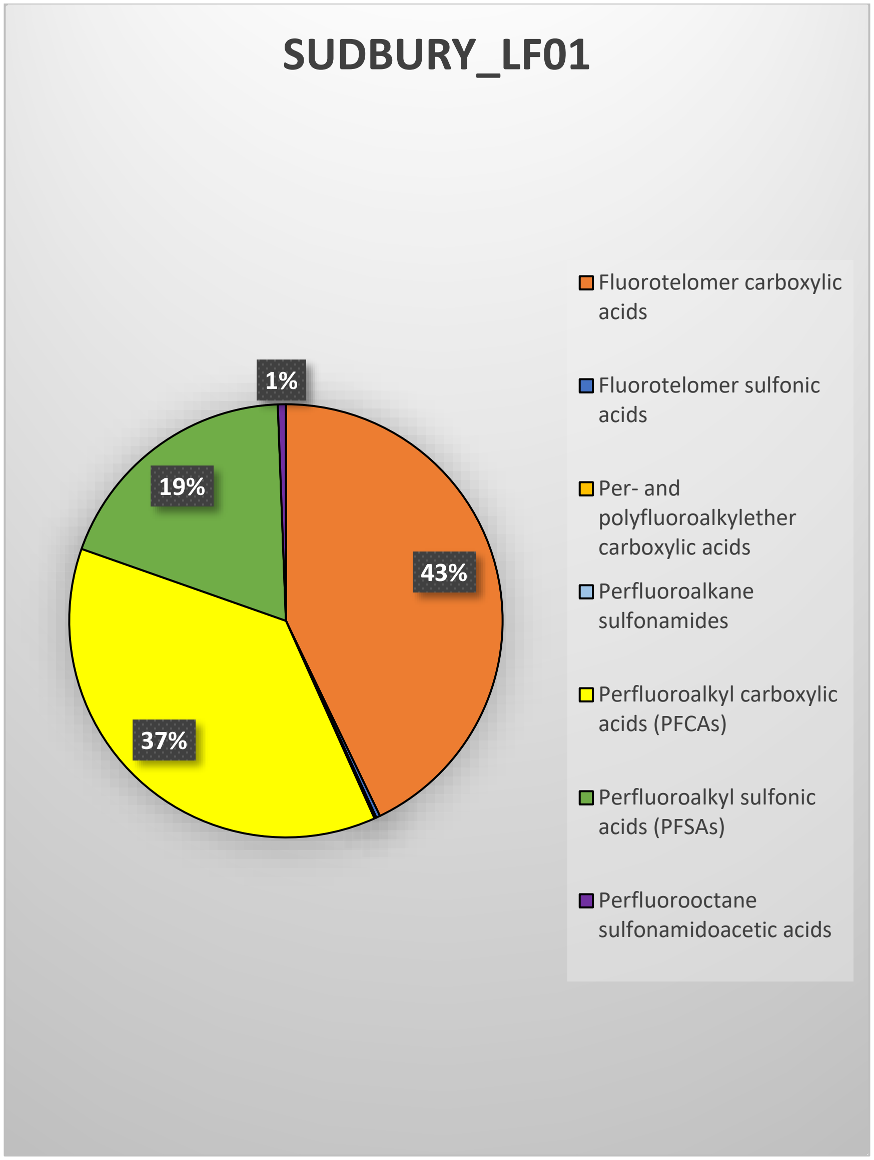

NORTHSIDE_LF01
41%
1%
38%
20%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

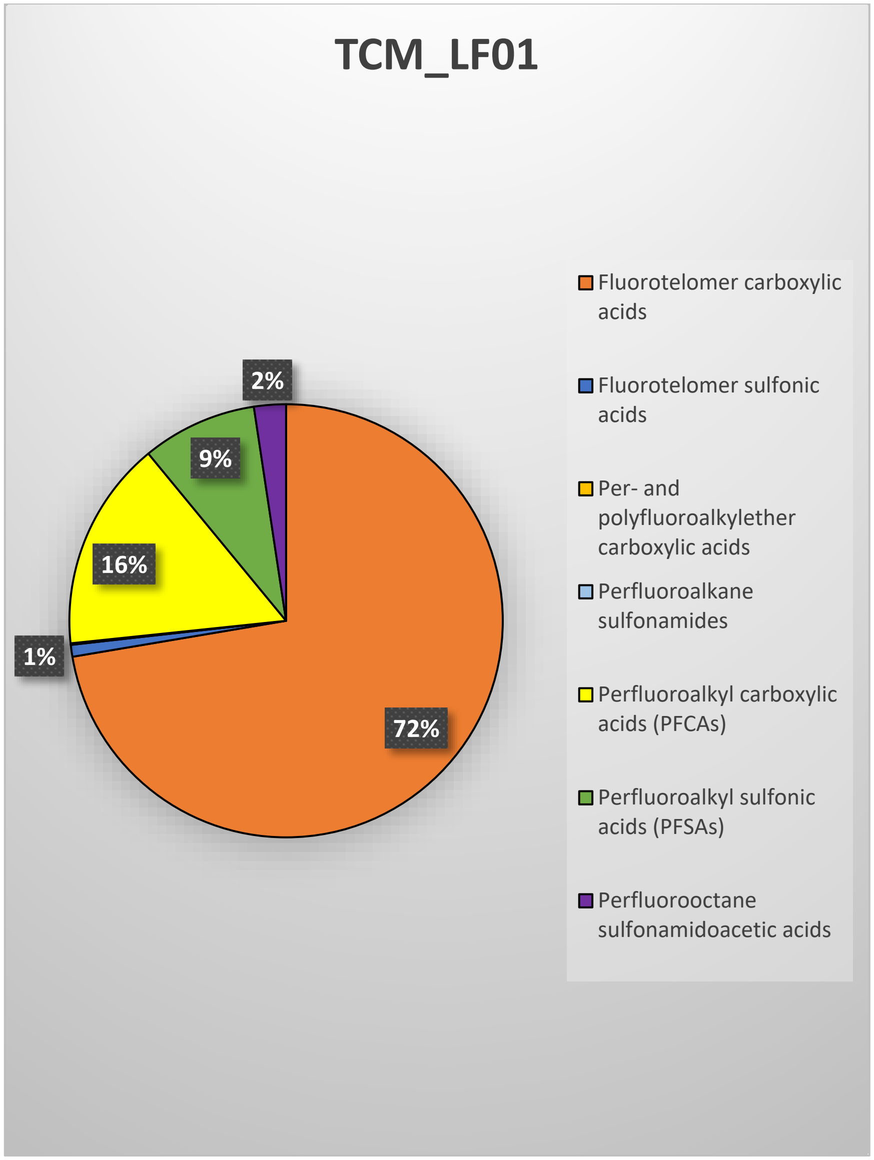

PT_ANGELES-LF01
2%
9%
17%
1%
71%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

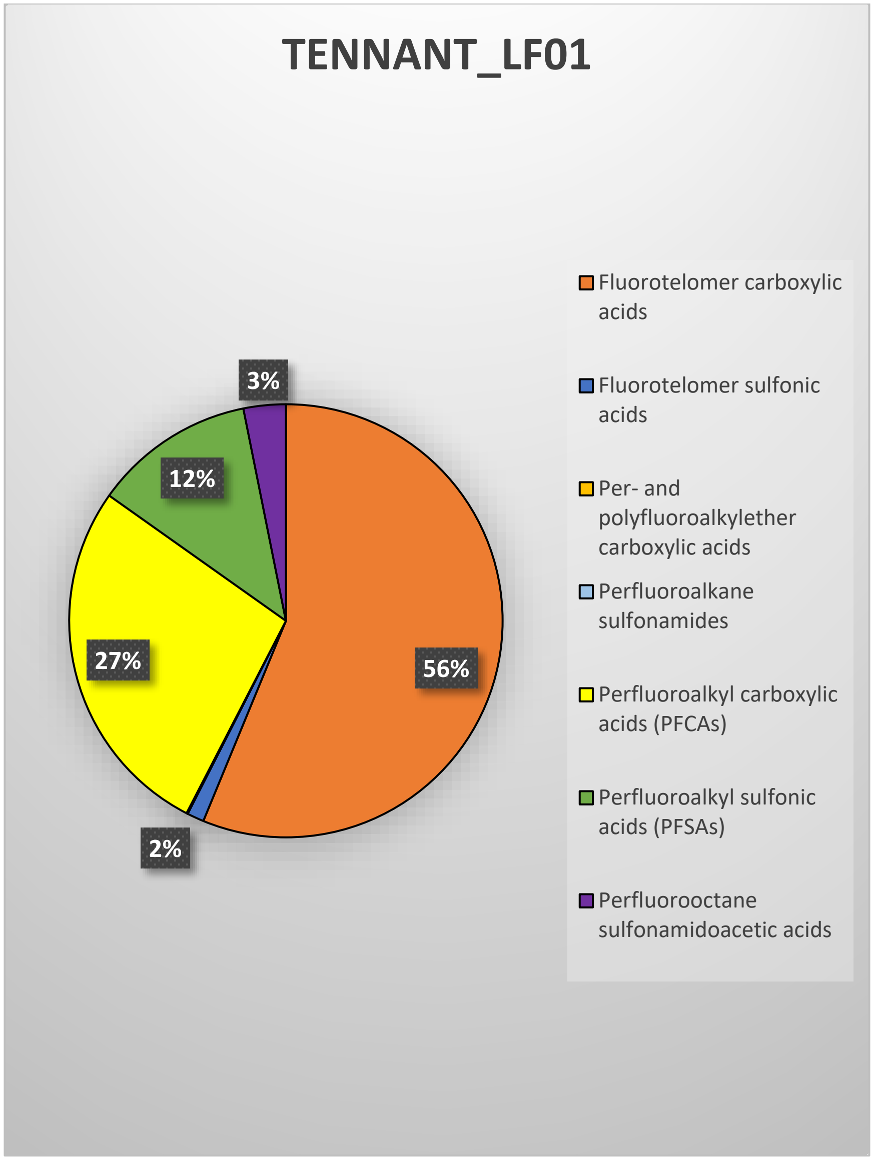

ROOSEVELT_LF01
4%
12%
22%
61%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

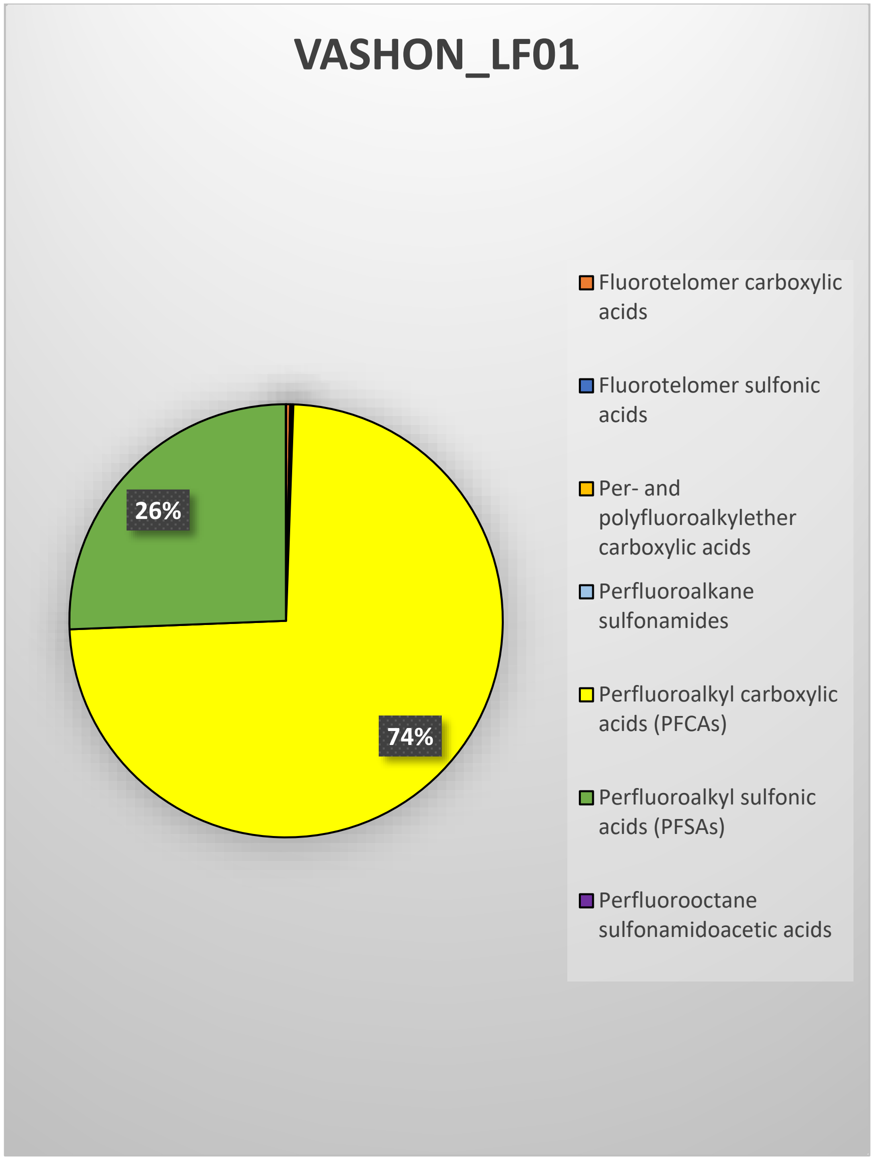

ROOSEVELT_LF_02
1%
9%
15%
1%
74%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

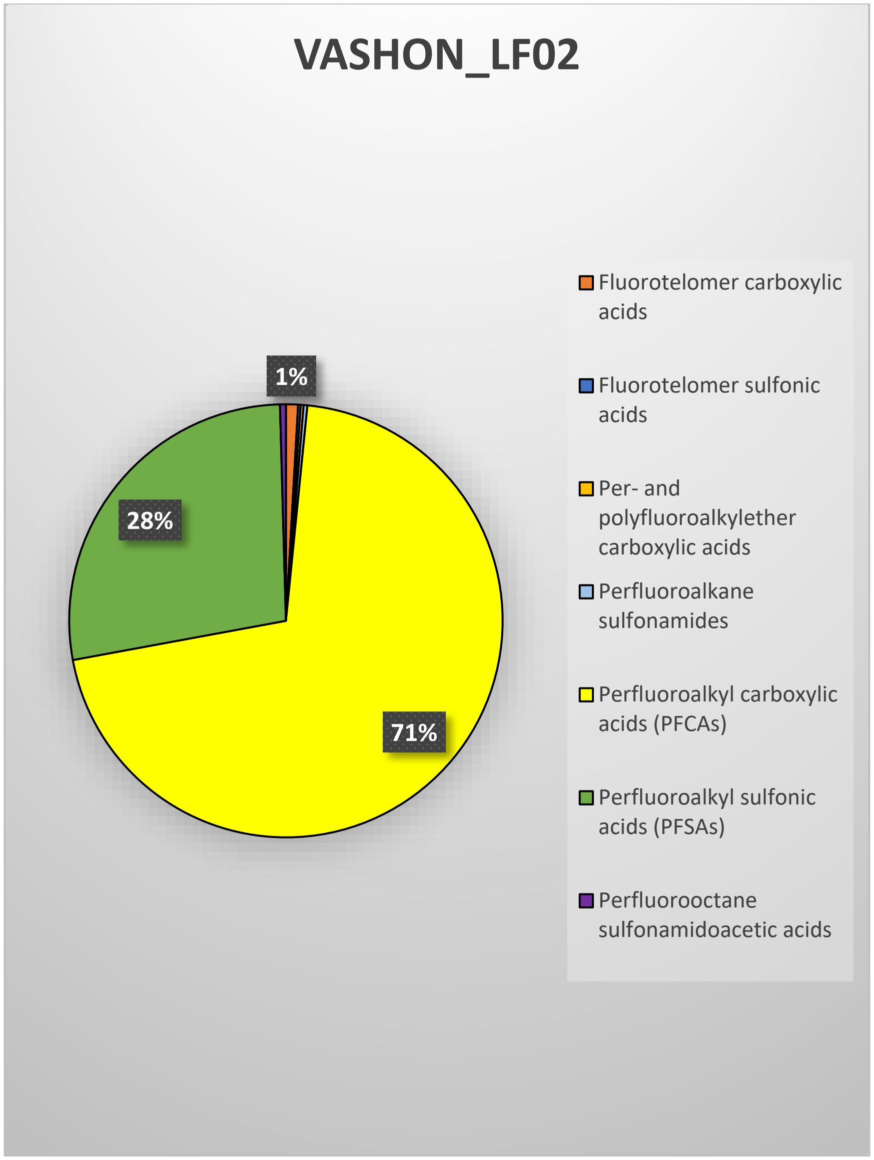

ROOSEVELT_LF03
5%
12%
22%
60%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

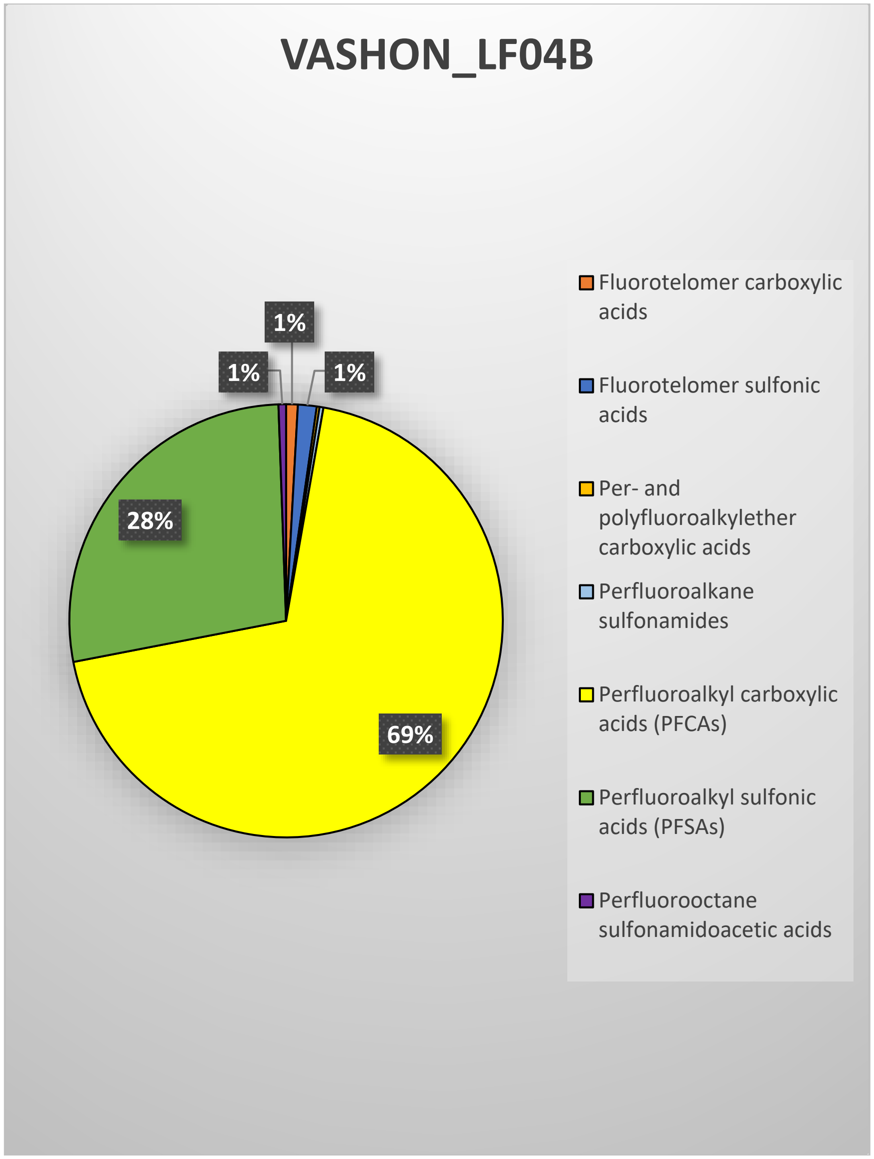

SUDBURY_LF01
1%
19%
43%
37%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids


TCM_LF01
2%
9%
16%
1%
72%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids


TENNANT_LF01
3%
12%
27%
56%
2%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids


VASHON_LF01
26%
74%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids


VASHON_LF02
1%
28%
71%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids


VASHON_LF04B
1%
1%
1%
28%
69%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

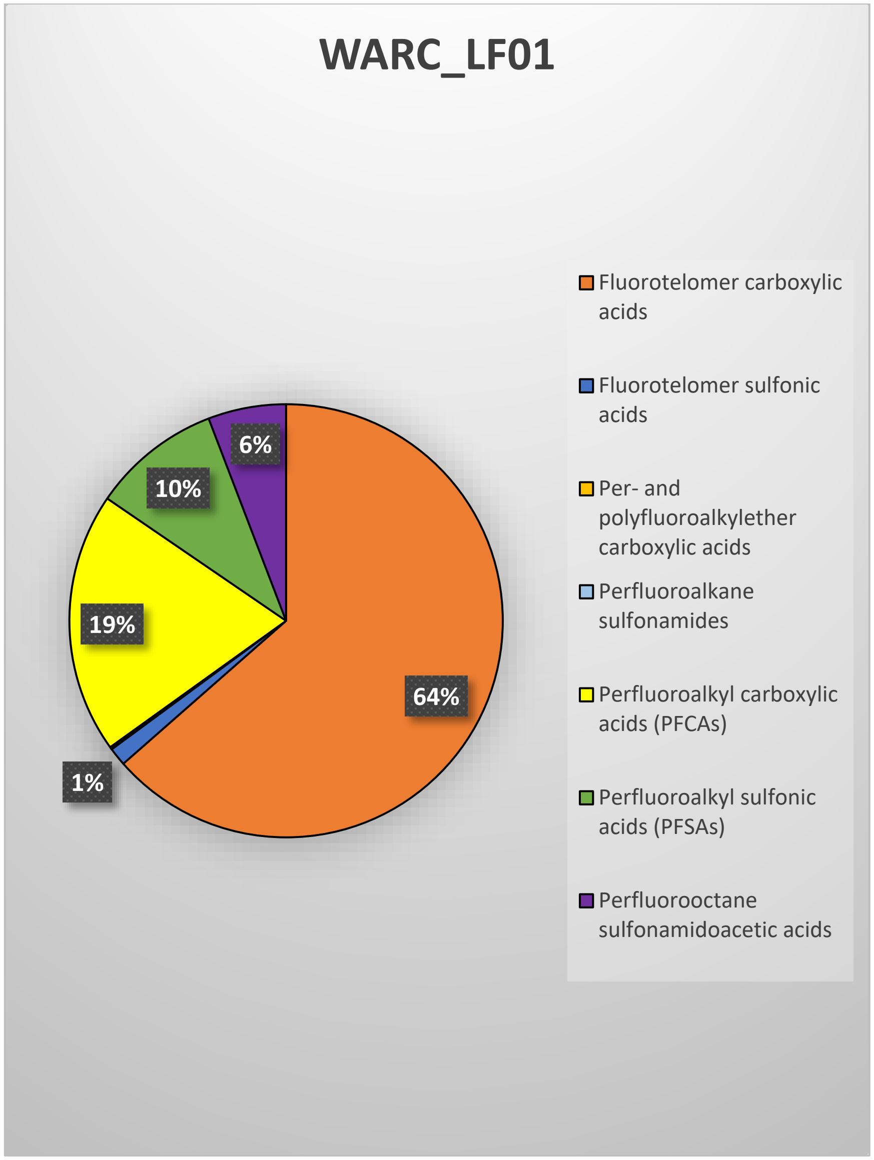
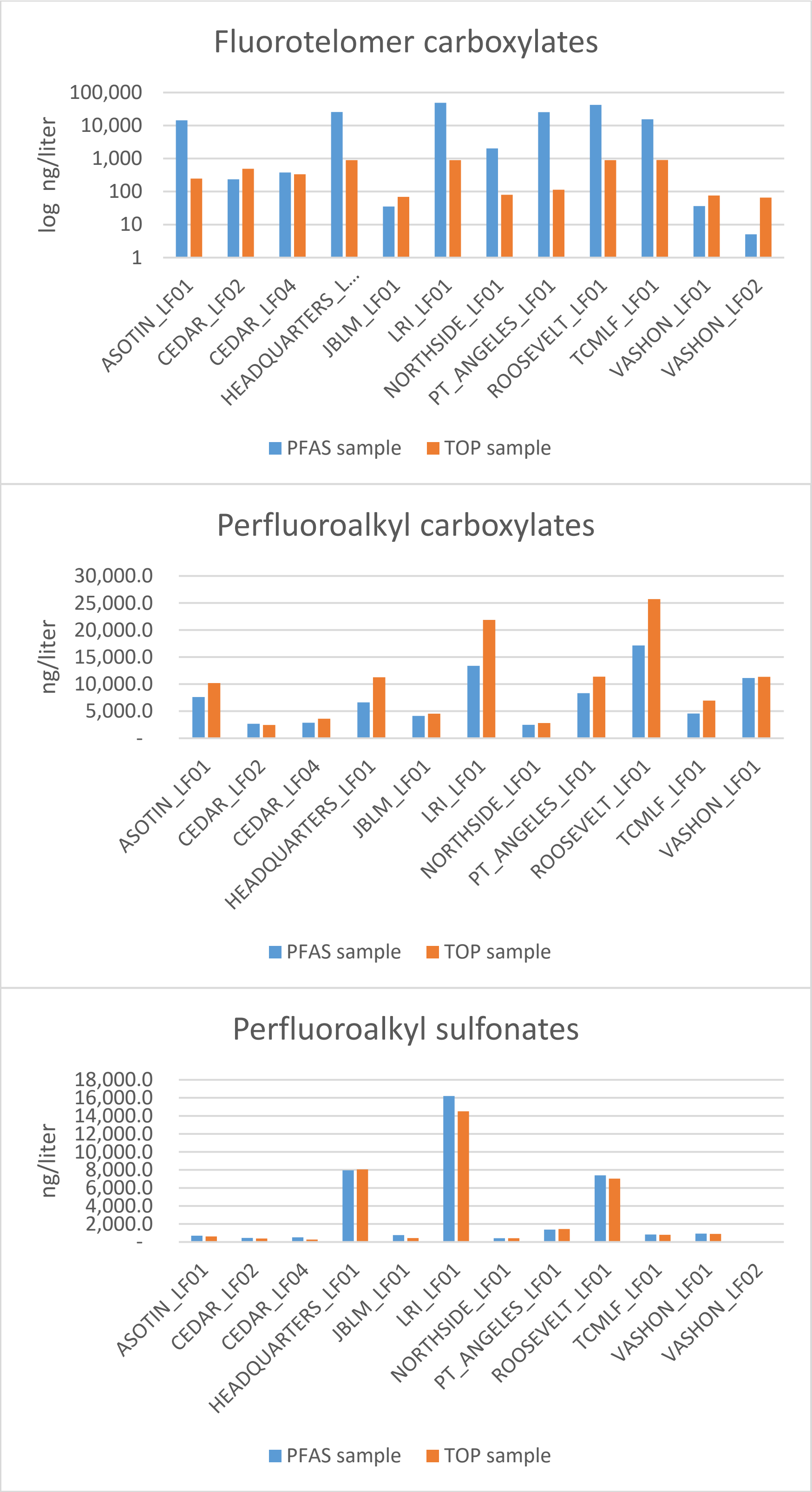
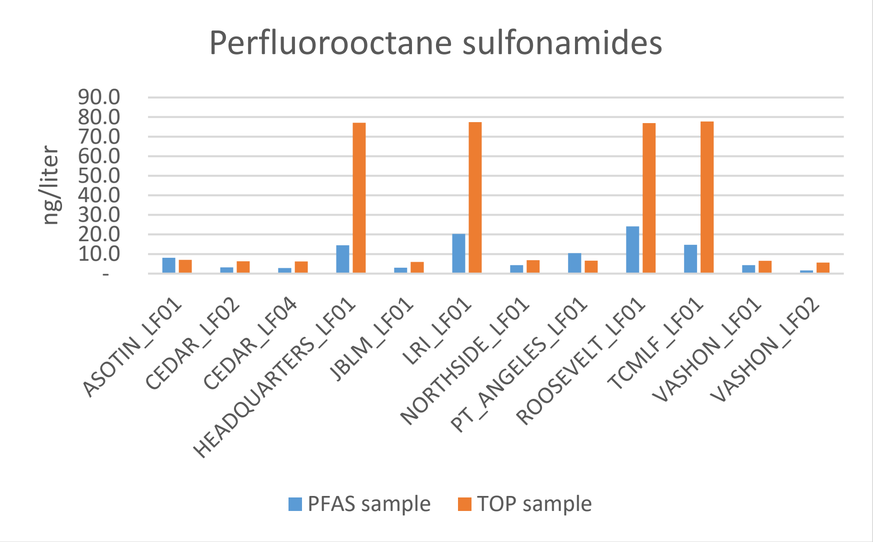

WARC_LF01
6%
10%
19%
64%
1%
Fluorotelomer carboxylic acids
Fluorotelomer sulfonic acids
Per- and polyfluoroalkylether carboxylic acids
Perfluoroalkane sulfonamides
Perfluoroalkyl carboxylic acids (PFCAs)
Perfluoroalkyl sulfonic acids (PFSAs)
Perfluorooctane sulfonamidoacetic acids

Figure 17. PFAS - TOP pair comparisons.




Perfluorooctane sulfonamides
ng/liter
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
-
ASOTIN_LF01
CEDAR_LF02
CEDAR_LF04
HEADQUARTERS_LF01
JBLM_LF01
LRI_LF01
NORTHSIDE_LF01
PT_ANGELES_LF01
ROOSEVELT_LF01
TCMLF_LF01
VASHON_LF01
VASHON_LF02
PFAS sample
TOP sample

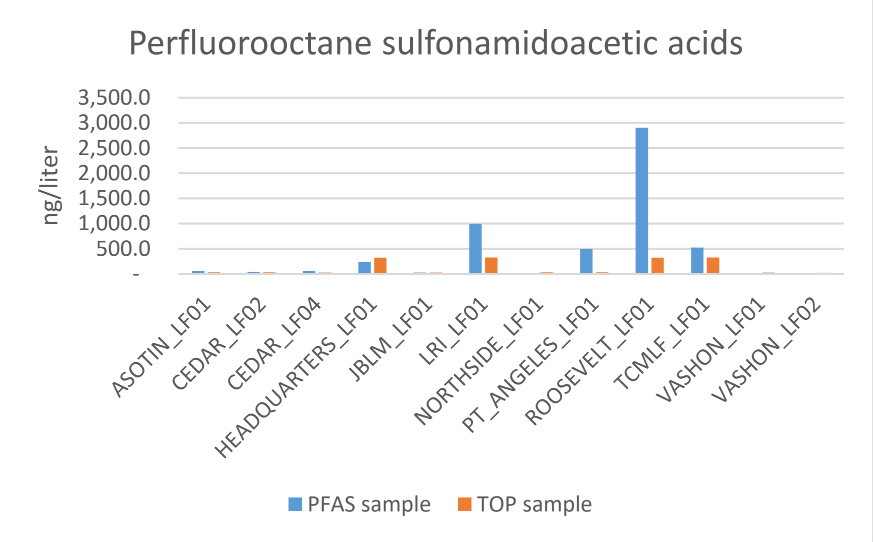

Perfluorooctane sulfonamidoacetic acids
ng/liter
3,500.0
3,000.0
2,500.0
2,000.0
1,500.0
1,000.0
500.0
-
ASOTIN_LF01
CEDAR_LF02
CEDAR_LF04
HEADQUARTERS_LF01
JBLM_LF01
LRI_LF01
NORTHSIDE_LF01
PT_ANGELES_LF01
ROOSEVELT_LF01
TCMLF_LF01
VASHON_LF01
VASHON_LF02
PFAS sample
TOP sample

Figure 18. Scatter diagram of conductance vs ∑PFAS.

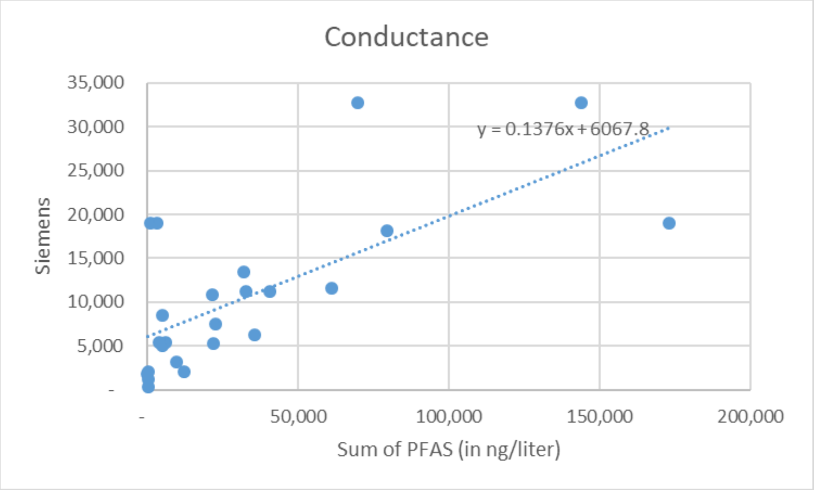


Figure 19. Scatter diagram of pH vs ∑PFAS.

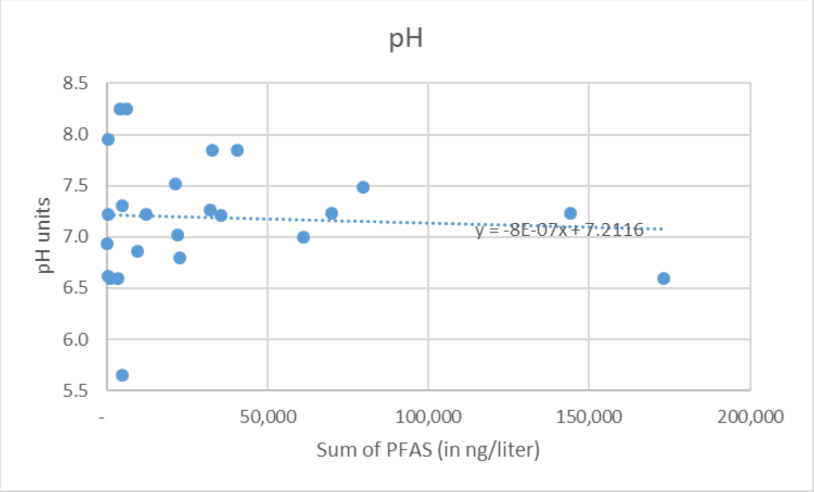


Figure 20. Scatter diagram of temperature vs ∑PFAS.

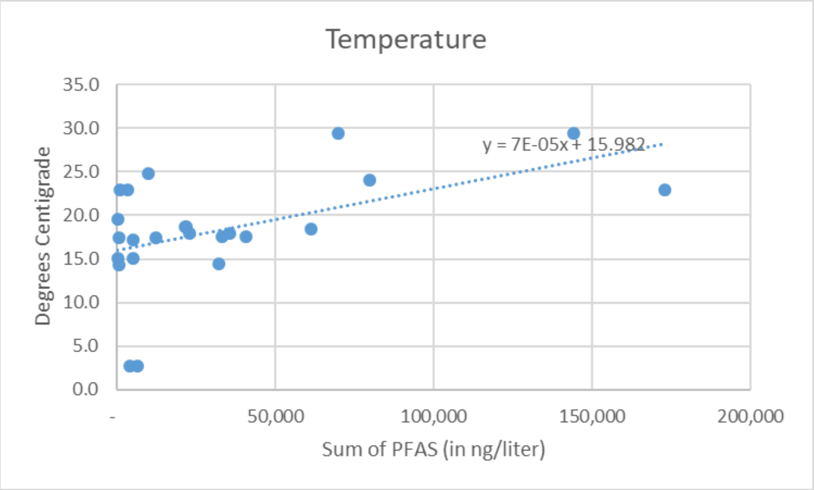


Figure 21. Scatter diagram of age vs ∑PFAS.

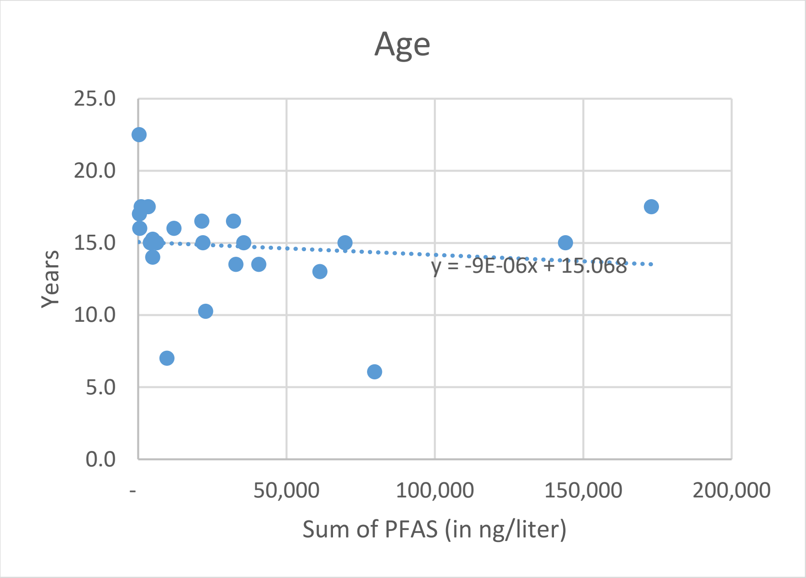
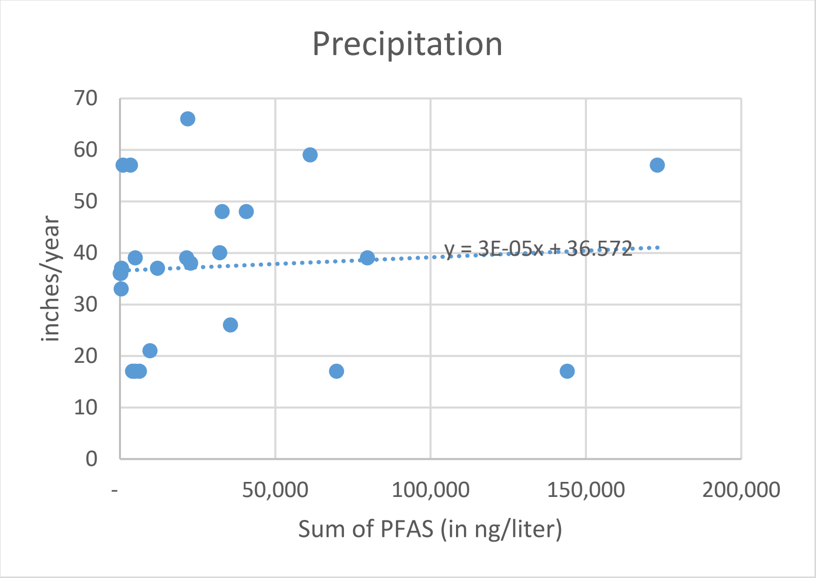


Figure 22. Scatter diagram of precipitation vs ∑PFAS.



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Appendices

- Appendix A: Data Validation Report State of Washington Landfill Leachate PFAS Study

Appendix A

Data Validation Report State of Washington Landfill Leachate PFAS Study

Prepared for:

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Project Narrative

Basis for the Data Validation

This report summarizes the results of data validation performed on landfill leachate and quality control (QC) sample data for the State of Washington Landfill Leachate PFAS project. The data received full validation (EPA Stage 4). A complete list of samples is provided in the Sample Index.

The PCB congener analyses were performed by SGS/Axys Analytical, Sydney, BC, Canada. The analytical method and EcoChem project chemists are listed in the table below.

ANALYSIS	METHOD	PRIMARY REVIEW	SECONDARY REVIEW
Per- and polyfluoroalkyl substances (PFAS)	SGS AXYS METHOD MLA-110 Rev 02	Alison Bodkin	Chris Ransom
PFAS Total Oxidizable Precursors (TOP)	SGS AXYS METHOD MLA-111 Rev 03		

The data were reviewed using guidance and quality control criteria documented in the analytical methods; Quality Assurance Project Plan (QAPP) Sampling for Per- and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate in the State of Washington (WA Dept. of Ecology, January 2020); National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2017); and National Functional Guidelines for High Resolution Superfund Methods Data Review (USEPA, 2016).

EcoChem's goal in assigning data assessment qualifiers is to assist in proper data interpretation. If values are estimated (J, NJ, or UJ), data may be used for site evaluation and risk assessment purposes but reasons for data qualification should be taken into consideration when interpreting sample concentrations. If values are assigned an R or DNR, the data should not be used for any site evaluation purposes. If values have no data qualifier assigned, then the data meet the data quality objectives as stated in the documents and methods referenced above.

Data qualifier definitions, reason codes, and validation criteria are included as Appendix A. A Qualified Data Summary Table is included in Appendix A. A qualified laboratory electronic data deliverable (EDD) is also submitted with this report.

Sample Index State of Washington Landfill Leachate PFAS Study

Work Group	Station ID	Sample ID	Lab ID	PFAS	TOP PFAS
WG74318	HEADQUARTERS_FIELD_B	2010047-1	L33825-1	✓	
WG74318	HEADQUARTERS_LF02	2010047-2	L33825-2	✓	
WG74318/WG74821	HEADQUARTERS_LF01	2010047-3	L33825-3	✓	✓
WG74318	TENNANT_LF01	2010047-4	L33825-4	✓	
WG74318/WG74329	WARC_LF01	2010047-5	L33825-5	✓	✓
WG74318/WG74329	VASHON_LF01	2010047-6	L33825-6	✓	✓
WG74318/WG74329	VASHON_LF02	2010047-7	L33825-7	✓	✓
WG74318/WG74329	VASHON_LF04B	2010047-8	L33825-8	✓	✓
WG74318/WG74821	TCMLF_LF01	2010047-9	L33825-9	✓	✓
WG74798/WG74329	JBLM_LF01	2010047-10	L33825-10	✓	✓
WG74318	CATHCART_LF01	2010047-11	L33825-11	✓	
WG74318	CEDAR_LF01	2010047-12	L33825-12	✓	
WG74798/WG74329	CEDAR_LF02	2010047-13	L33825-13	✓	✓
WG74318	CEDAR_LF03	2010047-14	L33825-14	✓	
WG74798/WG74329	CEDAR_LF04	2010047-15	L33825-15	✓	✓
WG74318	INMAN_LF01	2010047-16	L33825-16	✓	
WG74318	AIRPORT_LF01	2010047-17	L33825-17	✓	
WG74380	HIDDEN_LF01	2010047-18	L33852-1	✓	
WG74495/WG74821	LRI_LF01	2010047-19	L33852-2	✓	✓
WG74495/WG74329	ASOTIN_LF01	2010047-20	L33897-1	✓	✓
WG74495/WG74329	NORTHSIDE_LF01	2010047-21	L33897-2	✓	✓
WG74380	SUDBURY_LF01	2010047-22	L33897-3	✓	
WG74380/WG74821	ROOSEVELT_LF01	2010047-23	L33935-1	✓	✓
WG74380	ROOSEVELT_LF02	2010047-24	L33935-2	✓	
WG74380/WG74821	ROOSEVELT_LF03	2010047-25	L33935-3	✓	✓
WG74380/WG74329	RINSATE_LF02	2010047-26	L33935-4	✓	✓
WG74495/WG74329	PT_ANGELES_LF01	2010047-27	L33991-1	✓	✓

Data Validation Report

State of Washington Landfill Leachate PFAS Study
PFAS by SGS AXYS Method MLA-110 LC-MS/MS with Isotope Dilution

This report documents the review of analytical data from the analysis of leachate samples and the associated laboratory and field quality control (QC) samples. Samples were analyzed by SGS Axys Laboratories, Sidney, British Columbia, Canada. Refer to the Sample Index for a complete list of samples.

SDG	Batch	Number of Samples	Validation Level
DPWG74671	WG74380	4 Leachate, 1 Rinse Blank, 1 Field Duplicate	EPA Stage 4
DPWG74815	WG74495	4 Leachate	EPA Stage 4
DPWG74907	WG74318	12 Leachate, 1 Rinse Blank, 1 Field Duplicate	EPA Stage 4
	WG74798	2 Leachate, 1 Field Duplicate	EPA Stage 4

Data Package Completeness

The laboratory submitted all required deliverables. The laboratory followed adequate corrective action processes and all anomalies were discussed in the case narrative.

SDGs DPWG74671, DPWG74815, DPWG74907: The narrative indicated that the samples were stored at the laboratory at 4°C. The laboratory was contacted and confirmed that samples were stored frozen as per the laboratory SOP.

SDG DPWG74907: Analytes 3,3’ FCTA, PFMPA, and PFMBA were reported as not quantified (NQ) in samples CEDAR_LF01 and CEDAR_LF04 due to recoveries of <10% for the associated labeled compound (13C5-PFPeA). This was not in accordance with the lab method. The lab was contacted and submitted a revised report and EDD that included results for these compounds.

EDD to Hardcopy Verification

Sample IDs and results reported in the electronic data deliverable (EDD) were verified by comparing the EDD to the hardcopy laboratory data package. No transcription errors were noted; however, corrections were made based on the resubmitted EDD for DPWG74907. The following validation related fields were added: DV Result Value, DV Qualifier, DV Reason Code, Interpretive Qualifier, and DV Label Code.

Technical Data Validation

The QC requirements that were reviewed are listed below.

1	Sample Receipt, Preservation, and Holding Times	2	Field Blanks
✓	Pre-Treatment, Extraction, and Cleanup	✓	Laboratory Duplicates
✓	System Performance	2	Field Duplicates
1	Initial Calibration (ICAL)	2	Compound Identification
1	Continuing Calibration (CCV)	1	Compound Quantification
✓	Ongoing Precision and Recovery (OPR)	1	Reporting Limits
2	Labeled Compound Recovery	✓	Calculation Verification
1	Laboratory Blanks		

✓ Stated method quality objectives (MQO) and QC criteria have been met.
1 Quality control outliers are discussed below, but no data were qualified.
2 Quality control outliers that impact the reported data were noted. Data qualifiers were issued as discussed below.

Sample Receipt, Preservation, and Holding Times

Coolers were received at Axys at temperatures less than 6°C. Samples were stored at -20°C upon receipt. Samples were extracted within the holding time of 90 days for frozen aqueous samples and analyzed within the 30-day holding time from extraction to analysis.

SDG DPWG74907*:* One Chain of Custody (COC) form did not have relinquish signature and date. No action was taken on this basis.

Pre-Treatment, Extraction, and Cleanup

Aqueous samples are extracted by solid phase extraction (SPE) using weak anion exchange cartridges; wash and elution procedures are chosen to meet various analysis requirements. Sample extracts are then treated with carbon powder.

System Performance

The instrument is tuned according to the manufacturer’s specifications prior to each initial calibration. All instrument performance criteria were met. Peak asymmetry for PFBA and PFPeA measured in the ICAL midpoint calibration standard were 0.8 to 1.5 at 10% peak height.

Initial Calibration

The initial calibration (ICAL) was analyzed on 8/13/2020. The correct number of calibration standards were analyzed. All requirements for signal to noise ratio, and retention time were met. The percent relative standard deviation (%RSD) values were within the control limit of 20% for native compounds and labeled compounds. Each compound and labeled compound in the calibration standards must be within 70 to 130% of the true value. In cases where this criterion was not met, the standard was not used in the calibration curve.

The ion abundance ratio criteria for 13C2-8:2 FTS was not met for the two highest calibration standards. The ICAL RSD was acceptable and the ratios for the native compound were within control limits. Data was judged as not impacted. No qualifiers were applied.

Continuing Calibration

A continuing calibration verification (CCV) standard was analyzed at the at the beginning and end of each analytical sequence. All requirements for ion abundance ratio, signal to noise ratio, and retention time were met. Percent recovery (%R) values were within the criteria of 70%-130% for native compounds and labeled compounds, with the following exceptions.

SDG DPWG74 671: The %R values for one or more labeled standards in each CCV standard were less than the lower control limit. The %R values for the associated native compounds were acceptable. Data was judged as not impacted and no qualifiers were applied. The following outliers were noted:

- CCV 11/17/2020 at 00:12: 13C2-6:2 FTS (59.2%)
- CV 11/17/2020 at 6:43: 13C2-4:2 FTS (66.2%), 13C2-6:2 FTS (55.7%)

For the CCV analyzed on 11/17/2020 at 00:12, the %R value for NFDHA was greater than the upper control limit, at 152%. This analyte was not detected in the associated samples. No qualifiers were applied.

SDG DPWG74815: For the CCV analyzed on 12/4/2020 at 5:49, the %R value for 9Cl-PF3ONS was greater than the upper control limit at 131%. This analyte was not detected in the associated samples. No qualifiers were applied.

SDG DPWG74907: The %R values for one or more labeled standards in each CCV standard were less than the lower control limit. The %R values for the associated native compounds were acceptable. Data was judged as not impacted and no qualifiers were applied. The following outliers were noted:

- CCV 11/16/2020 at 16:29: 13C2-4:2 FTS (64.0%), 13C2-6:2 FTS (60.2%)
- CCV 12/17/2020 at 5:22: 13C2-6:2 FTS (60.2%)
- CCV 12/17/2020 at 7:32: 13C2-6:2 FTS (64.0%)

For the CCV analyzed on 12/17/2020 at 7:32, the %R value for NFDHA was greater than the upper control limit, at 134%. This analyte was not detected in the associated samples. No qualifiers were applied.

Ongoing Precision and Recovery

An ongoing precision and recovery (OPR) laboratory control sample was extracted and analyzed at the proper frequency of one per batch of 20 or fewer samples. With the following exception, recoveries were within the laboratory control limits.

SDG DPWG74671: The %R value for NFDHA (167%) was greater than the upper control limit of 140% indicating a potential high bias. There were no positive results for NFDHA in the associated samples. No qualifiers were applied.

SDG DPWG74815: The OPR concentrations were adjusted for evaporation of the spiking solution. An aliquot of the spiking solution was analyzed as a laboratory internal control sample. The results of this analysis were used as the true values for the evaluation of the OPR extracted with the samples.

Labeled Compounds

Labeled compounds were added to the samples prior to extraction as required by the method. With the exceptions noted below, the recoveries were within the laboratory control limits. For labeled compound outliers, the results for analytes quantitated using that internal standard were qualified. The following outliers were noted:

SDG DPWG74671:

Sample	Labeled Compound	Recovery	Associated Compounds	Bias	Qualifier
HIDDEN_LF01	13C4-PFBA	15.9	PFBA	Low	J-13L
	13C5-PFPeA	47.0	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J/UJ-13L
ROOSEVELT_LF01	13C4-PFBA	25.1	PFBA	Low	J-13L
ROOSEVELT_LF02	13C4-PFBA	11.0	PFBA	Low	J-13L
ROOSEVELT_LF03	13C4-PFBA	17.1	PFBA	Low	J-13L
SUDBURY_LF01	13C4-PFBA	11.6	PFBA	Low	J-13L

SDG DPWG74815:

Sample	Labeled Compound	Recovery	Associated Compounds	BIAS	Qualifier
LRI_LF01	13C4-PFBA	2.60	PBFA	Low	J-13L
	13C5-PFPeA	11.0	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J/UJ-13L
	13C2-PFTeDA	35.30	PFTeDA	Low	J-13L
	13C2-4:2 FTS	15.80	4:2 FTS	Low	UJ-13L
	13C3-HFPO-DA	39.1	HFPO-DA, ADONA, 9Cl-PF3ONS, 11Cl-PF3OUdS	Low	UJ-13L
ASOTIN_LF01	13C2-4:2 FTS	164	4:2 FTS	High	J-13H
NORTHSIDE_LF01	13C2-4:2 FTS	160	4:2 FTS	High	No positive result
PT_ANGELES_LF01	13C4-PFBA	5.0	PBFA	Low	J-13L
	13C5-PFPeA	35.7	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J/UJ-13L
	13C2-4:2 FTS	25.5	4:2 FTS	Low	J-13L

SDG DPWG74907:

Sample	Labeled Compound	Recovery	Associated Compounds	Bias	Qualifier

CATHCART_LF01	13C2-6:2 FTS	45.6	6:2 FTS	Low	J-13L
CEDAR_LF01	13C4-PFBA	2.04	PFBA	Low	J-13L
	13C5-PFPeA	5.24	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J-13L
	13C5-PFHxA	41.5	PFHxA, 5:3 FTCA, 7:3 FTCA, PFEESA, NFDHA	Low	J/UJ-13L
	13C2-PFTeDA	46.4	PFTeDA	Low	J-13L
	13C3-PFBS	47.6	PFBS	Low	J-13L
	13C2-4:2 FTS	14.5	4:2 FTS	Low	UJ-13L
	13C2-6:2 FTS	157.0	6:2 FTS	High	J-13H
	13C3-HFPO-DA	38.1	HFPO-DA, ADONA, 9Cl-PF3ONS, 11Cl- PF3OUdS	Low	UJ-13L
CEDAR_LF02	13C8-PFOS	38.3	PFHpS, PFOS, PFNS, PFDS, PFDoS	Low	J/UJ-13L
	13C2-4:2 FTS	31.1	4:2 FTS	Low	UJ-13L
	13C2-8:2 FTS	38.8	8:2 FTS	Low	UJ-13L
	13C8-PFOSA	20.5	PFOSA	Low	UJ-13L
	D3-N-MeFOSA	15.8	N-MeFOSA	Low	UJ-13L
	D5-N-EtFOSA	14.9	N-EtFOSA	Low	UJ-13L
	D3-MeFOSAA	27.3	MeFOSAA	Low	UJ-13L
	D5-EtFOSAA	21.9	EtFOSAA	Low	UJ-13L
	D7-N-MeFOSE	18.6	N-MeFOSE	Low	J-13L
	D9-N-EtFOSE	16.8	N-EtFOSE	Low	UJ-13L
	13C3-HFPO-DA	30.1	HFPO-DA, ADONA, 9Cl- PF3ONS, 11Cl-PF3OUdS	Low	UJ-13L
	13C4-PFBA	5.3	PFBA	Low	J-13L
	13C5-PFPeA	12.2	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J/UJ-13L
	13C5-PFHxA	39.7	PFHxA, 5:3 FTCA, 7:3 FTCA, PFEESA, NFDHA	Low	J/UJ-13L
	13C9-PFNA	43.6	PFNA	Low	UJ-13L
	13C6-PFDA	31.2	PFDA	Low	J-13L
	13C7-PFUnA	28.2	PFUnA	Low	UJ-13L
CEDAR_LF02	13C2-PFDoA	21.1	PFDoA	Low	UJ-13L
	13C2-PFTeDA	16.3	PFTeDA	Low	UJ-13L
CEDAR_LF03	13C2-6:2 FTS	48.4	6:2 FTS	Low	UJ-13L
CEDAR_LF04	13C4-PFBA	3.07	PFBA	Low	J-13L
	13C5-PFPeA	8.06	PFPeA, 3:3 FTCA, PFMPA, PFMBA	Low	J-13L
	13C5-PFHxA	28.1	PFHxA, 5:3 FTCA, 7:3 FTCA, PFEESA, NFDHA	Low	J/UJ-13L
	13C6-PFDA	42.1	PFDA	Low	UJ-13L
	13C7-PFUnA	39.6	PFUnA	Low	UJ-13L

Laboratory Blanks

A method blank was analyzed at the required frequency of one per batch of 20 or fewer samples. Action levels were established at five times (5x) the concentration reported in the method blank. If a contaminant is reported in an associated field sample and the concentration is less than the action level, the result is qualified as not detected (U-7). No action is taken if the sample result is greater than the action level, or for non-detected results.

SDG DPWG74671: There was a positive result for 6:2 FTS in the method blank. The result for Sample SUDBURY_LF01 was qualified as not detected (U-7) at the reported concentration.

Field Blanks

Two field blanks were submitted. HEADQUARTERS_FIELD_B was collected on 10/6/2020 at the Headquarters Landfill and Rinsate_LF02 was collected on 10/29/2020 at the Roosevelt Landfill. Both had positive results for PFOSA. The highest concentration (HEADQUARTERS_FIELD_B) was used to evaluate all samples. An action level was established at five times (5x) the concentration reported in the field blank. The following sample results were less than the action level and qualified as not detected (U-6).

SDG	SAMPLE	COMPOUND	RESULT (NG/L)	QUALIFIER
DPWG74907	CATHART_LF01	PFOSA	0.271	U-6
	INMAN_LF01	PFOSA	0.361	U-6
	VASHON_LF01	PFOSA	1.84	U-6
	VASHON_LF02	PFOSA	1.24	U-6
	VASHON-LF04B	PFOSA	1.30	U-6
DPWG74815	NORTHSIDE_LF01	PFOSA	1.69	U-6

Laboratory Duplicates

Laboratory duplicates were extracted and analyzed at the required frequency of one per batch. For results greater than 5x the RL, the QAPP specified RPD control limit is 40%. For results less than 5x the RL, the difference between the sample and duplicate must be less than the RL. Laboratory precision was acceptable.

Field Duplicates

For results greater than 5x the RL, the QAPP specified RPD control limit is 40%. For results less than 5x the RL, the difference between the sample and duplicate must be less than the RL.

SDG DPWG74671: One field duplicate was submitted: ROOSEVELT_LF01 & ROOSEVELT_LF03. All field precision criteria were met.

SDG DPWG74907: Two field duplicates were collected with these samples. VASHON_LF02 & VASHON_LF04 and CEDAR_LF02 & CEDAR_LF04. For samples VASHON_LF02 & VASHON_LF04 , the difference value for 6:2 FTS was greater than the RL. Results for this compound in these two samples were estimated (J/UJ-9).

Compound Identification

Relative retention times (RRT), ion abundance ratios, and signal/noise ratios were evaluated for each sample and were acceptable with the following exception:

An EMPC value was reported when a peak was detected but did not meet the ion ratio criteria, indicating an interference on either the quantification or confirmation ions. The laboratory “K” flagged results with ion ratio outliers. These results were qualified as estimated (J-25).

Compound Quantification

SDG DPWG74907: The laboratory method states that for labeled compound recoveries that were less than 10%, but greater than 1%, results for associated compounds are to be reported with an “H” flag. The recoveries for 13C5 PFPeA were greater than 1% in samples CEDAR_LF01 and CEDAR_LF04 Analytes 3:3 FTCA, PFMPA, and PFMBA were originally reported as not quantified (NQ). The lab submitted a revised report and EDD that included results for these compounds with appropriate flagging.

Reporting Limits

For several samples, a smaller sample size was extracted (approximately 60 mL instead of 500 mL) due to the dark color and the presence of particulates. Sample reporting and detection limits were adjusted accordingly. Some detection limits were greater than the QAPP-defined detection limits of 0.5 – 5 parts per trillion.

Calculation Verification

The QAPP requirement of 10% of samples, sample QC, and instrument QC were verified by recalculation from the raw data. No calculation or transcription errors were found.

Overall Assessment

As determined by this evaluation, the laboratory followed the specified analytical method. With the noted exceptions, accuracy was acceptable as demonstrated by the labeled compound and OPR recoveries and precision was acceptable as indicated by laboratory and field duplicate RPD values.

Detection limits were elevated based on method and field blank contamination. Results were estimated based on ion ratio outliers, labeled standard recovery outliers and a field duplicate outlier.

All data, as qualified, are acceptable for use.

State of Washington Landfill Leachate PFAS Study
Total Oxidizable Precursors (TOP) by SGS AXYS Method MLA-111

This report documents the review of analytical data from the analysis of leachate samples and the associated laboratory and field quality control (QC) samples. Samples were analyzed by SGS Axys Laboratories, Sidney, British Columbia, Canada. Refer to the Sample Index for a complete list of samples.

SDG	BATCH	NUMBER OF SAMPLES	VALIDATION LEVEL
DPWG75032	WG74329	9 Leachate, 1 Rinse Blank, 1 Field Duplicates	EPA Stage 4
	WG74821	4 Leachate, 1 Field Duplicate	EPA Stage 4

DATA PACKAGE COMPLETENESS

With the following exceptions, the laboratory submitted all required deliverables. The laboratory followed adequate corrective action processes and all anomalies were discussed in the case narrative.

For the Chain of Custody (COC) Form that listed samples HEADQUARTERS_LF01, VASHON_LF02, and VASHON_LF04B, the relinquish signature and date is missing.

The spike levels for precursors 4:2 FCS, 6:2 FCS, and 8:2 FCS were incorrect on the summary form for OPR WG74329-102. The lab submitted a corrected form.

The “H” flag was missing from the 3,3’ FCTA result for Sample CEDAR-LF01. A revised summary form and EDD were provided.

EDD TO HARDCOPY VERIFICATION

Sample IDs and results reported in the electronic data deliverable (EDD) were verified by comparing the EDD to the hardcopy laboratory data package. No transcription errors were noted; however, corrections were made based on the resubmitted EDD for DPWG75032. The following validation related fields were added: DV Result Value, DV Qualifier, DV Reason Code, Interpretive Qualifier, and DV Label Code.

TECHNICAL DATA VALIDATION

The QC requirements that were reviewed are listed below.

✓	Sample Receipt, Preservation, and Holding Times	1	Field Blanks
✓	Pre-Treatment, Extraction, and Cleanup	1	Laboratory Duplicates
✓	System Performance	✓	Field Duplicates
1	Initial Calibration (ICAL)	2	Compound Identification
1	Continuing Calibration (CCV)	1	Compound Quantification
✓	Ongoing Precision and Recovery (OPR)	1	Reporting Limits
2	Labeled Compound Recovery	✓	Calculation Verification
2	Laboratory Blanks		

✓ Stated method quality objectives (MQO) and QC criteria have been met.
1 Quality control outliers are discussed below, but no data were qualified.
2 Quality control outliers that impact the reported data were noted. Data qualifiers were issued as discussed below.

Sample Receipt, Preservation, and Holding Times

Coolers were received at Axys at temperatures less than 6⍰C. Samples were stored at -20°C upon receipt. Samples were extracted within the holding time of 90 days for frozen aqueous samples and analyzed within the 30-day holding time from extraction to analysis.

Four samples from Batch WG74329 were reextracted because of possible incomplete oxidation. They are reported in this SDG in Batch WG74821. All holding time criteria were met.

Pre-Treatment, Extraction, and Cleanup

For this method, oxidizable poly fluoroalkyl substances (PFAS) are converted into terminal perfluorinated carboxylic acids (PFCAs) through the use of persulfate oxidation and subsequent analysis of perfluorinated carboxylates and sulfonates.

Aqueous samples are oxidized using base and heat activated persulfate. After a pH adjustment, the samples are extracted and cleaned by solid phase extraction (SPE) using weak anion exchange cartridges; wash and elution procedures are chosen to meet various analysis requirements.

System Performance

The instrument is tuned according to the manufacturer’s specifications prior to each initial calibration. All instrument performance criteria were met. Peak asymmetry for PFBA and PFPeA measured in the ICAL midpoint calibration standard were 0.8 to 1.5 at 10% peak height.

Initial Calibration

The initial calibration (ICAL) was analyzed on 11/1/2020. The correct number of calibration standards were analyzed. All requirements for signal to noise ratio, and retention time were met. The percent relative standard deviation (%RSD) values were within the control limit of 20% for native compounds and labeled compounds. Percent recovery (%R) values for each compound and labeled compound in the calibration standards must be within the control limit of 70 to 130%. In cases where this criterion was not met, the standard was not used in the calibration curve.

Continuing Calibration

A continuing calibration verification (CCV) standard was analyzed at the at the beginning and end of each analytical sequence. All requirements for ion abundance ratio, signal to noise ratio, and retention time were met. All percent recovery (%R) values were within the criteria of 70%-130% for native compounds and labeled compounds, with the following exceptions.

The %R values for one or more labeled compounds were greater than the upper control limit. The %R values for the associated native compounds were acceptable. The labeled compounds were associated with precursor compounds only, which were not detected in the field samples. Data was judged as not significantly impacted based on the potential high bias and no qualifiers were applied.

- CCV 12/7/2020 at 20:29: 13C2-4:2 FTS (142%); D7-NMe-FOSE (164%); d9-N-etFOSE (166%)
- CCV 12/8/20 at 3:05: 13C2-4:2 FTS (152%); 13C2-6:2 FTS (147%); 13C2-8:2 FTS (144%); D5-EtFOSAA (136%); d7-NMe-FOSE (190%); d9-NEt-FOSE (194%)
- CCV 12/18/20 at 23:35: 13C2-4:2 FTS (142%)

Ongoing Precision and Recovery

A laboratory control sample was extracted and analyzed at the proper frequency of one per batch of 20 or fewer samples. All %R values were within the laboratory control limits.

The efficiency of oxidation is measured by conversion of model precursor compounds to perfluorinated acids in the OPR. The model precursor concentrations in the OPR should not exceed the method allowable blank limit as defined in the laboratory method. This criterion was met.

Labeled Compounds

Labeled compounds were added to the samples prior to extraction as required by the method. With the exceptions noted below, the recoveries were within the laboratory control limits. For labeled compound outliers, the results for analytes quantitated using that internal standard were qualified. The following outliers were noted:

Batch WG74329:

SAMPLE	LABELED COMPOUND	RECOVERY	ASSOCIATED COMPOUND	BIAS	QUALIFIER
JBLM_LF01	13C4-PFBA	47.7	PFBA	Low	J-13L
	13C2-PFDoA	37.6	PFDoA	Low	J-13L
	13C2-PFTeDA	24.2	PFTeDA	Low	J-13L
CEDAR-LF02	13C4-PFBA	1.54	PFBA	Low	J-13L
	13C5-PFPeA	7.21	PFPeA, 3:3 FTCA	Low	J-13L
SAMPLE	LABELED COMPOUND	RECOVERY	ASSOCIATED COMPOUND	BIAS	QUALIFIER
CEDAR-LF02	13C5-PFHxA	15.3	PFHxA, 5:3 FTCA, 7:3 FTCA	Low	J/UJ-13L
	13C4-PFHpA	28.8	PFHpA	Low	J-13L
	13C3-PFBS	37.8	PFBS	Low	J-13L
	13C4-PFBA	1.98	PFBA	Low	UJ-13L

CEDAR_LF04	13C5-PFPeA	10.1	PFPeA, 3:3 FTCA	Low	J/UJ-13L
	13C5-PFHxA	17.9	PFHxA	Low	J/UJ-13L
	13C4-PFHpA	26.6	PFHpA	Low	J-13L
	13C7-PFUnA	42.8	PFUnA	Low	UJ-13L
	13C2-PFDoA	42.4	PFDoA	Low	UJ-13L
	13C2-PFTeDA	45.6	PFTeDA	Low	UJ-13L
	13C8-PFOS	40.9	PFHpS, PFOS, PFNS, PFDS, PFDoS	Low	UJ-13L
NORTHSIDE_LF01	13C2-PFTeDA	47.5	PFTeDA	Low	UJ-13L
RINSATE_LF02	13C2-PFTeDA	46.3	PFTeDA	Low	UJ-13L
PT_ANGELES_LF01	13C2-PFDoA	47.1	PFDoA	Low	UJ-13L
	13C2-PFTeDA	41.8	PFTeDA	Low	UJ-13L
	13C2-8:2 FTS	155	8:2 FTS	High	J-13H
WARC_LF01	13C2-PFTeDA	45.7	PFTeDA	Low	UJ-13L
VASHON_LF01	13C2-PFDoA	43.0	PFDoA	Low	UJ-13L
	13C2-PFTeDA	39.3	PFTeDA	Low	UJ-13L
VASHON_LF02	13C2-PFDoA	39.3	PFDoA	Low	UJ-13L
	13C2-PFTeDA	36.5	PFTeDA	Low	UJ-13L

Batch WG74821:

SAMPLE	LABELED COMPOUND	RECOVERY	ASSOCIATED COMPOUND	BIAS	QUALIFIER
ROOSEVELT_LF01	13C2-PFTeDA	45.3	PFTeDA	Low	UJ-13L
ROOSEVELT_LF03	13C2-PFTeDA	44.9	PFTeDA	Low	UJ-13L
HEADQUARTERS_LF01	13C2-PFTeDA	49.8	PFTeDA	Low	UJ-13L

Laboratory Blanks

Three method blanks were extracted with each batch. Action levels were established at five times the highest concentration reported in the three blanks. If a contaminant was reported in an associated field sample and the concentration was less than the action level, the result was qualified as not detected (U-7). No action was taken if the sample result was greater than the action level or for non-detected results.

For Batch WG74329, there were positive results for target compounds in two of the three method blanks.

- WG74329-101: PFPeA, PFHxA, and PFOA. Positive results for PFPeA, PFHxA, and PFOA in Sample RINSATE_LF02 were qualified as not detected (U-7).
- WG74329-105: 6:2 FTS. Positive results for 6:2 FTS in Samples ASOTIN_LF01, CEDAR_LF02, CEDAR_LF04, JBLM_LF01, NORTHSIDE_LF01; PT_ANGELES_LF01, VASHON_LF02, VASHON_LF04B, and WARC_LF01 were qualified as not detected (U-7).

Field Blanks

One field blank was collected with these samples. Rinsate_LF02 was collected on 10/29/2020 at the Roosevelt Landfill and was used to evaluate all samples in this SDG. After qualification based on method blank contamination, there were no target analytes detected in this blank.

Laboratory Duplicates

Batch WG74329: All samples were initially extracted and analyzed in Batch WG74329. One laboratory duplicate sample was extracted using sample HEADQUARTERS_LF01 (WG74329-103); however, this sample did not oxidize properly and was re-extracted and re-analyzed in another batch (WG74821). Therefore, there is no laboratory duplicate associated with this batch.

Field Duplicates

For results greater than 5x the RL, the QAPP specified RPD control limit is 40%. For results less than 5x the RL, the difference between the sample and duplicate must be less than the RL.

Batch WG74329: One field duplicate was collected with these samples: VASHON_LF02 & VASHON_LF04. Precision was acceptable.

Batch WG74821: One field duplicate was collected with these samples: ROOSEVELT_LF01 & ROOSEVELT_LF03: Precision was acceptable.

Compound Identification

Relative retention times (RRT), ion abundance ratios, and signal/noise ratios were evaluated for each sample and were acceptable with the following exception:

An EMPC value was reported when a peak was detected but did not meet the ion ratio criteria, indicating an interference on either the quantification or confirmation ions. The laboratory “K” flagged results with ion ratio outliers. These results were qualified as estimated (J-25).

The efficiency of oxidation is measured by conversion of model precursor compounds to perfluorinated acids in the OPR. The model precursor concentrations in the samples should not exceed the method allowable blank limit as defined in the laboratory method. This criterion was met.

Compound Quantitation

For several samples in Batch WG74821, a smaller sample size was extracted (approximately 6 mL instead of 60 mL). Sample reporting and detection limits were adjusted accordingly.

Some detection limits were greater than the QAPP-defined detection limits of 0.5 – 5 parts per trillion.

For Sample CEDAR_LF04, approximately 30 mL out of 500 mL of the sample did not pass through the SPE. Some surrogate recoveries were low and qualified as described above. Since the loss occurred after the addition of labeled surrogate compounds and the isotope dilution quantification procedure adjusts for losses of target compounds, no further action was taken.

Calculation Verification

The QAPP requirement of 10% of samples, sample QC, and instrument QC were verified by recalculation from the raw data. No calculation or transcription errors were found.

OVERALL ASSESSMENT

As determined by this evaluation, the laboratory followed the specified analytical method. With the noted exceptions, accuracy was acceptable as demonstrated by the labeled compound and OPR recoveries and precision was acceptable as demonstrated by the laboratory and field duplicate RPD values.

Detection limits were elevated based on method and field blank contamination. Results were estimated based on ion ratio outliers and labeled compound recovery outliers.

All data, as qualified, are acceptable for use.

ECOCHEM
Data Quality

APPENDIX 1

To Data Validation Report

Definitions, Codes and Criteria

DATA QUALIFIER DEFINITIONS, REASON CODES AND CRITERIA TABLES, and DATA VALIDATION QUALIFIER CODES are based on National Functional Guidelines

DATA QUALIFIER DEFINITIONS

The following definitions provide brief explanations of the qualifiers assigned to results in the data review process.

U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents the approximate concentration.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

The following is an EcoChem qualifier that may also be assigned during the data review process:

DNR	Do not report; a more appropriate result is reported from another analysis or dilution.

DATA QUALIFIER REASON CODES

Group	Code	Reason for Qualification
Sample Handling	1	Improper Sample Handling or Sample Preservation (i.e., headspace, cooler temperature, pH, summa canister pressure); Exceeded Holding Times
Instrument Performance	24	Instrument Performance (i.e., tune, resolution, retention time window, endrin breakdown, lock-mass)
	5A	Initial Calibration (RF, %RSD, r^2)
	5B	Calibration Verification (CCV, CCAL; RF, %D, %R) Use bias flags (H,L)[1] where appropriate
	5C	Initial Calibration Verification (ICV %D, %R) Use bias flags (H,L)[1] where appropriate
Blank Contamination	6	Field Blank Contamination (Equipment Rinsate, Trip Blank, etc.)
	7	Lab Blank Contamination (i.e., method blank, instrument blank, etc.) Use low bias flag (L)[1] for negative instrument blanks
Precision and Accuracy	8	Matrix Spike (MS and/or MSD) Recoveries Use bias flags (H,L)[1] where appropriate
	9	Precision (all replicates: LCS/LCSD, MS/MSD, Lab Replicate, Field Replicate)
	10	Laboratory Control Sample Recoveries (a.k.a. Blank Spikes) Use bias flags (H,L)[1] where appropriate
	12	Reference Material Use bias flags (H,L)[1] where appropriate
	13	Surrogate Spike Recoveries (a.k.a. labeled compounds, recovery standards) Use bias flags (H,L)[1] where appropriate
Interferences	16	ICP/ICP-MS Serial Dilution Percent Difference
	17	ICP/ICP-MS Interference Check Standard Recovery Use bias flags (H,L)[1] where appropriate
	19	Internal Standard Performance (i.e., area, retention time, recovery)
	22	Elevated Detection Limit due to Interference (i.e., chemical and/or matrix)
	23	Bias from Matrix Interference (i.e. diphenyl ether, PCB/pesticides)
Identification and Quantitation	2	Chromatographic pattern in sample does not match pattern of calibration standard
	3	2nd column confirmation (RPD or %D)
	4	Tentatively Identified Compound (TIC) (associated with NJ only)
	20	Calibration Range or Linear Range Exceeded
	25	Compound Identification (i.e., ion ratio, retention time, relative abundance, etc.)
Miscellaneous	11	A more appropriate result is reported (multiple reported analyses i.e., dilutions, re- extractions, etc. Associated with “R” and “DNR” only)
	14	Other (See DV report for details)
	26	Method QC information not provided

[1] H = high bias indicated L = low bias indicated

DATA VALIDATION CRITERIA

Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-110/REV 02 Ver 08)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Sample Handling					
Cooler/Storage Temperature Preservation	High density polyethylene (HDPE) or amber glass containers Store at 0-4°C (dark) from collection (AFFF[5]: Room Temperature)	AXYS MSU-110[1]	J (pos)/UJ (ND) if greater than 4° C	1	Use **PJ** for temp outliers; see **TM20** Also see AXYS Analyte Stability Study
Holding Time	**Extraction:** stored frozen <-20°C: Aqueous=90 days; Solid=1 year; Tissue=1 year; blood/serum=1 year (AFFF[5] stored 0-4°C, 90 days) **Analysis**: stored < 4°C: 30 days from extraction	AXYS MSU-110[1]	J (pos)/UJ (ND) if HT exceeded J (pos)/R (ND) if gross exceedance (> 2x HT)	1	If samples are not frozen, EPA Method 8327[4] suggests holding time of 28 days from collection to extraction.
Instrument Performance					
Tuning - IDP (Initial demonstration of Proficiency)	Prior to initial calibration Valid mass calibration following manufacturer specified procedure. For PFBA and PFPeA in Cal E Standard of ICAL: 0.8 - 1.5 at 10% of peak height.	AXYS MSU-110[1]	PM contact lab		Lab required to perform instrument maintenance if criteria not met.
Initial Calibration (Cal B - Cal J)	Minimum 5 standards: %RSD of RRF< 20.0% 70-130%R for analytes and surrogates at each concentration level 3:1 S/N for quantification ion and confirmation ion	AXYS MSU-110[1]	J (pos) if %RSD > 20%	5A	Laboratory uses 9 standards for ICAL. Highest standards can be dropped if the %R criteria is not met.
Instrument Sensitivity Check (ICS)	Prior to analysis and every 12 hours 3:1 S/N for quantification ion	AXYS MSU-110[1]	Evaluate detection limits		

Initial Calibration Verification (ICV)	Second Source analyzed immediately following calibration Concentration similar to Cal E. %R = 70-130%	AXYS MSU-110[1]	J (pos) if %R >130% and high bias J (pos)/UJ (ND) if %R < 70% and low bias	5A (H,L)[3]	

Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-110/REV 02 Ver 08)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Retention Time Window Position Establishment	Use midpoint standard in ICAL or daily initial CCV standard to set retention times for each native and labeled compound. Retention time window = ±0.4 minutes Native standards must elute within 0.1 minutes of exact corresponding isotopically labeled analogs	AXYS MSU-110[1]	PJ if criteria not met		
Continuing Calibration Verification (CCV)	Beginning and end of analytical sequence and every 12 hours %D <30% (%R = 70-130%) Ratio of primary to secondary product ion responses of the total branced and linear isomers must fall within ±50% of ratio observed in ICAL midpoint (only where suitable secondary transitions are available).	AXYS MSU-110[1]	J (pos) if %D >30% and high bias J (pos)/UJ (ND) if %D > 30% and low bias PJ if ratio criteria not met	5B (H,L)[3]	
Blank Contamination					
Method Blank (MB)	MB: One per matrix per batch of (of ≤ 20 samples) No detected compounds > MDL	EcoChem standard policy	U(pos) if sample result is < 5X blank concentration EMPC in blank treated as non-detect	7	***Hierarchy of blank review: #1 - Review MB, qualify as needed #2 - Review FB , qualify as needed***
Field Blank (FB)	No detected compounds > MDL	EcoChem standard policy	U(pos) if sample result is < 5X blank concentration	6	

			EMPC in blank treated as non-detect		
Instrument Blank/ Instrument Carryover	0.3% carryover from CCV into Instrument Blank or from any sample into following sample	EcoChem standard policy	PJ: J(pos)		Lab should rerun any impacted samples. Discuss any issues with PM
Precision and Accuracy					
Ongoing Precision and Recovery (OPR or LCS)	One per lab batch (of ≤ 20 samples) Laboratory control limits Ratio of primary to secondary product ion responses must be ±50% of the same ratio in the ICAL midpoint standard (not applicable for some compounds)	AXYS MSU-110[1]	Qualify all associated samples J(pos) if %R > UCL J(pos)/UJ(ND) if %R < LCL J(pos)/R(ND) if %R < 10% - very low bias	*10 (H,L) [3]*	QAPP may have overriding accuracy limits. Qualify all associated samples. Discuss any rejected data with PM for PJ

Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-110/REV 02 Ver 08)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Reference Material (RM, SRM, or CRM)	Not required Result ± 20% of the 95% confidence interval of the true value for analytes	EcoChem standard policy[2]	J (pos)/UJ (ND) if < LCL J (pos) if > UCL	12 (H,L)[3]	QAPP may have overriding accuracy limits. Some manufacturers have different RM control limits
MS/MSD	Not required	AXYS MSU-110[1]	NA		Precision measured by laboratory duplicate Accuracy measured by OPR and Surrogates
Laboratory Duplicate	one set per matrix per batch (of ≤ 20 samples)	AXYS MSU-110[1] EcoChem standard policy[2]	J(pos) in parent sample: For conc > 5x LOQ, RPD < 40% For conc < 5x LOQ, RPD < 100%[1] or Diff < 1x LOQ (Aqueous), < 2x LOQ (solid)[2]	9	Qualify parent sample only. QAPP may have overriding precision limits.

Recovery Standards	Added prior to analysis External Standard quantitation 50%-200% recovery	AXYS MSU-110[1]	No action Note: Recovery Standard %R values are not reported on summary forms.		Recovery standards are used to quantitate surrogates. Qualifiers are not applied to surrogates. If criteria is grossly exceeded, discuss PJ with PM
Surrogates	Added prior to extraction Internal standard quantitation using Recovery Standards %R = 70-130% for standards Lab Limits[1] for field samples and prep QC Samples	AXYS MSU-110[1]	J (pos) if %R > UCL J (pos)/UJ (ND) if %R < LCL J (pos)/R (ND) if %R < 10%	13 (H,L)[3]	Qualify all associated compounds. Discuss any rejected data with PM for PJ
Field Duplicates	Aqueous: RPD < 35% OR difference < 1X LOQ (for results < 5X LOQ) Solids: RPD < 50% OR difference < 2X LOQ (for results < 5X LOQ)	EcoChem standard policy	J (pos)/UJ (ND) Qualify only parent and field duplicate samples	9	Use project limits if specified

Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-110/REV 02 Ver 08)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Compound Identification and Calculation					
Retention times and signal to-noise	Native analyte, surrogate, and recovery standard analyte RTs must fall within ±0.4 minutes of the predicted retention times from the midpoint standard of the ICAL or initial daily CCV Native standards must elute within 0.1 minutes of exact corresponding isotopically lableled analogs	AXYS MSU-110[1]	U (pos) if identification criteria not met	*25*	
EMPC (estimated maximum possible concentration)	If quantitation identification criteria are not met, laboratory should report an EMPC value.	AXYS MSU-110[1]	Qualify sample results J(pos)	25	
Calibration Range	Results greater than highest calibration standard	EcoChem standard policy[2]	Qualify J (pos)	20	If result from dilution analysis is not reported.
Electronic Data Deliverable (EDD)					

Verification of EDD to hardcopy data	Verify 10%. Increase if problems found.	EcoChem standard policy[2]	Discuss inconsistencies with PM		QAPP may have overriding requirements.
Dilutions, Re-extractions and/or Reanalyses	Report only one result per analyte	EcoChem standard policy[2]	Use "DNR" to flag results that will not be reported.	11	**TM-04** EcoChem Policy for Rejection/Selection Process for Multiple Results

[1] *AXYS MSU-110 (Rev 17, 12/2/20). Summary of AXYS MLA-110 (Rev 02, Ver 08) Analytical Procedure for the Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples, Solids, tissues, AFFF Products, Blood/Serums and Solvent Extracts by LC- MS/MS (Lab does not share full method)*

[2] *EcoChem Standard Policy*

[3] *EcoChem has chosen "H" = high bias indicated; "L" = low bias indicated.*

[4] *Method 8327: Proposed Per- and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). June 2019.*

[5] AFFF = aqueous film forming foams

Total Oxidizable Precursors (TOP) for Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography- Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-111/REV 03 Ver 01)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Sample Handling					
Cooler/Storage Temperature Preservation	High density polyethylene (HDPE) or amber glass containers Store at 0-4°C (dark) from collection (AFFF[5]: Room Temperature)	AXYS MSU-111[1]	J (pos)/UJ (ND) if greater than 4° C	1	Use **PJ** for temp outliers; see **TM20** Also see AXYS Analyte Stability Study
Holding Time	**Extraction:** stored frozen <-20°C: Aqueous=90 days; Solid=1 year; Biosolid=1 year (AFFF[5] stored 0-4°C, 90 days) **Analysis**: stored < 4°C: 30 days from extraction	AXYS MSU-111[1]	J (pos)/UJ (ND) if HT exceeded J (pos)/R (ND) if gross exceedance (> 2x HT)	1	If samples are not frozen, EPA Method 8327[4] suggests holding time of 28 days from collection to extraction.
Instrument Performance					
Tuning - IDP (Initial Demonstration of Proficiency)	Prior to initial calibration Valid mass calibration following manufacturer specified procedure. For PFBA and PFPeA in Cal E Standard of ICAL: 0.8 - 1.5 at 10% of peak height.	AXYS MSU-111[1]	PM contact lab		Lab required to perform instrument maintenance if criteria not met.

Initial Calibration (Cal B - Cal J)	Minimum 6 standards: %RSD of RRF< 20.0% 70-130%R for analytes and surrogates at each concentration level 3:1 S/N for quantification ion and confirmation ion	AXYS MSU-111[1]	J (pos) if %RSD > 20%	5A	Laboratory uses 9 standards for ICAL. Highest standards can be dropped if the %R criteria is not met.
Instrument Sensivity Check (ICS)	Prior to analysis and every 12 hours 3:1 S/N for quantification ion	AXYS MSU-111[1]	Evaluate detection limits		
Initial Calibration Verification (ICV)	Second Source analyzed immediately following calibration Concentration similar to Cal E. %R = 70-130% Ion ratios: 50-150% (PFNS 50-200%) of ratios determined from CAL E in ICAL	AXYS MSU-111[1]	J (pos) if %R >130% and high bias J (pos)/UJ (ND) if %R < 70% and low bias	5A (H,L)[3]	

Total Oxidizable Precursors (TOP) for Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography- Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-111/REV 03 Ver 01)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Retention Time Window Position Establishment	Use midpoint standard in ICAL or daily initial CCV standard to set retention times for each native and labeled compound. Retention time window = ±0.4 minutes Native standards must elute within 0.1 minutes of exact corresponding isotopically lableled analogs	AXYS MSU-111[1] & MSU-110[6]	PJ if criteria not met		
Continuing Calibration Verification (CCV)	Beginning and end of analytical sequence and every 12 hours %D <30% (%R = 70-130%) Ratio of primary to secondary product ion responses of the total branced and linear	AXYS MSU-111[1]	J (pos) if %D >30% and high bias J (pos)/UJ (ND) if %D > 30% and low bias PJ if ratio criteria not met	5B (H,L)[3]	

	isomers must fall within 50-150% (50- 200% for PFNS) of ratio observed in ICAL midpoint (only where suitable secondary transitions are available).				
Blank Contamination					
Method Blank (MB)	MB: One per matrix per batch of (of ≤ 20 samples) No detected compounds > MDL	EcoChem standard policy	U(pos) if sample result is < 5X blank concentration EMPC in blank treated as non-detect	7	***Hierarchy of blank review: #1 - Review MB, qualify as needed #2 - Review FB , qualify as needed***
Field Blank (FB)	No detected compounds > MDL	EcoChem standard policy	U(pos) if sample result is < 5X blank concentration EMPC in blank treated as non-detect	6	
Instrument Blank/ Instrument Carryover	If any sample concentrations exceed the highest allowed standard and the sample(s) following exceed this acceptance criteria (>½ C-CAL), they must be reanalyzed.	AXYS MSU-111[1]	PJ: J(pos)		Lab should rerun any impacted samples. Discuss any issues with PM
Precision and Accuracy					
Ongoing Precision and Recovery (OPR or LCS)[7]	One per lab batch (of ≤ 20 samples) Laboratory control limits Ratio of primary to secondary product ion responses must be ±50% of the same ratio in the ICAL midpoint standard (not applicable for some compounds)	AXYS MSU-111[1] & MSU-110[6]	Qualify all associated samples J(pos) if %R > UCL J(pos)/UJ(ND) if %R < LCL J(pos)/R(ND) if %R < 10% - very low bias	*10 (H,L)* [3]	QAPP may have overriding accuracy limits. Qualify all associated samples. Discuss any rejected data with PM for PJ
Reference Material (RM, SRM, or CRM)	Not required Result ± 20% of the 95% confidence interval of the true value for analytes	EcoChem standard policy[2]	J (pos)/UJ (ND) if < LCL J (pos) if > UCL	12 (H,L)[3]	QAPP may have overriding accuracy limits. Some manufacturers have different RM control limits

Total Oxidizable Precursors (TOP) for Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography- Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-111/REV 03 Ver 01)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
MS/MSD	Not required	AXYS MSU-111[1]	NA		Precision measured by laboratory duplicate Accuracy measured by OPR and Surrogates
Laboratory Duplicate	One set per matrix per batch (of ≤ 20 samples) (If there is enough sample)	AXYS MSU-111[1] & MSU-110[6] EcoChem standard policy[2]	J(pos) in parent sample: For conc > 5x LOQ, RPD < 40% For conc < 5x LOQ, RPD < 100%[1] or Diff < 1x LOQ (Aqueous), < 2x LOQ (solid)[2]	9	Qualify parent sample only. QAPP may have overriding precision limits.
Recovery Standards	Added prior to analysis External Standard quantitation 50%-200% recovery	AXYS MSU-110[1]	No action Note: Recovery Standard %R values are not reported on summary forms.		Recovery standards are used to quantitate surrogates. Qualifiers are not applied to surrogates. If criteria is grossly exceeded, discuss PJ with PM
Extraction Surrogates	Added prior to oxidation Internal standard quantitation using Recovery Standards %R = 70-130% for standards Lab Limits[1] (50-150%) for field samples and prep QC Samples	AXYS MSU-111[1]	J (pos) if %R > UCL J (pos)/UJ (ND) if %R < LCL J (pos)/R (ND) if %R < 10%	13 (H,L)[3]	Qualify all associated compounds. Discuss any rejected data with PM for PJ

Quantification Surrogates	Added after pH adjustment, before extraction Internal standard quantitation using Recovery Standards %R = 70-130% for standards Lab Limits[1] for field samples and prep QC Samples	AXYS MSU-111[1]	J (pos) if %R > UCL J (pos)/UJ (ND) if %R < LCL J (pos)/R (ND) if %R < 10%	13 (H,L)[3]	Qualify all associated compounds. Discuss any rejected data with PM for PJ
Field Duplicates	Aqueous: RPD < 35% OR difference < 1X LOQ (for results < 5X LOQ) Solids: RPD < 50% OR difference < 2X LOQ (for results < 5X LOQ)	EcoChem standard policy[2]	J (pos)/UJ (ND) Qualify only parent and field duplicate samples	9	Use project limits if specified

Total Oxidizable Precursors (TOP) for Per- and Polyfluorinated Alkyl Compounds by Isotope Dilution and Solid Phase Extraction and Liquid Chromatography- Tandem Mass Spectrometry (LC-MS/MS)

(Based on SGS AXYS Method MLA-111/REV 03 Ver 01)

QC Element	Acceptance Criteria	Source of Criteria	Action for Non-Conformance	Reason Code	Discussion and Comments
Compound Identification and Calculation					
Retention times and signal-to-noise	Native analyte, surrogate, and recovery standard analyte RTs must fall within ±0.4 minutes of the predicted retention times from the midpoint standard of the ICAL or initial daily CCV Native standards must elute within 0.1 minutes of exact corresponding isotopically lableled analogs	AXYS MSU-111[1] & MSU-110[6]	U (pos) if identification criteria not met	*25*	
EMPC (estimated maximum possible concentration)	If quantitation identification criteria are not met, laboratory should report an EMPC value.	AXYS MSU-110[1]	Qualify sample results J(pos)	25	
Oxidation[7]	Model precursor concentrations in the OPR and samples should not exceed the method allowable blank limit	AXYS MSU-111[1]	PJ if criteria not met		

Calibration Range	Results greater than highest calibration standard	EcoChem standard policy[2]	Qualify J (pos)	20	If result from dilution analysis is not reported.
Electronic Data Deliverable (EDD)					
Verification of EDD to hardcopy data	Verify 10%. Increase if problems found.	EcoChem standard policy[2]	Discuss inconsistencies with PM		QAPP may have overriding requirements.
Dilutions, Re-extractions and/or Reanalyses	Report only one result per analyte	EcoChem standard policy[2]	Use "DNR" to flag results that will not be reported.	11	TM-04 EcoChem Policy for Rejection/Selection Process for Multiple Results

AXYS MSU-111 (Rev 087, 12/4/20). Summary of AXYS MLA-111 (Rev 02, Ver 01) Total Oxidizable Precursors (TOP) in Aqueous and

[1] *Solid Matrices. Analytical Procedure for the Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples, Solids, tissues, AFFF Products, Blood/Seryms and Solvent Extracts by LC-MS/MS (Lab does not share full method)*

[2] *EcoChem Standard Policy*

[3] *EcoChem has chosen "H" = high bias indicated; "L" = low bias indicated.*

[4] *Method 8327: Proposed Per- and Polyfluoroalkyl Substances (PFAS) Using External Standard Calibration and Multiple Reaction Monitoring (MRM) Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). June 2019.*

[5] AFFF = aqueous film forming foams *(pos): Positive Result(s) (ND): Non-detects*

[6] *AXYS MSU-110 (Rev 17, 12/2/20). Summary of AXYS MLA-110 (Rev 02, Ver 08) Analytical Procedure for the Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous Samples, Solids, tissues, AFFF Products, Blood/Seryms and Solvent Extracts by LC-MS/MS (Lab does not share full method)*

[7] During the oxidation procedure the model precursors in the OPR react to form terminal perfluorinated acids. Recovery values of the perfluorinated acids spiked plus the predicted reaction products are determined to quantify recovery and used as indication of overall method performance

APPENDIX 2

To Data Validation Report

QUALIFIED DATA SUMMARY TABLES

Qualified Data Summary Table

State of Washington Landfill Leachate PFAS Study

Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
CATHCART_LF01	L33825-11	MLA-110 Rev 02	6:2 FTS	3.03	ng/L		J	13L
CATHCART_LF01	L33825-11	MLA-110 Rev 02	PFOSA	0.271	ng/L	J	U	6
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFBA	4570	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFPeA	2010	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFHxA	9300	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFTeDA	7.28	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFBS	10700	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFDoS	23	ng/L	K	J	25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	4:2 FTS	20.2	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	6:2 FTS	639	ng/L		J	13H
CEDAR_LF01	L33825-12	MLA-110 Rev 02	HFPO-DA	6.35	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	ADONA	5.33	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	9Cl-PF3ONS	5.35	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	11Cl-PF3OUdS	5.34	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	3:3 FTCA	514	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	5:3 FTCA	94100	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	7:3 FTCA	38900	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFEESA	5.25	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFMPA	3.61	ng/L	J,H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFMBA	9.45	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	NFDHA	11	ng/L	U	UJ	13L
CEDAR_LF03	L33825-14	MLA-110 Rev 02	6:2 FTS	0.705	ng/L	U	UJ	13L
INMAN_LF01	L33825-16	MLA-110 Rev 02	PFBA	111	ng/L		J	13L
INMAN_LF01	L33825-16	MLA-110 Rev 02	PFOSA	0.361	ng/L	J	U	6
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	PFBA	1130	ng/L		J	13L
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	PFTeDA	1.3	ng/L	U	UJ	13L
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	NFDHA	7.01	ng/L	K J	J	25
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFBA	1400	ng/L		J	13L
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFDoA	6.46	ng/L	K	J	25
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFTeDA	1.31	ng/L	U	UJ	13L
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	NFDHA	7.9	ng/L	K J	J	25
TENNANT_LF01	L33825-4	MLA-110 Rev 02	PFBA	3250	ng/L		J	13L
WARC_LF01	L33825-5	MLA-110 Rev 02	PFDoA	3.36	ng/L	K J	J	25
WARC_LF01	L33825-5	MLA-110 Rev 02	NFDHA	4.75	ng/L	K J	J	25

VASHON_LF01	L33825-6	MLA-110 Rev 02	6:2 FTS	10.8	ng/L	J	J	13L
VASHON_LF01	L33825-6	MLA-110 Rev 02	PFOSA	1.84	ng/L	J	U	6
VASHON_LF02	L33825-7	MLA-110 Rev 02	PFBA	127	ng/L		J	13L
VASHON_LF02	L33825-7	MLA-110 Rev 02	6:2 FTS	0.675	ng/L	U	UJ	9
VASHON_LF02	L33825-7	MLA-110 Rev 02	PFOSA	1.24	ng/L		U	6
VASHON_LF04B	L33825-8	MLA-110 Rev 02	PFBA	125	ng/L		J	13L
VASHON_LF04B	L33825-8	MLA-110 Rev 02	6:2 FTS	7.16	ng/L		J	9,13L
VASHON_LF04B	L33825-8	MLA-110 Rev 02	PFOSA	1.3	ng/L		U	6
ASOTIN_LF01	L33897-1 R	MLA-110 Rev 02	4:2 FTS	9.86	ng/L	J	J	13H
Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
CATHCART_LF01	L33825-11	MLA-110 Rev 02	6:2 FTS	3.03	ng/L		J	13L
CATHCART_LF01	L33825-11	MLA-110 Rev 02	PFOSA	0.271	ng/L	J	U	6
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFBA	4570	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFPeA	2010	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFHxA	9300	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFTeDA	7.28	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFBS	10700	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFDoS	23	ng/L	K	J	25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	4:2 FTS	20.2	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	6:2 FTS	639	ng/L		J	13H
CEDAR_LF01	L33825-12	MLA-110 Rev 02	HFPO-DA	6.35	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	ADONA	5.33	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	9Cl-PF3ONS	5.35	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	11Cl-PF3OUdS	5.34	ng/L	U	UJ	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	3:3 FTCA	514	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	5:3 FTCA	94100	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	7:3 FTCA	38900	ng/L		J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFEESA	5.25	ng/L	K J	J	13L,25
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFMPA	3.61	ng/L	J,H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	PFMBA	9.45	ng/L	H	J	13L
CEDAR_LF01	L33825-12	MLA-110 Rev 02	NFDHA	11	ng/L	U	UJ	13L
CEDAR_LF03	L33825-14	MLA-110 Rev 02	6:2 FTS	0.705	ng/L	U	UJ	13L
INMAN_LF01	L33825-16	MLA-110 Rev 02	PFBA	111	ng/L		J	13L
INMAN_LF01	L33825-16	MLA-110 Rev 02	PFOSA	0.361	ng/L	J	U	6
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	PFBA	1130	ng/L		J	13L
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	PFTeDA	1.3	ng/L	U	UJ	13L
HEADQUARTERS_LF02	L33825-2 (A)	MLA-110 Rev 02	NFDHA	7.01	ng/L	K J	J	25
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFBA	1400	ng/L		J	13L
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFDoA	6.46	ng/L	K	J	25
HEADQUARTERS_LF01	L33825-3	MLA-110 Rev 02	PFTeDA	1.31	ng/L	U	UJ	13L
HEADQUARTERS_LF0	L33825-3	MLA-110 Rev 02	NFDHA	7.9	ng/L	K J	J	25

1								
TENNANT_LF01	L33825-4	MLA-110 Rev 02	PFBA	3250	ng/L		J	13L
WARC_LF01	L33825-5	MLA-110 Rev 02	PFDoA	3.36	ng/L	K J	J	25
WARC_LF01	L33825-5	MLA-110 Rev 02	NFDHA	4.75	ng/L	K J	J	25
VASHON_LF01	L33825-6	MLA-110 Rev 02	6:2 FTS	10.8	ng/L	J	J	13L
VASHON_LF01	L33825-6	MLA-110 Rev 02	PFOSA	1.84	ng/L	J	U	6
VASHON_LF02	L33825-7	MLA-110 Rev 02	PFBA	127	ng/L		J	13L
VASHON_LF02	L33825-7	MLA-110 Rev 02	6:2 FTS	0.675	ng/L	U	UJ	9
VASHON_LF02	L33825-7	MLA-110 Rev 02	PFOSA	1.24	ng/L		U	6
VASHON_LF04B	L33825-8	MLA-110 Rev 02	PFBA	125	ng/L		J	13L
VASHON_LF04B	L33825-8	MLA-110 Rev 02	6:2 FTS	7.16	ng/L		J	9,13L
VASHON_LF04B	L33825-8	MLA-110 Rev 02	PFOSA	1.3	ng/L		U	6
ASOTIN_LF01	L33897-1 R	MLA-110 Rev 02	4:2 FTS	9.86	ng/L	J	J	13H

Qualified Data Summary Table

State of Washington Landfill Leachate PFAS Study

Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
ROOSEVELT_LF01	L33935-1	MLA-110 Rev 02	PFBA	5130	ng/L		J	13L
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	PFBA	3090	ng/L		J	13L
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	PFPeA	2880	ng/L		J	13L
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	PFUnA	2.61	ng/L	K J	J	25
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	3:3 FTCA	247	ng/L		J	13L
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	PFMPA	2.63	ng/L	U	UJ	13L
HIDDEN_LF01	L33852-1 (A)	MLA-110 Rev 02	PFMBA	2.26	ng/L	J	J	13L
SUDBURY_LF01	L33897-3	MLA-110 Rev 02	PFBA	914	ng/L		J	13L
SUDBURY_LF01	L33897-3	MLA-110 Rev 02	PFTrDA	0.368	ng/L	K J	J	25
SUDBURY_LF01	L33897-3	MLA-110 Rev 02	6:2 FTS	23	ng/L	B	U	7
ROOSEVELT_LF02	L33935-2	MLA-110 Rev 02	PFBA	5030	ng/L		J	13L
ROOSEVELT_LF03	L33935-3	MLA-110 Rev 02	PFBA	5210	ng/L		J	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFBA	5600	ng/L	H	J	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFPeA	1290	ng/L		J	13L
ASOTIN_LF01	L33897-1 R	MLA-110 Rev 02	PFMPA	3.49	ng/L	K J	J	25
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFTrDA	3.79	ng/L	K J	J	25
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFTeDA	2.93	ng/L	J	J	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	4:2 FTS	20.7	ng/L	K J	J	13L,25
LRI_LF01	L33852-2 R	MLA-110 Rev 02	HFPO-DA	5.48	ng/L	U	UJ	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	ADONA	5.77	ng/L	U	UJ	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	9Cl-PF3ONS	5.78	ng/L	U	UJ	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	11Cl-PF3OUdS	5.77	ng/L	U	UJ	13L
LRI_LF01	L33852-2 R	MLA-110 Rev 02	3:3 FTCA	116	ng/L	K	J	13L,25
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFMPA	19.5	ng/L	K	J	13L,25
LRI_LF01	L33852-2 R	MLA-110 Rev 02	PFMBA	4.26	ng/L	J	J	13L

NORTHSIDE_LF01	L33897-2 R	MLA-110 Rev 02	PFOSA	1.69	ng/L	J	U	6
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	PFBA	1750	ng/L	H	J	13L
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	PFPeA	1730	ng/L		J	13L
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	4:2 FTS	10.1	ng/L		J	13L
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	3:3 FTCA	231	ng/L		J	13L
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	PFMPA	1.68	ng/L	K	J	13L,25
PT_ANGELES_LF01	L33991-1 (A)	MLA-110 Rev 02	PFMBA	1.96	ng/L		J	13L
JBLM_LF01	L33825-10 R	MLA-110 Rev 02	PFUnA	3.44	ng/L	K J	J	25
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFBA	1210	ng/L	H	J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFPeA	308	ng/L		J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFHxA	781	ng/L		J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFNA	38	ng/L	K	J	13L,25
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFDA	4.27	ng/L	J	J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFUnA	1.5	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFTeDA	2.65	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFHpS	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFOS	33.7	ng/L		J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFNS	1.36	ng/L	U	UJ	13L

Qualified Data Summary Table

State of Washington Landfill Leachate PFAS Study

Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFDS	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFDoS	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	4:2 FTS	8.52	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	8:2 FTS	5.45	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFOSA	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	N-MeFOSA	1.57	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	N-EtFOSA	3.4	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	MeFOSAA	4.1	ng/L	K J	J	13L,25
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	EtFOSAA	2.04	ng/L	K J	J	13L,25
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	N-MeFOSE	31.3	ng/L	J	J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	N-EtFOSE	10.2	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	HFPO-DA	5.17	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	ADONA	5.45	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	9Cl-PF3ONS	5.46	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	11Cl-PF3OUdS	5.45	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	3:3 FTCA	56.4	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	5:3 FTCA	190	ng/L		J	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	7:3 FTCA	34	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFEESA	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFMPA	3.09	ng/L	U	UJ	13L

CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	PFMBA	1.36	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 R (A)	MLA-110 Rev 02	NFDHA	6.81	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFBA	1180	ng/L	H	J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFPeA	347	ng/L	H	J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFHxA	886	ng/L		J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFNA	59.8	ng/L	K	J	25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFDA	7.07	ng/L	K	J	13L,25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFUnA	2.1	ng/L	K J	J	13L,25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFDoA	1.22	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFTeDA	1.54	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFHpS	1.49	ng/L	J	J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFOS	38.9	ng/L		J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFNS	1.22	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFDS	1.22	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFDoS	1.22	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	4:2 FTS	8.6	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	8:2 FTS	4.89	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFOSA	1.22	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	N-MeFOSA	1.41	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	N-EtFOSA	3.06	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	MeFOSAA	5.76	ng/L		J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	EtFOSAA	6.22	ng/L	K	J	13L,25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	N-MeFOSE	37.3	ng/L	J	J	13L

Qualified Data Summary Table

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Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	N-EtFOSE	9.15	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	HFPO-DA	5.57	ng/L	K J	J	13L,25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	ADONA	4.89	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	9Cl-PF3ONS	4.9	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	11Cl-PF3OUdS	4.9	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	3:3 FTCA	47.5	ng/L	K,H	J	13L,25
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	5:3 FTCA	314	ng/L		J	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	7:3 FTCA	30.6	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFEESA	1.65	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFMPA	2.45	ng/L	U,H	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	PFMBA	1.22	ng/L	U,H	UJ	13L
CEDAR_LF04	L33825-15 R	MLA-110 Rev 02	NFDHA	2.45	ng/L	U	UJ	13L
JBLM_LF01	L33825-10 i	MLA-111 Rev 03	PFBA	659	ng/L		J	13L
JBLM_LF01	L33825-10 i	MLA-111 Rev 03	PFDoA	3.01	ng/L	J	J	13L
JBLM_LF01	L33825-10 i	MLA-111 Rev 03	PFTeDA	2.58	ng/L	U	UJ	13L

JBLM_LF01	L33825-10 i	MLA-111 Rev 03	PFDS	2.96	ng/L	K J	J	25
JBLM_LF01	L33825-10 i	MLA-111 Rev 03	6:2 FTS	10	ng/L	J	U	7
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFBA	650	ng/L	H	J	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFPeA	516	ng/L	H	J	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFHxA	875	ng/L		J	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFHpA	199	ng/L		J	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFBS	147	ng/L		J	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	PFNS	9.44	ng/L	K J	J	25
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	6:2 FTS	56.7	ng/L		U	7
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	EtFOSAA	5	ng/L	K J	J	25
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	3:3 FTCA	174	ng/L	U,H	UJ	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	5:3 FTCA	199	ng/L	U	UJ	13L
CEDAR_LF02	L33825-13 i	MLA-111 Rev 03	7:3 FTCA	433	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFBA	76.5	ng/L	U H	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFPeA	2480	ng/L		J	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFHxA	613	ng/L		J	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFHpA	228	ng/L		J	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFUnA	6.73	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFDoA	4.81	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFTeDA	4.35	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFHpS	30.9	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFOS	44.7	ng/L	K	J	13L,25
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFNS	16.7	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFDS	9.68	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	PFDoS	14	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	6:2 FTS	56.2	ng/L		U	7
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	3:3 FTCA	113	ng/L	U	UJ	13L
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	5:3 FTCA	182	ng/L	U	UJ	13L

Qualified Data Summary Table

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Sample ID	Lab ID	Method	Analyte	Result	Units	LAB QUAL	DV QUAL	DV CODE
CEDAR_LF04	L33825-15 i	MLA-111 Rev 03	7:3 FTCA	373	ng/L	U	UJ	13L
ASOTIN_LF01	L33897-1 i	MLA-111 Rev 03	PFDA	8.26	ng/L	K J	J	25
ASOTIN_LF01	L33897-1 i	MLA-111 Rev 03	6:2 FTS	70.5	ng/L		U	7
NORTHSIDE_LF01	L33897-2 i	MLA-111 Rev 03	PFDA	5.61	ng/L	K J	J	25
NORTHSIDE_LF01	L33897-2 i	MLA-111 Rev 03	PFTeDA	2.96	ng/L	U	UJ	13L
NORTHSIDE_LF01	L33897-2 i	MLA-111 Rev 03	6:2 FTS	52.6	ng/L		U	7
RINSATE_LF02	L33935-4 i	MLA-111 Rev 03	PFPeA	7.21	ng/L	B J	U	7
RINSATE_LF02	L33935-4 i	MLA-111 Rev 03	PFHxA	6.37	ng/L	K B J	U	7
RINSATE_LF02	L33935-4 i	MLA-111 Rev 03	PFOA	6.64	ng/L	J	U	7
RINSATE_LF02	L33935-4 i	MLA-111 Rev 03	PFTeDA	3.51	ng/L	U	UJ	13L

PT_ANGELES_LF01	L33991-1 i	MLA-111 Rev 03	PFDoA	2.83	ng/L	U	UJ	13L
PT_ANGELES_LF01	L33991-1 i	MLA-111 Rev 03	PFTeDA	2.83	ng/L	U	UJ	13L
PT_ANGELES_LF01	L33991-1 i	MLA-111 Rev 03	6:2 FTS	81.2	ng/L		U	7
PT_ANGELES_LF01	L33991-1 i	MLA-111 Rev 03	8:2 FTS	33.5	ng/L	J	J	13H
WARC_LF01	L33825-5 i	MLA-111 Rev 03	PFTeDA	2.54	ng/L	U	UJ	13L
WARC_LF01	L33825-5 i	MLA-111 Rev 03	6:2 FTS	12.3	ng/L	J	U	7
WARC_LF01	L33825-5 i	MLA-111 Rev 03	8:2 FTS	39.6	ng/L	K J	J	25
VASHON_LF01	L33825-6 i	MLA-111 Rev 03	PFDA	7.42	ng/L	K J	J	25
VASHON_LF01	L33825-6 i	MLA-111 Rev 03	PFDoA	2.81	ng/L	U	UJ	13L
VASHON_LF01	L33825-6 i	MLA-111 Rev 03	PFTeDA	2.81	ng/L	U	UJ	13L
VASHON_LF02	L33825-7 i	MLA-111 Rev 03	PFNA	4.42	ng/L	K J	J	25
VASHON_LF02	L33825-7 i	MLA-111 Rev 03	PFDA	3.74	ng/L	K J	J	25
VASHON_LF02	L33825-7 i	MLA-111 Rev 03	PFDoA	2.43	ng/L	U	UJ	13L
VASHON_LF02	L33825-7 i	MLA-111 Rev 03	PFTeDA	2.43	ng/L	U	UJ	13L
VASHON_LF02	L33825-7 i	MLA-111 Rev 03	6:2 FTS	10.5	ng/L	J	U	7
VASHON_LF04B	L33825-8 i	MLA-111 Rev 03	PFDA	3.23	ng/L	K J	J	25
VASHON_LF04B	L33825-8 i	MLA-111 Rev 03	6:2 FTS	35.4	ng/L	J	U	7
HEADQUARTERS_LF01	L33825-3 R (A)	MLA-111 Rev 03	PFTeDA	33.2	ng/L	U	UJ	13L
HEADQUARTERS_LF01	L33825-3 R (A)	MLA-111 Rev 03	PFPeS	50.9	ng/L	K J	J	25
LRI_LF01	L33852-2 R	MLA-111 Rev 03	PFOS	169	ng/L	K	J	25
ROOSEVELT_LF01	L33935-1 R	MLA-111 Rev 03	PFTeDA	33.1	ng/L	U	UJ	13L
ROOSEVELT_LF03	L33935-3 R	MLA-111 Rev 03	PFTeDA	33.1	ng/L	U	UJ	13L