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Appendix G: PFAS Destruction Technology Bench-Scale Study Summary and Analysis

Project 1007 Feasibility Study
Minnesota Pollution Control Agency

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Acronyms and Abbreviations

°C	degrees Celsius
%	percent
µg/L	microgram per liter
3:3 FTCA	3-perfluoropropyl propanoic acid
5:3 FTCA	5:3 fluorotelomer carboxylic acid
7:3 FTCA	2H,2H,3H,3H-perfluorodecanoic acid
AFFF	aqueous film-forming foam
AOC	Area of Concern
AOF	adsorbable organic fluorine
CAPEX	capital expenditure
CTAB	cetyl trimethylammonium bromide
DBP	disinfection byproduct
EHS	environmental, health, and safety
EO	electrochemical oxidation
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GAC	granular activated carbon
gpm	gallons per minute
HALT	Hydrothermal Alkaline Treatment
HBV	Health-Based Value
HF	hydrofluoric acid
HFPO-DA	hexafluoropropylene oxide dimer acid
IPA	isopropyl alcohol
IX	ion exchange
kWh	kilowatt hours
kWh/gal	kilowatt hours per gallon
kWh/m ³	kilowatt hours per cubic meter
LOQ	limit of quantitation
LPM	liters per minute
MCL	Maximum Contaminant Level
MDH	Minnesota Department of Health
mL/min	milliliter per minute
MPCA	Minnesota Pollution Control Agency
NaOH	sodium hydroxide
ND	non-detect
NEtFOSAA	N-ethylperfluorooctane sulfonamidoacetic acid
ng/L	nanograms per liter
nm	nanometer
NR	not reported

NTA	non-targeted analysis
O&M	operations and maintenance
OPEX	operating expenditure
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFDA	perfluorodecanoic acid
PFDoA	perfluorododecanoic acid
PfecHS	perfluoroethylcyclohexane sulphonate
PFHpA	perfluoroheptanoic acid
PFHpS	perfluoroheptane sulfonic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PFMBA	perfluoro-4-methoxybutanoic acid
PFMPA	perfluoro-3-methoxypropanoic acid
PFNA	perfluorooctane nonanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonic Acid
PFPeA	perfluoropentanoic acid
PFPeS	perfluoropentane sulfonic acid
PFTeDA	perfluorotetradecanoic acid
PFUnA	perfluoroundecanoic acid
PRD	photoactivated reductive defluorination
psi	pounds per square inch
QA/QC	Quality Assurance/Quality Control
RFP	Request for Proposal
RO	reverse osmosis
SAFF®	Surface Active Foam Fractionation
SCWO	supercritical water oxidation
TFA	trifluoroacetic acid
TOF	total organic fluoride
TOP	total oxidizable precursor
TRL	Technology Readiness Level
UV	ultraviolet

G1 Introduction

The area surrounding the Project 1007 Conveyance System (Site) has widespread per- and polyfluoroalkyl substances (PFAS) contamination within groundwater, surface water, and sediment. The purpose of this Feasibility Study (FS) is to recommend potential alternatives and develop conceptual plans to address the widespread PFAS impacts with a focus on protecting drinking water aquifers. While the alternatives focus more on where treatment should occur and whether the treated water can be used for municipal supply, PFAS treatment technologies were evaluated to determine which could be used in a treatment train approach to separate, concentrate, and destroy or dispose of the PFAS from surface water, groundwater, and sediment. As the efficiency of many technologies is dependent on the PFAS mixture at a specific site and other characteristics of the water or sediment, the Minnesota Pollution Control Agency (MPCA) conducted treatability studies to better inform the recommendations of this FS.

In 2022, the MPCA began a pilot-scale study of foam fractionation, specifically Surface Active Foam Fractionation (SAFF®). Foam fractionation is a separation and concentration technology and does not result in the destruction of PFAS, thus additional process step(s) are required if destruction of PFAS is desired. The results and evaluation of SAFF® are in Appendix E (SAFF® Pilot Study Report). PFAS destruction technologies were evaluated as part of this FS to determine the feasibility of destroying PFAS onsite to reduce the transfer of the liability and hazards associated with the PFAS waste to a different community through other disposal methods. Onsite PFAS destructive technologies have the potential to mineralize, or completely destroy, PFAS, eliminating the need for offsite incineration, landfilling, and other management measures. Pairing these technologies with a separation and concentration technology, like foam fractionation, can greatly reduce energy consumption as a smaller volume would require treatment. The objective of the bench scale studies was to understand which technology or technologies can be used to effectively and efficiently treat SAFF® concentrate from Project 1007.

The MPCA released a Request for Proposal (RFP) to complete bench-scale tests of PFAS destructive technologies using SAFF® concentrate from the Project 1007 pilot study. The following vendors responded to the RFP:

- Axine Water Technologies (electrochemical oxidation [EO])
- Onvector (thermal plasma)
- General Atomics (supercritical water oxidation [SCWO])
- Revive Environmental (SCWO)
- 374Water° (SCWO)
- Claros Technologies (ultraviolet [UV]-activated photoreduction)
- Enspired Solutions (UV-activated photoreduction)

A field demonstration was also conducted using a DE-FLUORO™ pilot unit to assess the ability of EO to destroy PFAS. As that study was at a larger scale and conducted in the field, it is not directly comparable to bench-scale studies. The results are presented in Appendix F (DE-FLUORO™ PFAS Destruction Pilot Study).

This appendix reviews the operational basics of each technology, followed by discussion of PFAS destruction results, byproduct formation, energy consumption, and technology-specific considerations (e.g. use of reagents). The adaptability of destructive technologies, pre- and post-treatment needs, and

operational considerations are also discussed. Collectively, the results and discussion presented in this appendix are intended to inform decision making toward eventual selection of a pilot technology appropriate for the Project 1007 needs. A destruction technology, however, was not selected as part of this FS as it is dependent on the selection of a separation and concentration technology, the unique PFAS mixture at a treatment location, and pilot-scale testing with the specific technologies. Additional pilot-scale testing is recommended with Site-specific PFAS concentrate.

G1.1 Overview of Foam Fractionation Pilot Study

Foam fractionation utilizes air injection to remove PFAS from the bulk water, concentrating the PFAS within foam at the top of the water column. PFAS removal can also occur in low- or non-foaming water, where PFAS adhere to the air-water interface of bubbles and are concentrated to the top of the water column. This PFAS can be further concentrated into a smaller volume through a second fractionation step. This separation and concentration technology keeps PFAS in an aqueous solution as opposed to transferring it to a solid matrix, such as what occurs in media filtration with ion exchange (IX) or granular activated carbon (GAC). This can greatly reduce operating costs by eliminating the need for changeouts of the solid media and allowing for more options of destruction technologies.

In 2022, a pilot study was implemented to assess the feasibility of foam fractionation technology for treatment of PFAS-impacted Site surface water and groundwater to remove PFAS from surface water and groundwater and concentrate the PFAS into a small volume. The pilot study was conducted using a SAFF®20 treatment system, which was manufactured by EPOC Enviro, and deployed at Tablyn Park in Lake Elmo, MN in November 2022. The SAFF® system is discussed in greater detail in Section 10 and Appendix E of this FS. The SAFF® system performance was tested on groundwater from the Shakopee and Jordan Aquifers and surface water from Raleigh Creek. The initial phase of SAFF® pilot testing was completed in June 2024. The concentrated PFAS from the treatment of Raleigh Creek was used in this evaluation of PFAS destruction technologies.

G1.2 MPCA RFP and Methods for Evaluation of Bench Scale Tests

To evaluate potential destructive technologies on a Site-specific PFAS mixture, the MPCA released a public RFP, and seven PFAS-destruction technology vendors responded. Axine Water Technologies (EO), Onvector (thermal plasma), General Atomics (SCWO), Revive Environmental (SCWO), 374Water® (SCWO), Claros Technologies (UV-activated photoreduction) and Enspired Solutions (UV-activated photoreduction) responded to the RFP. Each vendor was provided five gallons of SAFF® concentrate from the treatment of surface water by the MPCA; analytical results from samples analyzed for the MPCA are given in Table G.1.

The evaluation of the seven vendor reports specifically considered the extent of PFAS degradation reported, the supporting data (i.e. quantification of organic fluorine and inorganic fluoride), byproducts generated, and energy consumed. Quantification of total organic fluoride (TOF) provides additional insight into the changes in total PFAS, including those analytes not included in United States Environmental Protection Agency (EPA) Method 1633, although it likely does not capture ultra short chain PFAS (<4 carbons). Inorganic fluoride (F) provides evidence of complete destruction of PFAS, as increases in inorganic fluoride indicate destruction of carbon – fluorine bonds. All PFAS and byproducts results were taken as reported, except where conversions to comparable units were made. Specific discussion related to these reported values versus third party laboratory reports is provided in Section E3.0. The discussion presented in this appendix does not attempt to recalculate vendor or laboratory data. Instead, data gaps that need to be addressed prior to or as part of a pilot study RFP are presented. In Section E4.0, data gaps were identified by reviewing the vendor reports in the context of evaluation checklists prepared under SERDP Project ER18-1633 (Deeb et al., 2021). Energy consumption reporting is not yet standardized, including in terms of PFAS destruction technologies. Therefore, to have

comparable energy consumption results the reported energy used, time, and volume treated were used to calculate the kilowatt hours per cubic meter (kWh/m³) treated, where it was not already provided.

Table G.1: SAFF® Concentrate PFAS Composition.

PFAS Species	Abbreviation	Concentration (ng/L)
Perfluorooctane sulfonic Acid	PFOS	4,670,000
Perfluorooctanoic acid	PFOA	2,440,000
Perfluoroheptanoic acid	PFHpA	84,800
Perfluorohexane sulfonic acid	PFHxS	149,000
Perfluorohexanoic acid	PFHxA	2,650
Perfluoropentanoic acid	PFPeA	135
Perfluorobutanesulfonic acid	PFBS	194
Perfluorobutanoic acid	PFBA	463
Perfluorooctane nonanoic acid	PFNA	12,000
Perfluorodecanoic acid	PFDA	14,700
Perfluoroundecanoic acid	PFUnA	28.1
Perfluorododecanoic acid	PFDoA	< 33.3

Legend: ng/L = nanograms per liter.

G1.3 Destructive Technologies Overview

An overview of the different general categories of PFAS destructive technologies are discussed below. A high-level summary of the commercially available PFAS destruction technologies is providing in Table G.2, adapted from DiGuseppi et al (2024). Additional destruction technologies are being developed than those listed in Table G.2; however, those included here represent the technologies that are the furthest in development and have completed field demonstrations.

Table G.2: Summary of PFAS-Destructive Technologies Discussed in Appendix G.

Assessment Category	Electrochemical Oxidation	Non-Thermal Plasma	UV-Activated Photoreduction	Supercritical Water Oxidation (SCWO)	Hydrothermal Alkaline Treatment (HALT)	Thermal Arc Plasma
Reaction Mechanism	Oxidation	Oxidation & Reduction	Reduction	Oxidation	Nucleophilic Substitution	Oxidation
Reaction Time	Hours	Hours	Hours	Seconds	Minutes	Milliseconds
Ability to Achieve Complete Mineralization	Moderate	Moderate	Moderate	High	High	High
Operating Conditions	Ambient	Ambient	Ambient	High pressure, high temperature	High Pressure, High Temperature, High pH	High temperature
Treats Other Organics	Yes	Yes	Partially	Yes	Partially	Yes
Reagents Required	None to minimal	None to minimal	Yes	No	Yes	No
Representative North America-Based Technology Vendors	- Axine - Aclarity - DE-FLUORO™ - E2Metrix - OxbyEl	- DMAX Plasma	- Haley & Aldrich - Enspired Solutions - Claros Technologies	- 374Water® - General Atomics - Revive Environmental	- Aquagga	- Pyrogenesis - Onvector
Technology Readiness Level [TRL] (2024)	8	7-9	6-7	9	6-7	6-7

Table adapted from DiGuseppi et al., 2024.

Vendors that responded to the MPCA RFP are highlighted in bold.

G1.3.1 Overview of Electrochemical Oxidation

Electrochemical oxidation treatment is accomplished using electrode (anode-cathode) pairs. Treatment is accomplished via direct oxidation at the anode surface and via radical species (e.g., hydroxyl) (ITRC, 2023). Various iterations of electrochemical oxidation have been tested at bench and pilot scale, with increasingly larger units becoming commercially available. There is variability in the materials that are used for the electrodes including boron-doped diamond and titanium suboxide (DiGuseppi, 2024). Axine Water Technologies responded to the MPCA RFP proposing using their electrochemical oxidation destruction system. The DE-FLUORO™ system was evaluated in a field demonstration with results presented in Appendix F. The results of the DE-FLUORO™ field demonstration were not compared to the bench scale studies.

G1.3.2 Overview of UV-Activated Photoreduction

UV-based PFAS reduction has been increasingly investigated because UV treatment is relatively simple to implement and can operate at ambient temperature and pressure. Different reaction chemistries have been investigated but generally wavelengths of 254 nanometers (nm) or greater are typically used and additional reagents (e.g. Fenton, $S_2O_8^{2-}$) are needed to produce sufficient radical species and hydrated electrons to break carbon-fluorine bonds (ITRC, 2023). UV excitation of molecules occurs, generating the radical species which, in turn, attack the PFAS headgroup and sequentially at carbon-fluorine bonds. Alternatively, micelles produced with a cationic surfactant can be used to concentrate the PFAS and the hydrated electron donor to improve the destruction efficiency. The specific radical species produced may vary with wavelength and reagent (Umar, 2021). Photoreductive processes have been observed to fully defluorinate short-chain perfluorocarboxylic acids and long-chain perfluorosulfonic acids (e.g. PFOS) preferentially to short-chain perfluorosulfonic acids (e.g. PFBS) (DiGuseppi et al., 2024). Claros Technologies and Enspired Solutions responded to the MPCA RFP proposing using their UV destruction systems.

G1.3.3 Overview of Super Critical Water Oxidation

Supercritical water refers to the state of matter that exists between liquid water and water vapor. The supercritical phase occurs when temperature and pressure are controlled above 374 degrees Celsius (°C) and 3,200 pounds per square inch (psi). These conditions produce oxidative radical species that can break carbon-fluorine bonds. Increasing the temperature above 575°C was found to be more effective for sulfonic acid degradation than lower temperatures (Scheitlin, 2023); commercial reactors are generally kept at temperatures above 500°C to reduce residence time and to ensure complete destruction (DiGuseppi et al., 2024). SCWO reactors are available either for installation onsite or for waste to be handled offsite directly by a vendor. The capacity of the SCWO reactors is larger and there are energy efficiencies for running larger volumes waste as opposed to starting and stopping the reactors. For this reason, onsite treatment by SCWO is more optimal with larger volumes of waste. Alternatively, Revive Environmental and General Atomics also offer treatment at their facilities where waste can be treated if it is more economical than operating a system onsite. 374Water®, Revive Environmental, and General Atomics responded to the MPCA RFP with their SCWO destruction technologies.

G1.3.4 Plasma Treatment

PFAS destruction with plasma treatment can be broken into two main categories: Thermal arc plasma destruction and non-thermal plasma. Thermal arc plasma utilizes a high-voltage electrical discharge to water at or near the surface, with temperatures reaching approximately 9,750°C in the plasma core and 2,250 – 3,750°C at the edge of the plasma, to destroy PFAS in milliseconds (DiGuseppi et al., 2024). A

variety of radical species may be produced, including aqueous electrons which are thought to be more effective for PFAS degradation than hydroxyl radicals (Horst et al., 2020).

Non-thermal plasma utilizes a high-voltage electrode to create highly reactive oxidative and reductive species in water. These reactive species non-selectively degrade organic contaminants including PFAS (DiGuseppi et al., 2024). Non-thermal plasma tends to have a lower energy consumption compared to thermal plasma.

Onvector responded to the MPCA RFP proposing using their thermal arc plasma treatment technology. No non-thermal plasma vendors responded to the RFP; however, a pilot study has been published at a different site (Nau-Hix et al., 2021)

G1.3.5 Overview of Hydrothermal Alkaline Treatment

Hydrothermal Alkaline Treatment (HALT) is a PFAS destruction technology that utilizes subcritical water and soluble caustic soda (sodium hydroxide [NaOH]) to fully mineralize PFAS. Recent studies indicated that the nucleophilic substitution removes the PFAS functional group creating a reactive species that subsequently reacts with hydroxyl radicals (Pinkard et al., 2024). This results in defluorination of PFAS species, including short-chain PFAS such as PFBA and trifluoroacetic acid (TFA). Hydrothermal alkaline processes have historically been used in other industries, for example hydrothermal activation of oil shale fly ash (Reinik et al., 2007).

HALT has been developed and commercialized for PFAS by Aquagga. Their process uses elevated pH (pH > 14), temperature (between 150 °C and 350 °C), and pressure (less than 22 megapascals, or 145 psi). Aquagga's research and development has included demonstrations of HALT to treat PFOA, PFOS, TFA, aqueous film-forming foam (AFFF), PFAS-impacted water, and solids including soil and spent GAC (Pinkard et al., 2024). Study results included greater than 90 percent (%) degradation and defluorination in 90 minutes of treatment for all 62 detected PFAS (Hao et al., 2023). Recently published work specifically addressed mass balance closure. Up to 99% of fluorine mass was recovered at an operating temperature of 300 °C, providing strong evidence of PFAS destruction (Pinkard et al., 2024). Additionally, HALT is more selective towards PFAS than other destructive technologies and may only partially degrade non-PFAS water chemistry constituents like organic matter (DiGuseppi et al., 2024). Aquagga did not respond to the MPCA RFP; however, HALT is included in this overview because the effectiveness has been thoroughly documented for multiple PFAS in multiple matrices, as noted above. These past demonstrations were well supported by evaluation of byproducts and energy analysis. Therefore, HALT may be considered for later demonstration.

G2 Report Summaries – PFAS Reduction and Energy Consumption

The MPCA engaged seven PFAS destruction technology vendors, via a publicly available RFP, to complete bench-scale studies using SAFF® concentration from Project 1007. Each vendor received five gallons of SAFF® concentrate produced through the treatment of surface water from the same concentrate drum to ensure consistency between the destruction tests. Each vendor determined the optimum method to test PFAS destruction with their respective technology. The RFP asked that vendors provide:

- Test procedure
- PFAS destruction efficiency calculation
- Quality Assurance/Quality Control (QA/QC) procedures
- TOF or adsorbable organic fluorine (AOF) results

- Energy cost or consumption
- Waste shipping manifests
- Summary of limitations
- Summary of PFAS transformation or terminal end products

Vendors responded with treatment results quantified with a variety of methods. Follow-up questions were posed to the vendors after the initial reports were reviewed to fill data gaps. Any remaining data gaps are noted in the text that follows. The results from each vendor have been reported as-is with no reanalysis, except to standardize units. Organofluorine and fluoride anion results are summarized in Table G.3 and discussed below in each vendor section.

Table G.3: Organofluorine and Fluoride Anion Results.

Company	Initial Organofluorine (ng/L)	Final Organofluorine (ng/L)	Initial Fluoride (ng/L)	Fluoride Final (ng/L)
374Water°	4,720,000	56,900	0	NR
Axine	3,700,000	10,000	120,000	2,470,000
General Atomics	1,500,000	<2,000	500,000	1,200,000
Claros Technologies	1,200,000	180,000	NR	NR
Enspired Solutions	5,400,000	450,000	120,000	6,700,000
Onvector	4,856,300,000	1,498,000,000	100,000	7,000,000
Revive Environmental	4,150,000	289,000	125,000	3,839,000

Legend: NR = not reported.

Though all vendors were provided with SAFF® concentrate from the same drum, the number of PFAS and their respective concentrations detected in the untreated SAFF® concentrate were highly variable. Reported influent concentration is summarized by vendor in Table G.7. This is likely due in part to elevated PFOA and PFOS concentrations affecting laboratory reporting limits. The lack of reproducible initial concentrations is an acknowledged limitation of this evaluation. Test method details are given in reports provided by each vendor. Analytical method details are available from the respective laboratory or agency.

Energy consumption was requested as part of the RFP, but a reporting format was not specified. Thus, each vendor had the option to report energy consumption on a basis that made sense for the specific technology. For comparison within this appendix energy consumption was quantified to like units as kWh/m³ and kilowatt hours per gallon (kWh/gal). As a full lifecycle analysis was not requested as part of the MPCA RFP and therefore, smaller contributions (i.e. manufacturing the system or operating support equipment) to energy and materials consumption are not quantified in the reports or in this appendix. It is understood that the primary reoccurring energy use comes from reactor operation.

G2.1 374Water - SCWO

374Water° utilized a bench-scale AirSCWO™ reactor at their laboratory in Durham, NC to evaluate their technology for application to SAFF® concentrate. This bench-scale system is a scaled-down version of their commercial AirSCWO reactor. A notable difference between the systems is that the bench-scale system uses a furnace to provide all heat required by the system, while the full-scale system includes an energy recovery system. The bench-scale system uses dual piston pumps operated at 3,500 psi to feed waste through a pre-heater and then into a furnace that is operated at 600 °C. Isopropyl alcohol (IPA) was used as starter fuel, and the system was operated at 6 to 10 milliliters per minute (mL/min), which

roughly equates to a 11-17 second reactor residence time, which is similar to residence times in their full-scale reactor. The MPCA concentrate tests were generally completed with a 10 second residence time. Two trials were conducted, with treated effluent samples collected for both experiments after the reactor had reached steady state.

G2.1.1 PFAS Reduction

From an initial total PFAS concentration of 4,906,128 nanogram per liter, total PFAS was reduced to 1.95 ng/L (99.99996% reduction) in Run 1 and to non-detect (ND) in Run 2 (100% reduction), as presented in the 374Water^o report. It should be noted that 100% destruction may be an overestimate as PFAS may be present below the laboratory reporting limits. PFOA and PFNA were non-detect in the effluent samples. PFHxS and PFOS were detected in the final Run 1 samples at 2.86 ng/L and 1.04 ng/L, respectively. The Run 2 final sample had no detections. A sample collected from the system prior to waste being added did have a detection of PFOS at 2.69 ng/L. AOF was reduced from 4,270,000 ng/L to 56,900 ng/L (Table G.2). Fluoride anion measurements were noted to be affected by matrix interferences and only initial concentrations of fluoride, sulfate, and bromine were provided. A mass balance analysis was not provided as part of the project and is a necessary step to confirm the PFAS concentration reductions.

G2.1.2 Energy Consumption

The energy consumption rate was reported as 1.12 kWh/gal treated (Table G.4). As with all energy-intensive remediation processes, the resulting cost scales with the volume treated. Thus, treating a highly concentrated solution reduces energy costs and may reduce treatment time. In addition to the electrical energy consumed, co-fuel (IPA) was also used to facilitate PFAS degradation. The use of co-fuel can be considered as part of the total energy required to achieve complete PFAS mineralization but quantifying the energy expended was outside the scope of this review. Additionally, if a higher energy PFAS containing feedstock such as GAC was blended into the SAFF[®] concentrate, less IPA would be required.

G2.1.3 Summary

The results of this trial are promising given the significant reduction of PFAS and AOF. The average cost of electricity in Minneapolis, Minnesota was 16.3 cents per kilowatt hour (kWh) in 2023 (Bureau of Labor Statistics, 2024). Therefore, the approximate energy cost is 18.3 cents per gallon. Capital expenditure (CAPEX) and operational expenditure (OPEX) costs will vary depending on the required capacity as this will impact the size of the system, installation requirements, and operations and maintenance (O&M) requirements. IPA was used as a co-fuel and sodium carbonate was used to maintain reaction chemistry. Both IPA and sodium carbonate are inexpensive and do not have intensive safety requirements for handling. A pilot study is necessary to fully characterize both PFAS reduction and operations considerations.

G2.2 Axine Water Technologies – Electrochemical Oxidation

Axine Water Technologies ('Axine') utilized a bench-scale treatment system at their laboratory in Vancouver, BC to evaluate their proprietary electrochemical oxidation technology for destruction of SAFF[®] concentrate. The bench-scale study was performed using a 10-liter glass cell using a proprietary electrode set, which is a scaled down version of the commercial-scale reactor which contains 30 cells. It should be noted that glass is generally known to adsorb PFAS and desorption tests were not presented in the report. Sodium hydroxide was added prior to testing to prevent hydrofluoric acid (HF) accumulation as carbon-fluorine bonds were broken. NaOH was initially dosed throughout the experiment to maintain pH between 8 and 9 for prevention of HF accumulation; sulfuric acid was then

added at the end of the run to maintain a pH between 8 and 9 to prevent precipitation of dissolved minerals as destruction of organics began to increase the pH outside this range. The system was operated at 100 kWh/m³ to achieve initial PFAS concentration reduction. Energy input was subsequently increased up to 800 kWh/m³ to achieve additional PFAS concentration reduction. Rather than basing the tests on time or power, percent concentration reduction was used and thus treatment occurred until 100% reduction was achieved. Samples were taken at various timepoints until the sample was considered fully treated but the total treatment time was not reported, and these time points are denoted based on the percentage treated.

Axine also offers onsite pilot testing with their commercial-scale treatment system which requires a minimum of 150 gallons for testing as well as Treatment-as-a-Service for outsourced PFAS waste handling.

G2.2.1 PFAS Reduction

All detected PFAS concentrations, including those recently regulated, were reduced to below detection or greater than 99% under the 800 kWh/m³ condition (Table G.8). Following treatment, PFOA and PFOS were detected at 3.8 ng/L each. No other targeted analytes remained above detection limits (< 2 ng/L). The AOF concentration was reduced from 3,700,000 ng/L to 10,000 ng/L. The fluoride anion concentration increased from 120,000 ng/L to 2,470,000 ng/L (Table G.3) and sulfate increased from 3,890,000 ng/L to 2,370,000,000 ng/L (Table G.4). The anion data support PFAS degradation occurred, including sulfonic acid degradation.

G2.2.2 Energy Consumption

The energy consumption was 2,973 kWh/m³ treated (Table G.5). As with all energy-intensive remediation processes, the resulting cost scales with the volume treated. Thus, treating a highly concentrated solution reduces energy costs and may reduce treatment time. The approximate electricity cost per gallon is \$1.83. Axine noted in their report that energy usage by the bench-scale reactor is less energy efficient than their larger pilot-scale system and that energy efficiency was not optimized during the testing.

G2.2.3 Summary

The results of the Axine trial are promising, given reportedly high PFAS degradation coupled with the corresponding AOF decrease and fluoride increase. A thorough mass balance is needed to verify that destruction has occurred and to evaluate the role sorption to glass plays in removing PFAS from the bulk liquid being treated. A pilot study is needed to understand how the results scale, including the energy demand.

G2.3 General Atomics – SCWO

General Atomics (as part of a joint venture with Bay West) used their full-scale industrial SCWO, or iSCWO, unit to treat the 5-gallon SAFF® concentrate sample provided by MPCA as they do not have a bench scale system. Due to the relatively small volume of the sample provided compared to normal system feed rates, General Atomics operated the iSCWO unit at the lowest flow setting resulting in reduced system pressure and subsequently reduced retention time. Longer retention times would likely further degrade PFAS within the reactor. Therefore, increasing flow and back pressure may be necessary if a pilot-scale test is conducted. The iSCWO test proceeded in two phases, and Phase 1 had three tests while Phase 2 had one test. Phase 1 consisted of 2.5 gallons of diluted SAFF® concentrate, with an influent feed rate of 3.8 liters per minute (LPM). In Phase 2, 2.5 gallons of SAFF® concentrate fed at 0.2 LPM without prior dilution. Phase 1 tests also used Antifoam C Emulsion (Sigma-Aldrich) to mitigate foaming during recirculation. NaOH was also used to control pH and neutralize acidic byproducts. The

reactor was operating at temperatures between 637.2 °C and 707.1 °C and pressure between 2,552 psi and 2,973 psi. The iSCWO unit used municipal water for quenching. The General Atomics report acknowledges PFAS are present in the water, albeit at low concentrations relative to the SAFF® concentrate.

G2.3.1 PFAS Reduction

Initial PFAS detections reported by General Atomics (Table 1 of the General Atomics report) were PFDA, PFHpA, perfluoroheptane sulfonic acid (PFHpS), PFHxS, PFNA, PFOA, PFOS, perfluoropentane sulfonic acid (PFPeS). Influent samples reported in Table 7 of the General Atomics report only included PFBS, PFBA, PFHxS, PFHxA, PFOA, and PFOS. PFAS concentrations were reduced in Phase 1 and in Phase 2 (Table G.8). General Atomics reported detections for PFBA, PFBS, PFHxA, PFHxS, PFOA, and PFOS. Of the selected PFAS reported, only PFBA was reduced to below detection (< 35 ng/L) in Phase 1 Test 2. The maximum remaining detected concentration was 56 ng/L PFBA in Phase 1 Test 1. The minimum detected concentration was 1.8 ng/L PFHxS in Phase 1 Test 3. The reported AOF concentration was reduced from 1,500,000 ng/L to non-detect (< 2,000 ng/L) for Phase 1 Test 2 (Table G.3). Fluoride anion concentrations increased in Phase 1 Test 2 from 500,000 ng/L to 1,200,000 ng/L.

G2.3.2 Energy Consumption

Energy consumption was estimated at 1,800 kWh for 4.27 hours. Based on treatment volumes, including dilution water, the energy per volume was estimated at 2,250 kWh/m³ (Table G.5) which is moderate relative to the other technologies evaluated. It should be noted that due to use of dilution water, the energy consumption estimates made during review are not entirely representative. If future tests can be performed without dilution (e.g. if a larger volume of SAFF® concentrate is used) energy consumption may be less. In general, energy consumption per unit volume is likely to change with scaleup for all technologies.

G2.3.3 Summary

Based on the provided data the General Atomics SCWO system is viable for further consideration for a pilot scale system. Additional information is needed, including a complete mass balance to support consideration for a pilot scale demonstration.

G2.4 Claros – UV-Activated Photoreduction

The Claros Technologies ('Claros') Elemental™ technology utilizes UV irradiation to create radical species. Claros initially determined that UV transmittance was poor (0%) for the provided SAFF® concentrate. The concentrate was subsequently diluted 1:5 such that UV transmittance increased to 40%. It should be noted that of all vendors that completed a bench study with MPCA SAFF® concentrate, the Claros samples had the fewest number of PFAS detections in the influent sample (PFHxS, PFHpS, PFOA, PFOS). The dilute solution was tested under Condition 1 (standard) and Condition 2 (modified) and each was completed in triplicate. The results for each triplicate test were not provided but a summary was provided, along with the associated error for each sample time point, for Conditions 1 and 2. The details of what is considered standard and modified were not provided. The Condition 1 and Condition 2 tests were performed over a 24-hour period.

G2.4.1 PFAS Reduction

Claros reported change in concentration over time for PFHxS, PFHpS, PFOA, and PFOS. Discussion of additional PFAS related to Claros data will be covered in Section E3.2. Under Condition 1, after 24 hours of treatment, concentrations of those PFAS decreased as follows: PFHxS from 36.5 ng/L to 0.07

(reported as the instrument limit of quantitation [LOQ]), PFHpS from 13,500 ng/L to 0 ng/L (LOQ), and PFOA from 338,100 ng/L to 20 ng/L (LOQ). PFOS was reduced from 930,700 ng/L to 230 ng/L. The Condition 2 treatment outcome resulted in higher remaining PFAS concentrations after 24 hours. Concentrations were reduced under Condition 2 as follows: PFHxS from 33,300 ng/L to 2,790 ng/L, PFHpS from 12,800 ng/L to 160 ng/L (LOQ), PFOA from 314,600 ng/L to 70 ng/L, PFOS from 1,072,900 ng/L to 2,400 ng/L. Under Condition 1 and Condition 2, the majority of decrease in PFAS concentrations occurred in the first 6 hours of treatment. The remainder of the PFAS mass required an additional 18 hours of treatment time to reach concentrations at or below the LOQ. A secondary treatment step after the first 6 hours could increase overall efficiency. The AOF concentration was reduced from 1,200,000 ng/L to 180,000 ng/L (Table G.3). The reduction indicates fluorinated compound degradation occurred; however, no byproducts (e.g., fluoride) concentrations were reported.

G2.4.2 Energy Consumption

Energy consumption was not quantified in the provided report. The energy consumption was estimated per unit volume from operation of three 100-watt lamps, operating for 24 hours to treat 5 gallons diluted 5 times. The estimated result was 153 kWh/m³, which may be an underestimation depending on the total equipment draw versus lamp wattage. A thorough investigation of energy requirements is needed in the context of treating SAFF® concentrate.

G2.4.3 Summary

Photochemical oxidation is not a rapid treatment technology as compared to plasma or SCWO. However, for low-flow applications, photochemical oxidation may be feasible. The Claros data demonstrated that the majority of PFAS mass can be removed in 6 hours of treatment, but another 18 hours was needed to reach >99% removal. Efficiency may be increased with an alternate polishing step. However, additional data, particularly at pilot-scale validation, is needed to demonstrate the same (or improved) results can be achieved. Pilot results should be supported by a carefully conducted mass balance and with detailed energy consumption results. The need to dilute the concentrate prior to treatment also shows that there may be issues with PFAS concentrates with low UV transmittance such as that observed with the treatment of surface water.

G2.5 Enspired Solutions – UV-Activated Photoreduction

Ensplied Solutions™ (“Ensplied”) developed a photoactivated reductive defluorination (PRD) system called the PFASigator. The PRD system operates at ambient temperature and pressure and is noted to not produce problematic byproducts. PRD is a sequential defluorination process, inherently generating short-chain PFAS which are subsequently reduced until fluoride and carbon dioxide remain. Cetyl trimethylammonium bromide (CTAB) was added to encourage micelle formation which accumulates PFAS at the micelle. A proprietary chemical was also added which produces hydrated electrons within the micelle surface when irradiated with UV. The bench-scale study treated SAFF® concentrate in a 300-milliliter reaction cell using a 36-watt low-pressure mercury lamp with wavelength of 254 nm. The PFASigator is available at larger scales, however the bench-scale reactor was appropriate for the volume of SAFF® concentrate used in testing. The operating temperature was maintained between 35 °C and 40 °C. The test was defined by increasing applied energy from 0 kWh/m³ to 5,400 kWh/m³. The results varied depending on the UV dose. This also impacts the costs and energy usage.

Ensplied submitted an addendum to the final report in which they updated the cost and energy requirements based on field studies completed with foam fractionation. If recirculation of the treated SAFF® concentrate back into the SAFF® is possible, then the effluent of the destruction technology does not have to meet a discharge criteria. Instead, the concentrations must be reduced to the extent that the SAFF® can still meet the overall discharge requirement. Ensplied found this to be about a 90%

reduction in PFAS. The results below discuss destruction at the maximum UV dosage of 5,400 kWh/m³ and a lower dose of 800 kWh/m³. The recommended dose would be dependent on the treatment targets and if a 90% reduction was achieved for the PFAS with drinking water standards, total known PFAS, or total known PFAS and unknown precursors. While that decision is not made as part of this appendix, comparing the treatment efficiency, energy requirements, and cost for two UV dosages shows the impacts these decisions have on a full-scale system.

G2.5.1 PFAS Reduction

Treatment with 5,400 kWh/m³ shows the maximum destruction that occurred. Concentrations of all PFAS detected in the influent sample were reduced 99% to concentrations less than the detection limit. PFOA and PFOS were reduced by a minimum of 99.5%. Of sixteen initially detected PFAS, seven had initial concentrations less than the detection limit and five were reduced to below the detection limit, though the detection limits were elevated. Of those five PFAS, PFBS, perfluoro-4-methoxybutanoic acid (PFMBA), and hexafluoropropylene oxide dimer acid (HFPO-DA) had corresponding initial concentration below detection. This difference presents particular uncertainty with changes in concentration, due to elevated detection limits. The TOF concentration decreased from 5,400,000 ng/L to 450,000 ng/L while fluoride anion concentration increased from 120,000 ng/L to 6,700,000 ng/L (Table G.4). The TOF and fluoride results are an indicator that near-complete PFAS degradation occurred. A complete PFAS and TOF mass balance is needed to verify the results.

As a comparison, treatment with 800 kWh/m³ also showed degradation of over 99% reduction for PFNA, PFOA, PFOS, PFHxS, PFDA, and PFHpS. PFPeS was reduced by 90%. Total PFAS decreased by 97% or from 4,100,000 ng/L to 110,000 ng/L.

G2.5.2 Energy Consumption

Enspired reported 20.5 kWh per gallon treated, or 5,400 kWh/m³ (Table G.5). In comparison, as described in the addendum, if only 90% reduction of total known PFAS and unknown precursors were degraded, the energy usage is reduced to 1,300 kWh/m³. At 19 cents per kWh, the approximate cost per gallon is \$2.96.

G2.5.3 Summary

The Enspired Solution results were promising at bench scale, achieving greater than 99.9% concentration reduction for most measured PFAS. In addition, a corresponding increase in fluoride anion further supports that destruction is occurring. While energy costs were high to achieve this level of reduction compared to other technologies, these costs could be greatly decreased when considering the ability to recirculate the effluent back to the SAFF®. There are also other added benefits of this technology such as no unwanted by products, limited air emissions, and the ability to operate at ambient conditions.

G2.6 Onvector – Thermal ArcPlasma

Onvector has developed a Plasma Vortex technology (reactor). The reactor consists of a sealed tank with sufficient headspace to allow argon, the plasma-forming gas, to be pumped in. Water and PFAS foam are each pumped into the reactor separately where they both come in contact with the plasma. PFAS destruction occurs as numerous reactive species are produced including hydroxyl radicals and aqueous electrons. The reactor was used to treat the provided 5-gallon SAFF® sample with a tungsten electrode and a 25-kW generator. The solution was recirculated at 8-10 gallons per minute (gpm) under an argon atmosphere for seven hours. The temperature was maintained at approximately 60°C. The plasma treatment effluent was then treated using reverse osmosis (RO) to further reduce remaining PFAS concentrations in the effluent and concentrate the PFAS for more efficient destruction. RO was used as

a polishing step in the experiment to determine impact on overall PFAS removal. Two RO passes were included but the results were reported as sample S9. The concentrate from the first RO pass went back to the plasma system for additional treatment. The first pass RO permeate went to the second RO system. A sample of the first permeate was collected but the fate of the second permeate was not clear.

G2.6.1 PFAS Reduction

Plasma treatment (before RO polishing) generally reduced PFAS concentrations by 99% or more. It should be noted that concentrations less than the reporting limit were assumed as 0 ng/L, which is discussed further in Section G3.1. Concentrations of perfluorotetradecanoic acid (PFTeDA [-300.00%]), PFBA (-620.00%), perfluoro-3-methoxypropanoic acid (PFMPA [-27.78%]), and PFPeA (-476.92%) all increased (as indicated by negative percent values) following plasma treatment. These increased concentrations indicate either incomplete defluorination and/or presence of oxidizable precursors. 3-perfluoropropyl propanoic acid (3:3 FTCA), 5:3 fluorotelomer carboxylic acid (5:3 FTCA), 2H,2H,3H,3H-perfluorodecanoic acid (7:3 FTCA) were all present in the solution and may have contributed to increases in concentrations of PFBA, PFMPA, PFPeA. The TOF concentration was reduced from 4,856,300,000 ng/L to 1,498,000,000 ng/L while the fluoride concentration increased from 100,000 ng/L to 7,000,000 ng/L (Table G.3). No additional byproduct data were provided. Following plasma treatment, two RO passes were used for cleanup. RO further reduced concentrations to below detection for all but PFBA, PFNA, PFHxS, PFOA, and PFOS. Each of the aforementioned PFAS were detected at 22 ng/L (PFOS) or less. As discussed with previous PFAS destruction technology vendors, this ability to reconcentrate the treated effluent of the destruction technology may provide energy and cost savings.

G2.6.2 Energy Consumption

Onvector reported energy consumption at 3,442 kWh/m³ (Table G.5), without the RO process, which was moderate to high, relative to the other vendor reports. It is known that energy demand for RO is significant; reducing or eliminating the need for RO would be ideal to decrease energy, equipment, and O&M costs. Instead, the treated effluent could potentially be recirculated back to the SAFF® system.

G2.6.3 Summary

Based on the provided data, the Onvector plasma system is viable for further consideration for a pilot-scale system. However, additional information is needed, including a complete mass balance, as well as determining the need for an RO system.

G2.7 Revive Environmental - SCWO

Revive Environmental Technology LLC ('Revive') developed an iteration of SCWO, called the PFAS Annihilator®. The Revive system is mobile and available in containerized systems. The Revive system pre-filters influent prior to system heating. The system treated the provided 5-gallon SAFF® sample in one batch at 625 °C and 3,500 psi for approximately 30 minutes, followed by neutralization by NaOH.

G2.7.1 PFAS Reduction

All PFAS, including those recently regulated by the EPA, were reduced to non-detect in the final samples (Table G.8). The TOF concentration was reduced from 4,150,000 ng/L to 289,000 ng/L, indicating degradation of fluorinated organic molecules. TOF concentrations were 4,154,000 ng/L in the baseline sample and 288,700 ng/L in the final sample. Fluoride anion increased from 120,300 ng/L to 3,839,800 ng/L. The TOF and fluoride data support Revive conclusions that PFAS destruction was occurring.

G2.7.2 Energy Consumption

Energy consumption was not quantified in the provided report. Insufficient information was available to estimate energy demand, though it is anticipated to be comparable (order of magnitude) to other SCWO systems. Any potential future testing should include quantification of energy demand.

G2.7.3 Summary

Based on the provided PFAS data the Revive Environmental system appears promising. However, byproducts analysis, mass balance, and energy consumption data are needed to support consideration for pilot-scale demonstration.

G3 Discussion of Results

Each technology is quantitatively evaluated here based on concentration reduction of total detected and individual PFAS, TOF (typically measured as AOF), production of fluoride anion, energy consumed in the process, and costs. Total PFAS, in this case, refers to the sum of detected PFAS concentrations as measured by EPA Method 1633 in a sample. Additional PFAS may be present that are not part of the analytical method and would require analysis with a different method or non-targeted analysis (NTA) to identify. Semi-qualitative evaluation was also completed based on available installation and O&M considerations. As discussed in later sections, these metrics may not scale one-to-one from bench to pilot or full-scale application.

G3.1 Vendor Data Report Review

A detailed review of vendor summary reports and associated analytical laboratory data was completed during preparation of this appendix. Vendors were not required to standardize their results reporting because each technology has different operational parameters. Further, variable detection limits between analytical laboratories and as a result of required sample dilution to quantify the high PFOS and PFOA concentrations resulted in inconsistent detection of various individual PFAS present at lower concentrations. The following data quality observations were made after review of the reports:

- 374Water° reported final concentrations (Table 9 in the 374Water° report) following Run 1 of non-detect for all PFAS except PFHxS (1.04 ng/L) and PFOS (2.86 ng/L). However, Table 1 in the 374Water° report states that total PFAS in Run 1 were reported as 1.95 ng/L. In Run 2, Table 9 showed final PFOS concentration was 2.69 ng/L while Table 1 stated no detections.
- Axine reported values as “<” in several cases where results were less than one or more analytical reporting limits. A percent removal value was reported, despite no defined endpoint, which makes it difficult to determine what final value the percent was calculated from.
- General Atomics reported data for a selection of PFAS. However, supporting tables provided by General Atomics show additional PFAS detections (e.g. PFPeS).
- Claros reported detections with the error value from standard deviation of triplicate runs. Review of laboratory data did not readily support matching the results to those in the tables.
- Revive did not provide detailed results in their summary report and instead provided analytical laboratory reports. The laboratory reports show the final samples were all non-detect, while the reporting limit was generally 0.99 ng/L. The PFAS removal discussed in the report text does not specifically indicate the final values referenced or percent removal of specific PFAS.

This data review is intended to add context to the results reported above and discussed below. In general, care should be taken when discussing samples with NDs to ensure it is clear that non-detect

does not equate to zero. This is especially important as the Minnesota Department of Health (MDH) Health-Based Value (HBV) for PFOA is below the detection limit. When discussing the results, stating that 100% destruction is achieved should be avoided for this reason and instead either a range of destruction should be provided based on the detection limits or stating that destruction was greater than the percent calculated based on the laboratory detection limits. This potential destruction range may be large as detection limits of over 1,000 ng/L were observed. These data gaps create uncertainty when assessing PFAS removal by technologies discussed in this evaluation and others. This discussion is also important when evaluating the potential PFAS byproducts of a destruction technology and when determining the disposal options of the treated concentrate and if additional polishing is required to ensure PFAS is not being discharged back to the environment.

G3.2 PFAS Degradation Discussion

G3.2.1 PFAS Reduction

The following discussion compares the PFAS reduction between the seven destruction technologies and acknowledges reduction in PFAS concentration but, on the basis of available data, cannot confirm that destruction (i.e. complete defluorination) occurred without the availability of a complete mass balance. NTA was not utilized as part of any of the seven studies. It is probable that ultra short-chain PFAS (less than four carbon) were generated during destruction, further highlighting the need for fluorine mass balance utilizing multiple lines of evidence.

PFOA and PFOS concentrations were reduced to at least 99.9% in each experiment conducted. Degradation of PFOA and PFOS have historically been the benchmark for success of a given PFAS treatment technology, as these tend to have the lowest discharge criteria. These two PFAS are also present in the highest concentrations across the Site. That is particularly true for PFOS because the presence of the sulfonate functional group has greater bond dissociation energy than the carboxylic group on PFOA. These long-chain PFAS also have greater affinity for adsorption to surfaces than short-chain PFAS and concentration reduction may be incorrectly associated with destruction when adsorption is instead occurring. A thorough mass balance, including desorption tests, is needed for that reason. Nonetheless, PFOA and PFOS were reduced in processes lasting a minimum of 10 seconds (374Water®) and maximum of 24 hours (Claros). Based on PFOA and PFOS reduction alone, any of the seven options may be viable; however, additional PFAS should be considered to reduce the risk associated with PFAS exposure.

Degradation of PFAS with carbon chain lengths of four to seven are of increasing interest due to various PFAS regulations and guidance. Although out of scope of this project, ultra-short chain PFAS or those with chain lengths less than four carbons should also be considered and will be evaluated in future destruction studies for Project 1007. Vendors with detections of PFBA, PFBS, PFPeA, PFPeS, PFHxA, PFHxS, PFHpA, and PFHpS reported were generally reduced to below detection. Specific exceptions included: PFBA (General Atomics) and PFHxS (Claros). As shown in Table G.8 and discussed in Section E3.1, multiple vendors used varied approaches to present final concentration and percent change in concentration. The interpretation of data where values less than detection were used or where 0 ng/L was assumed should be considered with caution. The individual PFAS detected in the influent samples varied between all seven vendors. That was likely due to particularly high concentrations of PFOA and PFOS which resulted in many PFAS reported as estimated values. Further evaluation is warranted to demonstrate that each system is capable of treating short- and long-chain PFAS and evaluating treatment outcomes in the presence of known and unknown precursors. Overall, detected PFAS were mostly reduced to below detection, indicating that any of the technologies may be appropriate. These reductions occurred within the same timeframe of PFOA and PFOS reductions and did not lag causing increased treatment time.

An emerging consideration for PFAS treatment is the presence of precursor compounds. These precursor compounds are PFAS which may be oxidized or reduced to a PFAS end product (PFOS, PFOA). Precursor oxidation to perfluorinated PFAS can cause significant increases in time required to meet treatment goals. The precursor PFAS can also be reduced or oxidized by PFAS treatment processes resulting in measurable increases in end-product PFAS, particularly carboxylic acids (Houtz and Sedlak, 2012). Thus, a time-concentration plot may show one or more PFAS increasing over time until the precursor(s) are fully processed and subsequent end-product concentrations begin to decrease. Depending on the treatment method, energy input, and required residence time, conversion may occur in minutes or many hours. Only Enspired (3:3 FTCA) and Onvector (3:3 FTCA, 5:3 FTCA, 7:3 FTCA) reported detections of known precursor PFAS in their received SAFF® sample. The resulting concentration reduction was unclear for Enspired because initial precursor concentrations were below detection limits, but final concentrations were not. However, based on the detection limits and final concentrations, it is possible concentrations were measurably lower in the effluent. Onvector reported 100% removal for each detected precursor PFAS.

None of the aforementioned precursor PFAS are currently regulated and are not directly drivers for treatment goals. However, when precursors transform to perfluorinated end products of interest and additional treatment time is required to reduce the concentrations, efficiency may subsequently be reduced. As technologies continue to develop, intentional analysis of environmental samples or laboratory mixtures of PFAS, which include precursors, is critical to understand how overall PFAS reduction occurs and how treatment of end product PFAS proceeds when precursor PFAS are present. Precursor PFAS have been found to be low across the Site, likely because of the historical nature of the Site and because of the wastes originally disposed of. However, this should be considered when evaluating PFAS destruction elsewhere as even low concentrations of precursors in the impacted water being treated can be greatly concentrated in foam fractionation and other concentrating technologies.

EPA Methods 1633 or 537 quantify PFAS concentrations using analytical standards for each targeted PFAS, thus only compounds that are part of the specific method are reported. As a result, there may be one or more PFAS present which cannot be quantified if the species is not part of EPA Methods 1633 or 537. The total concentration of precursor PFAS that transform to perfluoroalkyl carboxylic acids (PFCA) can be semi-quantitatively estimated from the total oxidizable precursor (TOP) assay. The TOP assay compares concentrations of PFCAs in a control to an oxidized sample. If precursor PFAS are present, the PFCA concentrations in the oxidized sample will likely be greater than those in the control (Houtz and Sedlak, 2012). 374Water® and Axine included TOP assay data in their respective reports. 374Water® used the TOP assay on post-SCWO treatment samples. The results indicated that there were 0.48 ng/L total oxidizable precursors remaining after SCWO treatment. The limited precursor quantity is a promising result for SCWO treatment; however, influent sample TOP assay results were not provided so the effectiveness of SCWO for precursors cannot be explicitly determined. TOP assay results provided by Axine demonstrated that not only were precursors present, but the majority of the precursor burden was reduced by the 67% treatment mark. After the 100% treatment stage, oxidizable precursors were apparently reduced by at least 99.9% or to below detection limits. The TOP assay results support that the precursor burden was reduced almost entirely such that additional impacts from precursor transformation may be considered unlikely.

The maximum PFAS reduction efficiency, in terms of percent reduction of total analyzed PFAS per unit time, was completed by 374Water® where residence time was 10 seconds and thirteen PFAS were reduced to near or below detection. As reduction per unit time increases, efficiency typically increases because energy consumption per unit time is likely less and more feed material can be processed. As the influent volume increases and/or as concentration decreases, the efficiency subsequently decreases. The 374Water® system operated at 9 mL/min in the first batch and residence time was 10 seconds. Energy efficiency for larger scale and higher flow rate systems may be more favorable, dependent upon any resultant increases in the necessary energy input. 374Water® also used a furnace that would not be

used with their pilot scale system. Given that the furnace is not used in larger scale systems, the related energy consumption was not included in 374Water° calculations.

G3.3 Byproducts Generation

PFAS destruction technologies may result in a variety of byproducts including short-chain PFAS, anions, disinfection byproducts (DBPs), and others. Some byproducts can be used to quantify the extent of PFAS destruction while others, like DBPs, may be harmful to human health when produced in sufficient quantities and require additional treatment for removal. Byproduct quantification is recommended as standard best practice when evaluating PFAS remediation technologies (Deeb et al., 2021). Byproducts reported by vendors are summarized in Table G.5.

Anions are assessed because they are indicators of the extent of PFAS destruction. For example, fluoride is produced from defluorination, and sulfate is produced from functional group cleavage (Ateia et al., 2021). It must be noted that electrochemical oxidation processes typically involve the addition of an electrolyte such as sodium sulfate to increase electrical conductivity, thus elevated levels of sulfate in treated effluent may not be derived solely from degradation of sulfonic acid functional groups. Table G.4 provides the results of byproducts analysis. Fluoride production was reported by Enspired, 374Water°, General Atomics, and Axine. Sulfate and chlorine were quantified by General Atomics and Axine.

As shown in Table G.3, concentrations of fluoride increased at least one order of magnitude from baseline measurements for each of the studies that reported fluoride. Measurable increases in fluoride from baseline are a strong indicator that defluorination is occurring. It is possible that fluorinated compounds not part of the speciated PFAS analytical suite are present in the water. Therefore, simultaneous decline in measurable PFAS and TOF is also necessary, as TOF does not rely on identification of individual species. The combination of PFAS, TOF, and fluorine is the basis for a complete mass balance, although TOF analysis, typically completed through AOF analysis, may not capture ultra short chain PFAS. The release of fluoride does require management because of the formation of HF. This can be accomplished through the addition of a base.

Sulfate measured by General Atomics approximately doubled in concentration in the Phase 1 trial from 120,000,000 ng/L to 260,000,000 ng/L. Axine reported influent sulfate concentration was 3,890,000 ng/L and effluent was 2,370,000,000 ng/L, though it is unclear if this increase is due solely to sulfonic acid functional group cleavage or if a sulfate salt was added during the test to increase electrical conductivity. Axine also reported that additional perfluorosulfonic acids were present in the influent that were not detected by General Atomics. These were PFPeS, PFHpS, and perfluoroethylcyclohexane sulphonate (PFecHS) which represented approximately 1.5% of total PFAS and may account for the greater increase in sulfate concentration. Axine did not dilute the received SAFF® sample as was done by General Atomics, which ultimately affected reporting limits. Sulfate quantification is a useful secondary check for extent of destruction of PFAS species which contain sulfonic acid.

Table G.4: Vendor Reported Byproduct Results.

Vendor	374Water°	Axine	General Atomics ⁽¹⁾	Claros Technologies	Enspired Solutions	Onvector	Revive Environmental
Technology	SCWO	EO	SCWO	Photochemical	PRD	Plasma	SCWO
Fluoride (µg/L)	Initial = 0; Final = NR	Initial = 120 Final = 2,470	Initial = 500; Final = 1,200	NR	Initial = 120 Final = 6,700	Initial = 100 Final = 7,000	Initial = 120 Final = 3,800
Sulfate (µg/L)	NR	Initial = 3,890 Final = 2,370,000	Initial = 120,000 Final = 260,000	NR	NR	NR	NR
Nitrate as N (µg/L)	NR	NR	Initial = 810 Final = 1,300	NR	NR	NR	NR
Chloride (µg/L)	Initial = 240,000 Final = NR	Initial = 204,000 Final = <10,000	Initial = 88,000 Final = 180,000	NR	NR	NR	NR
Bromine (µg/L)	Initial = 0 Final = NR	NR	NR	NR	NR	NR	NR
Silicon (µg/L)	NR	NR	Initial = 4,300 Final = 8,500	NR	NR	NR	NR
Calcium (µg/L)	NR	NR	Initial = 1,700 Final = 590	NR	NR	NR	NR
Chromium (µg/L)	NR	NR	Initial = 0.690 Final = 22	NR	NR	NR	NR
Iron (µg/L)	NR	NR	Initial = 260 Final = 100	NR	NR	NR	NR
Magnesium (µg/L)	NR	NR	Initial = 600 Final = 240	NR	NR	NR	NR
Nickel (µg/L)	NR	NR	Initial = 1.5 Final = 57	NR	NR	NR	NR
Sodium (µg/L)	NR	NR	Initial = 150,000 Final = 460,000	NR	NR	NR	NR
Titanium (µg/L)	NR	NR	Initial = ND Final = 8.9	NR	NR	NR	NR

⁽¹⁾ Results reported from Phase 1 Test 2.

Legend: µg/L = microgram per liter; ND = non-detect; NR = not reported by vendor (gray cells).

General Atomics quantified the following byproducts in the influent and effluent of the Phase 1 trial, which were not reported for the other bench studies: Silicon, calcium, chromium, iron, magnesium, nickel, sodium, titanium. As shown in Table G.4, the concentrations of the following analytes quantified by General Atomics increased as follows: nitrate (37% increase), chlorine (51% increase), silicon (49% increase), chromium (96% increase), nickel (97% increase), sodium (67% increase), and titanium (non-detect to 8.9 µg/L). These concentration increases do not directly reflect PFAS destruction but were indicators of reactor corrosion, as discussed in Section E2.3. Concentrations of the following analytes were reduced: Calcium (67% decrease), iron (61% decrease), and magnesium (60% decrease). Concentration reduction of these analytes is not a direct indicator of PFAS destruction. The concentration loss may be the result of precipitation, sorption or potential recombination with other byproducts.

DBPs, including trihalomethanes, are observed when disinfectants like chlorine react with naturally occurring organics in water (CDC, 2024). DBPs, particularly perchlorate, have also been identified in effluent from oxidative destructive treatment technologies (Yang et al., 2019). Methods to mitigate DBP formation have been demonstrated; however, quantification of DBPs is still necessary to ensure accumulation above regulatory action levels is not occurring. This is more significant for technologies that will be used to treat drinking water sources, which is not currently proposed for the destructive treatment technologies. DBPs analysis was not required under the RFP, and DBPs were not reported in any of the seven bench scale study reports. Nonetheless, any future pilot scale studies will benefit from DBP evaluation to ensure compliance with existing DBP drinking water regulations or potential discharge criteria. DBPs can also be managed through recirculation of the treated effluent back into the SAFF® system.

Gases can also be produced during treatment. Electrolysis in electrochemical oxidation results in the generation of hydrogen gas. While not necessarily a concern at the bench scale, hydrogen will likely need to be managed in a full-scale system to ensure concentrations remain below the lower explosive limit (LEL). This was not discussed by Axine but was incorporated into the DE-FLUORO™ field demonstration (Appendix F). The production of carbon dioxide was discussed by General Atomics but not by 374Water or Revive. As 374Water used IPA as a cofuel and discussed how diesel could also be used, carbon dioxide production is expected.

For SCWO systems, the resulting ash must also be disposed of. The vendors have stated the PFAS is not found in the ash, but this would have to be confirmed during a pilot study.

Enspired uses a surfactant that does have aquatic toxicity and is present at the end of the treatment time. This surfactant can be easily destroyed if needed prior to disposal.

G3.4 Energy Efficiency

At present, PFAS destructive technologies processes require energy inputs, typically electricity. Energy consumption by destructive technologies varies greatly between systems and, to a lesser degree, by operating conditions. Energy consumption has been assessed in the literature in detail at both bench- and pilot-scale (Horst et al., 2020; Meegoda et al., 2022; Yanagida et al., 2022; Shields et al., 2024). As the treatment volume increases and concentration decreases, energy consumption generally increases for a corresponding decrease in PFAS. Thus, treating concentrates like SAFF® concentrate is substantially more efficient than treatment of a large volume of dilute PFAS. Of the seven companies completing bench scale studies, all but Revive Environmental and Claros Technologies provided energy consumption data (Table G.5). Energy usage could not be estimated for Revive Environmental but was estimated for Claros Technologies by using the lamp wattage (100 watts), number of lamps (3), and known operation time (24 hours) then dividing by the number of gallons treated (5 gallons). Data for Claros Technologies may not be accurate given the method of calculating energy usage. The data provided by General Atomics was given in total kWh rather than per unit volume treated. Given the fact four tests were done

with variable volume, energy usage as kWh/m³ is not explicitly provided. General Atomics reported 1,800 kWh for 4.27 hours of operation. This was not adjusted for dilution because it was assumed that the same energy would be required to treat the diluted volume regardless of the PFAS concentration. Enspired provided multiple energy calculations. If recirculation back to the foam fractionation system is possible, less energy can be used. This predicted energy is given in Table G.5 and results in 90% degradation of total known PFAS and unknown precursors. This is likely the case for other vendors as well, especially those where a shorter treatment time could be utilized such as Axine, Claros, and Onvector.

Table G.5: Vendor Reported Energy Consumption by Technology.

Technology	Company	Value (kWh/m ³)	Value (kWh/gal)
Electrochemical Oxidation	Axine	2,973	11.3
SCWO	374Water°	296	1.1
	General Atomics	1,800	6.8
	Revive Environmental	NR	NR
Photochemical Reduction	Claros Technologies	153	0.6
	Enspired Solutions	1,300	4.9
Thermal Arc-Plasma	Onvector	3,442	13.0

Legend: NR = not reported.

To qualify these results, it is important to relate this to PFAS concentration reduction achieved, dilution required, and time to treat. As discussed in Section E3.2 PFAS concentration was generally reduced by 90% or more for all technologies with very few exceptions. Treatment of PFAS present without quantifying may limit overall efficiency. If additional PFAS species were to be included in treatment goals, treatment time could increase and efficiency could decrease. Data from PFAS-spiked experiments would need to be collected and compared to energy consumption to better understand the potential extent of PFAS destruction relative to energy consumed.

To reduce overall energy consumption, it may also be beneficial for some of the technologies to recirculate the effluent of the destruction process back to the foam fractionation or other PFAS concentrating technology. While overall destruction efficiency may be lower within a single treatment (batch or continuous flow), this may result in optimized treatment by utilizing each technology for its optimal role.

G3.5 System Lifecycle Cost Considerations

A system lifecycle cost assessment includes installation and O&M costs, operating time and more. The specific lifecycle considerations (costs, energy consumption, required maintenance frequency) will vary between end users based on influent conditions. However, understanding total cost and operating considerations is essential to prepare for successful implementation, including avoiding excess downtime. Additionally, the cost is highly dependent on efficiency and treated volume. Generally, decreasing volume (and increasing concentration) decreases treatment time and cost. As part of system scale-up, efficiency and cost must be considered in order to avoid excessive costs or otherwise inefficient use of resources. Specific costs provided below are not specific to the Project 1007 Site and could vary with Site-specific considerations. In this section the available cost, operation, and maintenance information is discussed. In instances where information was not explicitly provided, potential implications were discussed based on information about the overall technology.

374Water°: The report did not include discussion of CAPEX or OPEX costs or considerations. Additional information was provided in response to follow-up questions. 374Water° provided cost estimates for a system operating at 1,600 gallon/day where CAPEX was estimated at \$2,500,000 and OPEX at \$75,000 (or 3% of the capital cost per year. In practice, the total treatment volume per day is likely to be much less than 1,600 gallons. As a result, actual OPEX costs for the 374Water° SCWO system may vary considerably from estimates provided here. Costs provided are for onsite destruction; however, multiple SCWO vendors have indicated there would be significant cost savings if waste was shipped to one of their permitted, offsite SCWO facilities although this has not been discussed with 374Water°. Therefore, this should be a consideration when evaluating future applications of SCWO at the pilot- or full-scale.

Axine: Axine did not provide a lifecycle cost or maintenance consideration assessment in the report, However, they did note that a full-scale, rather than bench-scale, reactor would operate more efficiently. Based on the photos of the bench-scale system provided in the report, it is assumed that the reactor and electrode configuration is different in a full-scale system, but this was not described in the report. Electrochemical oxidation systems often require electrode replacement which may not be off-the-shelf purchases and can be vulnerable to degradation, particularly where corrosive conditions occur. Additional equipment is needed for reactor condition control and automated operation. The cost and lifespan for those components may vary. Finally, the option to rent or purchase the unit from Axine was not discussed in the report.

General Atomics: General Atomics reported that their basic iSCWO system costs \$3,000,000 and inclusion of a high-pressure air compressor would cost an additional \$1,000,000. Operating costs were based on the consumption and cost of municipal water, diesel fuel, propane, NaOH, and electricity. The annual maintenance cost was estimated to be approximately \$50,000. Potential downtime for maintenance was not detailed but monthly and annual maintenance is anticipated. Costs provided are for onsite destruction; however, SCWO vendors (General Atomics and Revive) have indicated there would be significant cost savings if waste was shipped to one of their permitted, offsite SCWO facilities. Therefore, this should be a consideration when evaluating future applications of SCWO at the pilot- or full-scale.

Claros Technologies: Claros did not provide a lifecycle cost or consideration assessment as part of the report submitted to MPCA. Claros did note that estimated total pricing is \$3.77/gallon treated including the reactor unit and peripheral equipment, IP sublicense costs, consumables, and energy. The SAFF® sample was diluted in order to increase UV transmission through the sample media. In addition, the dilute sample was treated for 24 hours. As a result, the total time to treat a larger concentrate volume may be relatively significant compared to other technologies discussed in this document.

Enspired Solutions: In addition to electricity demand and cost discussed in Section E3.3, Enspired provided the following information regarding CAPEX and OPEX: CAPEX is \$0.64-\$1.92/gallon for the concentrate, and OPEX is \$0.99 - \$2.96/gallon. Enspired noted that the costs are dependent upon the remediation goal. For example, removal to below EPA Maximum Contaminant Levels (MCLs) for applicable PFAS or removal of total known PFAS. Additional PFASigator units may be needed for the more stringent treatment targets as longer treatment times would be required. Incorporation of polishing with a foam fractionation system or another technology (e.g. RO membranes) could also be considered to reduce treatment time and unit size. Enspired offers subscription-based materials supplies (e.g. reagents) where the system is fully automated, potentially only requiring monthly visits. In addition to electricity and reagents, minimal waste disposal costs could occur depending upon pre-concentration steps and system operation and any necessary permits or other ancillary costs. Given that UV equipment has been thoroughly demonstrated in the water industry, minimal additional health and safety costs, unique maintenance costs, or rare parts are expected.

Onvector: The report did not discuss CAPEX costs or rental versus purchase. Onvector offers plasma reactors at various scales, for example their Type 10 model was recommended in the report to treat 360

gallons per day at a 7.2-hour plasma destruction cycle. Onvector had previously collected sufficient data to prepare cost estimates per gallon of foamate treated. The costs include capital and operating costs but do not include the RO process. The estimated cost for treatment of the SAFF® concentrate is \$4.93/gallon. Onvector also highlights the advantages of using a concentrating step as treatment is more energy efficient when at higher concentrations. The report focuses on RO but recirculation back to the SAFF® system may also be possible. Energy costs do account for about 60% of the expected operating costs so efforts to maintain high PFAS concentrations during operations of the system could result in large cost savings.

Revive Environmental: The PFAS Annihilator technology has been evaluated elsewhere at the pilot- and full-scale. Larger units are available containing multiple SCWO reactors. The report did not specifically address if units are available for rental or purchase, nor did it specify maintenance responsibility or frequency. There may be multiple cost and service models available from Revive, one of which is that costs could be determined on a per gallon treated basis. Therefore, more information is needed to evaluate specific lifecycle considerations. The report did note that the 5-gallon SAFF® sample was treated in 30 minutes. It can then be assumed that at this scale, the time to treat volumes with similar concentrations are approximately: 100 gallons would require 10 hours, 1,000 gallons would require 100 hours, and 10,000 gallons would require 1,000 hours. Using this assumption, estimated total volume of waste to be treated can be compared to maintenance frequency requirements, if they become available. Updated costs projections were provided in March 2024 which estimate that the costs to treat SAFF®-concentrated groundwater and surface water are between \$1.83/gallon and \$4.88/gallon. Costs provided are for onsite destruction; however, multiple SCWO vendors have indicated there would be significant cost savings if waste was shipped to one of their permitted, offsite SCWO facilities. Therefore, this should be a consideration when evaluating future applications of SCWO at the pilot- or full-scale.

G3.6 Assessment of Data Gaps

Each vendor report was reviewed in detail in order to evaluate, and potentially recommend, the technology (e.g., EO, SCWO) for pilot-study consideration. No specific vendor recommendations are provided as part of this assessment. After reviewing the individual reports, the results and details were considered in the context of three tables published as part of SERDP Project ER18-1633 *Lines of Evidence to Assess the Effectiveness of PFAS Remedial Technologies* (Deeb et al., 2021).

Table 2 in ER18-1633 covers three categories: 1) decrease in target PFAS concentrations in context of mass balance, 2) treatment mechanism is proposed that is consistent with previous studies and supported by data, and 3) PFAS transformation products have been identified and quantified. Each of the destruction technologies represented by the vendor bench tests are generally backed by one or more assessments of effectiveness for multiple PFAS, measurable decrease in concentration, performance in the presence of other organics. Additionally, destruction mechanisms have been proposed in the literature, byproducts (e.g., fluoride, sulfate) have been detected and byproducts support the proposed mechanism. The individual vendor reports did not necessarily assess all items in the checklist because the technologies were already established, and the evaluation was not part of the RFP. However, a few items are not as well elucidated and should be considered for further work under a pilot RFP.

- Impact of dilution on apparent PFAS concentration decreases
- Performance for different influent streams in the event other areas of the Site are treated
- PFAS aerosolization
- Definitive evaluation of sorption to different reactor materials
- Specific tracking of changes in carboxylic acid, sulfonic acid, short- and long-chain, and precursor PFAS over time

- Detailed mass balance

To better understand the individual technologies and evaluate performance specific to SAFF® concentrate, quantifying performance in the above areas will be invaluable. The data can subsequently be used to assess moderate changes to the conditions as work progresses.

Table 3 of ER18-1633 addressed the following general categories: 1) use verified analytical methods for PFAS that are commonly analyzed, 2) use established research methods for PFAS precursors and other PFAS, 3) follow and document laboratory best practices for sample preparation and analysis, 4) include controls in study design, and 5) account for statistical significance in study design and presentation of results.

Each vendor provided data from third party analytical laboratories using EPA Method 1633. In addition, vendors provided fluoride anion, AOF or TOF, and in some cases TOP results from third party laboratories. It is assumed that all third-party analytical data can be considered produced using an established and rigorously tested method. Instead, what may be lacking between reports are multiple lines of evidence to quantify all PFAS sources, though it is acknowledged these methods can be expensive. Statistical variation was documented in the reports by some vendors, including Claros, but not all. In some cases, the volume of SAFF® concentrate was insufficient for multiple runs in triplicate without dilution that would add uncertainty. Future work may consider at least three treatment periods per SAFF® sample to better understand performance. Three key considerations to better complete Table 3 from ER18-1633 are:

- Complete additional analytical evaluation (e.g., NTA).
- Completion of periodic control experiments; and
- Completion of multiple runs with the same conditions to understand possible variability.

In Table 4 of ER18-1633 additional “other” categories are presented: 1) effect of PFAS mixtures, concentrations, co-occurring chemical, and other water quality parameters, 2) long-term treatment system performance, 3) generation of harmful byproducts, 4) value relative to other available technologies.

SAFF® concentrate from the same drum was provided to each of the seven vendors reporting under the MPCA RFP. While these vendors have tested their technologies on other sources, only one Project 1007 source (SAFF® concentrate from surface water) has been tested. Therefore, it would be valuable to complete additional bench tests with SAFF® concentrate from groundwater, as well as any other potential influent streams. It is common for performance variation to occur when organic loads and suspended solids vary between sources. Long-term performance specific to SAFF® concentrate has not been evaluated. Data for individual technologies that have been demonstrated at pilot-scale with continuous operation for a month or more can indicate the likely capacity for SAFF® concentrate. However, it is possible that long-term operation would reveal specific O&M needs not previously realized.

A thorough evaluation of harmful byproducts generation such as perchlorate and metals was not detailed in all vendor reports and remains an important data gap to address. DBPs, particularly perchlorate, are commonly produced by oxidation of chloride (as discussed in Section E1.0). Perchlorate production is particularly a concern for electrochemical oxidation. Significant reduction in chloride concentrations was observed in Axine benchtop testing. While this is not addressed in the Axine report nor was perchlorate analyzed, it is likely that most this reduction in chloride resulted in the formation of perchlorate as this is typical of oxidative reactions. In addition to metal precipitants, some of the reaction conditions may result in corrosion of the system, resulting in higher metal concentrations in the effluent. This may not be apparent until a longer pilot-scale study is complete.

While the selection of a technology will be dependent on its PFAS destruction capabilities, additional information will be evaluated when comparing the technologies including costs and qualitative data, like site footprint, electricity requirements, chemical additive requirements, health and safety, treatment capacity, and operating logistics. While provided by some of the vendors, this additional information would be collected and compared from the vendors prior to finalizing decisions to proceed with a pilot-scale study. Pilot studies would then provide additional information to support the installation of a full-scale system including the following:

- Consistency in destruction efficiency with variations that may occur with the PFAS-containing influent water
- Longer-term performance, ideally up to 3 months in length, or longer
- Generation of harmful byproducts and understanding of specific conditions required for production
- Quantitative and qualitative assessment of installation and O&M

Additionally, there are other vendors and additional technologies that did not submit proposals under the RFP and thus the technologies were not reviewed in this appendix. For example, HALT uses high temperature and pressure with a caustic soda amendment to defluorinate PFAS (Millevolte and Pinkard., 2024). Other companies, including Invicta Water, have also developed novel photocatalytic PFAS destruction technologies. Therefore, when addressing data gaps, the applicability of technologies not evaluated under the MPCA bench-scale RFP may be an important consideration.

G4 Destructive Technology Implementation and O&M

Demonstrating that a given technology is capable of destroying PFAS at the bench-scale is key to project success. However, the final selected technology must be capable of being scaled to a full-scale installation for use in the final remedial design. In this section, implementation, adaptability, and operational considerations are discussed for electrochemical oxidation, SCWO, UV, and plasma technologies. These sections do not provide a final decision, rather, they are intended to provide guidance during the selection process. Detailed checklists from Deeb et al (2021) were used as part of this discussion and can be referenced for a thorough evaluation as technology selection progresses.

G4.1 Destructive Technology Adaptability

The bench-scale studies discussed in this appendix focused on treatment of surface water, concentrated in the SAFF® system. There are at least two adaptability considerations that apply. First, will a given destruction technology produce comparable results if the surface water quality or source changes. And second, can a given destruction technology be used with groundwater concentrated in the SAFF® system or other concentration technology for groundwater or surface water. In any of these hypothetical cases, it is necessary to know what changes might be required to change the technology application.

Surface water quality may be subject to change seasonally and with rain events. These changes may subsequently alter pre-treatment requirements or otherwise inhibit system performance. For example, elevated organic loads may inhibit UV light propagation necessary to create radical species, increase the amount of energy or time required for treatment, or result in the precipitation of more metals (Lee et al, 2022). Similar considerations would apply in the event the surface water source changes or for the treatment of groundwater.

Specific PFAS mixture is likely to vary depending on the locations of treatment and the concentration technologies used. For example, some areas are higher in PFBA, thus PFBA could be present at higher

concentrations in different waste streams. Additionally, different concentrations of PFAS could be observed in a PFAS concentrate from two different concentration/separation technology. For example, foam fractionation provides a much higher concentration factor but mainly removes long-chain PFAS, while RO will remove a much broader range of PFAS as well as most dissolved ions but does not concentrate the PFAS as much as foam fractionation. Thus, the resulting waste streams from foam fractionation and RO are likely to be very different water chemistries and PFAS compositions. A full-scale system would be sized to accommodate the waste generated across the Site and potentially other aqueous wastes in the region, such as landfill leachate, if determined to be appropriate. In that scenario, multiple PFAS sources and varying water chemistries would have to be accommodated with limited or no interruption to treatment. Prior to installing a destructive technology for the Site-wide remedial approach, it is imperative that treatability testing be completed with the specific waste streams and potential combination of waste streams that will be treated for PFAS destruction.

Adaptability may also be needed for implementation. It has become increasingly common to house PFAS destruction technologies in convenient, mobile trailers that can be moved and installed quickly. However, the use of trailers presents some challenges including limited working space, particularly while performing maintenance and repairs. Additionally, winter conditions in Minnesota can pose a risk to operations. Trailers are generally not well insulated, requiring sufficient heat and/or electricity load to prevent lines or tanks from freezing. If a line does freeze, this can damage equipment and lead to even longer downtime and extensive repairs. Trailer sizes vary, as do electrical, water, and storage requirements. Additionally, chemical and materials storage could vary with changing system requirements. For example, SCWO, electrochemical oxidation, HALT, and PRD all use NaOH in their processes which would need to be stored with appropriate environmental, health, and safety controls.

While many of the vendors have systems that could be sized appropriately for the volume of waste generated for Project 1007, overall cost savings may be realized by integrating these waste streams with other PFAS containing waste generated around the state of Minnesota. For some of the technologies, this may result in less downtime because of insufficient waste volume to run at full capacity, better utilizing the installed technology. There can also be other cost savings such as reducing the number of operators compared to having multiple PFAS destruction facilities around the state and reducing building costs by centralizing the facility. Other benefits may also be realized through the mixing of wastes such as diluting out problematic constituents such as heavy metals in some waste streams or changing the organic carbon content. This concept is not going to be discussed further as it is outside of the scope of this project but should be considered prior to the selection of a destruction technology.

G4.2 Pre- and Post-Treatment

Destruction technologies may require some form of pre-treatment or post-treatment to optimize performance. Notably, none of the vendors recommended pre-treatment in their reports. However, Claros did need to dilute the SAFF® concentration to increase UV transmittance through the sample. Pilot-scale studies utilizing a UV technology may require dilution or pre-treatment to remove suspended solids to improve performance. Any suspended solids removal must be carefully evaluated as PFAS may be sorbed to those solids, requiring additional disposal considerations.

Post-treatment requirements may be used to address residual PFAS concentrations or byproducts produced during PFAS treatment. PFAS destruction by some of the technologies proceeds through sequential defluorination, producing short-chain PFAS. Depending on the technology and operating conditions, these short-chain species may accumulate or continue to degrade. An example of the need for post-treatment was demonstrated with the addition of RO as a polishing step for the Onvector plasma system. RO removed the remaining PFAS concentrations following plasma treatment of SAFF® concentrate to below detection limits. Pre-treatment can be used to remove suspended or dissolved materials that might otherwise inhibit PFAS destruction.

Further, depending on the operating conditions and PFAS mixture in the influent, other PFAS can be produced, some of which may not be quantified with commercially available laboratory methods. Reaction byproducts can include fluoride, sulfate, HF, DBPs, carbon dioxide, and others (Meegoda et al., 2022). The specific byproducts will be dependent on the influent water and reaction conditions. Fluoride and sulfate are helpful indicators that PFAS destruction is occurring and generally do not require treatment while others, like HF and DBPs typically need to be addressed. For example, water containing chlorine, when oxidized, produces perchlorate (a DBP) which can be harmful when ingested. Therefore, if perchlorate is quantified in the reactor effluent pre-treatment for chlorine removal or post-treatment for perchlorate removal may be required, depending on where the effluent is to be discharged. Prior to technology selection, potential byproducts must be thoroughly quantified, and a management plan developed and tested.

Post-treatment could also be used to decrease the required size of a destructive technology or decrease run times and energy usage. This could be achieved through recirculation of the effluent of a destruction technology back into the influent of a concentration technology. Alternatively, a polishing technology like IX resin or a separation technology like RO could allow for higher effluent concentrations from the destruction technology. Instead of targeting non-detect or complete destruction of all TOF in the effluent, a reactor could be run to destroy the majority of PFAS species to a concentration that maximizes efficiency of energy input. For example, Ensplied observed a 91% reduction in total PFAS after an applied dose of 400 kWh/m³, a 97% reduction after an applied dose of 800 kWh/m³, and a >99% reduction after an applied dose of 5,400 kWh/m³. Destruction of the final approximately 8% of PFAS destroyed required 12.5x the energy to destroy the initial 91%, demonstrating the diminishing returns with higher energy inputs and longer treatment times. In an addendum provide by Ensplied in March 2024 that incorporates analysis and interpretation of non-Project 1007 testing, Ensplied recommends treating the PFAS concentrate to approximately 90% of the total PFAS concentration to reduce the overall cost of the treatment train as opposed to treating for a longer length of time. The partially treated water could then be recirculated to a concentration technology such as RO or foam fractionation. The RO concentrate or foam fractionation concentrate could then be retreated to destroy more PFAS. Alternatively, IX could be used to polish the residual PFAS and allow direct discharge of treated water; however, it also generates spent media as a waste. This approach could significantly shorten treatment times, increasing reactor throughput and decrease energy use per gallon of water treated.

Appendix J (Technology Analysis for Project 1007 Non-Drinking Water Treatment Alternatives) presents possible treatment train approaches for PFAS removal and application across various Areas of Concern (AOCs). For AOCs where a destruction technology may be appropriate, one of the treatment train approaches in Appendix J may address pre- and/or post-treatment concerns.

G4.3 Operational Considerations

Destructive technology operational considerations consist of the following categories. Additional technology-specific considerations may arise that are not covered here.

- Operator training requirements
- Automatic or manual operation requirements
- Availability of continuous flow operation or ease of batch treatment implementation
- Availability of system data auto log and data backup plan
- Frequency of consumables replacement and subsequent downtime
- Replacement of key components of the system, availability of these components, and subsequent downtime

- Frequency and ease of sampling
- Hazards of consumables
- Waste generation and management

While the ultimate goal of these systems is PFAS destruction, operator safety must be the top priority, along with environmental, health, and safety (EHS) considerations. Based on these bench-scale results, there is insufficient data to understand what EHS considerations are required for safe operations. While not exhaustive, the following list should be evaluated at the pilot-scale and considered in designs for full-scale systems.

- Management of HF in the aqueous and gaseous emissions
- Prevention of PFAS containing air emissions from being released to the atmosphere
- Safety control of systems operating at high temperatures and/or pressures
- Proper chemical storage, especially of strong acids and bases, of required reagents

Design of a full-scale system will need to carefully evaluate how often an operator is expected to be onsite. If a system does not require 24-hour coverage, it is possible an operator may not need to be onsite every day, reducing operational costs. However, sufficient automation would be required in this case to allow for remote monitoring and data logging, which would likely increase capital costs. Additionally, system reliability would need to be well established before selecting a system to ensure the system will have sufficient uptime to treat PFAS. System operations will also impact operator staffing needs.

Validation of destruction is assumed to be required for full-scale operations. To accomplish this, sufficient storage volume would be built to hold treated effluent until sampling results are received. If effluent limits are not met, treated water would be recirculated and re-treated. Sufficient testing, both at the pilot-scale and at initial commissioning of a full-scale installation, would be required to develop operational procedures that maximize PFAS destruction. Polishing may also be necessary to ensure compliance with discharge permits and to guarantee PFAS is not released into the environment.

Replacement frequency of consumable components (e.g., pre-filter cartridges) and chemicals (e.g. NaOH) and the available redundancies can also affect downtime and operator needs. This component should also include parts that may need periodic replacement such as electrodes for EO systems, UV ballasts for photochemical reduction technologies, and pumps that may be likely to fail as a result of the reaction conditions. Replacements, especially specialty items, should be kept on site so they are readily available if needed and are included in OPEX estimates.

Waste should be minimized to the extent practicable. The cost to dispose of PFAS-impacted waste is typically high, and options may be limited to disposal in a hazardous waste landfill or incineration. Further, the State of Minnesota would prefer PFAS containing waste be destroyed in-state to reduce liabilities. Out-of-state destruction may be considered but this should be discussed on a case-by-case basis.

G5 Summary and Recommendations

Seven destruction vendors were provided with samples of PFAS concentrate from the SAFF® system piloted for Project 1007. The seven companies included iterations of electrochemical oxidation, photochemical oxidation, plasma, and SCWO. Following treatment by each vendor, PFAS concentrations were reduced to below detection in most cases. Cases where concentration reduction was much lower than 99% are noted in Section E4.1. In some cases, TOP and/or byproducts were presented in the report but a detailed mass balance that highlights individual system components was not provided. Energy

consumption, materials, O&M requirements, and CAPEX/OPEX costs were presented to varying degrees in reports from each of the companies. Table G.6 summarizes the data provided by vendors as well as notes on data gaps.

In addition to the identified data gaps, other factors must be considered and evaluated prior to making a recommendation for a pilot test or full-scale treatment. As listed below, these factors include more information about the capabilities at the pilot-scale in addition to Site-specific factors that should be explored further.

- Efficiency of destruction at pilot- and full-scale as this may be different than what is achieved at a bench-scale system;
- Additional waste streams that may need to be considered at the full-scale;
- Potential air emissions;
- Ease and safety of operations;
- PFAS concentrate characteristics generated in a full-scale system separation and concentration system;
- Ability to recirculate effluent from the destruction system to the separation/concentration technology to reduce energy requirements;
- Additional PFAS waste streams from Project 1007 or the East Metro that may require destruction; and
- Ability to mix in PFAS containing waste streams from other sites.

Based on this analysis, the following highlights the conditions under which it may be ideal to conduct a follow up pilot-study with each of these technologies. It should be noted again that the destruction efficiency can change between a bench-scale and pilot- or full-scale system. Completing a pilot study is crucial in determining the efficiency in addition to O&M requirements. The following is also based off discussions with the companies about their pilot- and full-scale systems.

- SCWO (General Atomics, Revive, 374Water®): Ideal for larger volumes which may result in the technology sitting idle while larger volumes of waste are generated and stockpiled on site; can be used to destroy solid wastes like GAC and IX resin; offsite treatment should be considered.
- Plasma (Onvector): Field demonstrations at other sites are more limited to-date, so a discussion of the ability to build and operate a full-scale system should be evaluated.
- UV-Activated Photoreduction (Claros): This technology had difficulties with the high turbidity and should not be pursued further for this waste stream unless it can be demonstrated that they can treat the generated waste without dilution.
- UV-Activated Photoreduction (Enspired): Longer treatment times may require more systems if a larger waste volume is generated or if low effluent concentrations are required; benefit of having fewer byproducts because it is a reductive destruction process.
- Electrochemical Oxidation (Axine): Improved understanding of electrode longevity, treatment time, and byproducts is needed prior to further testing.

Additionally, other technologies should be evaluated in any further evaluation of destruction technologies. Specifically, HALT should be evaluated for pilot testing as literature results demonstrate destruction of short-chain PFAS (Pinkard et al, 2024). As stated previously, pilot-studies are crucial in determining destruction efficiency of larger systems and to understand the O&M needs and issues that may arise during long-term treatment system operation. These pilot studies should be carefully designed to ensure the questions and potential issues raised in this appendix are addressed. It is

recommended that at least two technologies be piloted prior to selection of a technology; however, the selection of those cannot be completed until the location and type of separation/concentration technology is selected.

Table G.6: Summary of PFAS Degradation and Operations Information.

Assessment Category	Vendor	Electrochemical Oxidation	UV-Activated Photoreduction		Supercritical Water Oxidation			Thermal Arc Plasma
		Axine	Claros	Enspired	374Water ^o	Revive	General Atomics	Onvector
Reaction Time (minutes)	Vendor Result	Not clear from report.	1440	Not clear from report.	0.167	30	80	360
	Data Gap	Time to achieve unit of destruction (e.g., 10%) for any specific influent. To be determined with additional testing.						
Extent of PFAS Degradation	Vendor Result	All detected PFAS to >99.9% or below detection.	PFHpS, PFOA, and PFHxS (Condition 1 only) removed to below the limit of quantitation; Residual PFHxS (Condition 2) and PFOS detected.	PFAS degradation >99% (PFHxA 98%); Short-chain PFAS indeterminant due to high RL for influent.	No PFAS detected except residual PFHxS (Run 1) and PFOS (Run 1 and run 2).	All detected PFAS concentrations were reduced to non-detect.	Detected PFAS concentrations were reduced to less than 10 ng/L in all tests except for PFBA (Phase 1 Test 1, Phase 2 Test 1), PFOA (Phase 1 Test 1 and Phase 1 Test 2), PFOS (Phase 1 Test 1).	PFAS degradation with plasma only >90% removal except for PFBA, PFBS, PFMPA, PFPeA, PFDOA, PFTeDA. After RO all PFAS removed 100% (except PFBA).
	Data Gap	Repeat experiments and analysis, attempting to reduce reporting limits to near-zero reducing uncertainty of destruction.	Repeat experiments and analysis, attempting to reduce reporting limits to near-zero reducing uncertainty of destruction.	N/A	Repeat experiments and analysis, attempting to reduce reporting limits to near-zero reducing uncertainty of destruction.	Repeat experiments and analysis, attempting to reduce reporting limits to near-zero reducing uncertainty of destruction.	Repeat experiments and analysis, attempting to reduce reporting limits to near-zero reducing uncertainty of destruction.	N/A
Byproducts Formation	Vendor Result	Organic fluorine and Fluoride measured.	Organic fluorine measured; fluoride results not provided.	Organic fluorine and Fluoride measured.	Organic fluorine and baseline fluoride measured. Final fluoride not provided due to matrix interference.	Organic fluorine and Fluoride measured.	Organic fluorine and Fluoride measured.	Organic fluorine and Fluoride measured.
	Data Gap	Quantify perchlorate and other DBPs.	Quantify fluoride, and perchlorate and other DBPs.	Quantify perchlorate and other DBPs.	Repeat work to demonstrate production of fluoride ion. Quantify perchlorate and other DBPs.	Quantify perchlorate and other DBPs.	Quantify perchlorate and other DBPs.	Quantify perchlorate and other DBPs.
Reagent Use	Vendor Result	Sulfuric acid and NaOH for pH control and citric acid for routine descaling.	Reagents required but not specified in the report.	CTAB, Proprietary reagent to encourage hydrated electron production, and acid and base (less than one gallon per month).	Sodium carbonate for pH control to prevent HF formation.	NaOH for pH control.	NaOH and soft water source.	None except argon gas essential for plasma formation.
	Data Gap	Usage of reagents as well as estimated cost per gallon of waste treated is not well quantified in reports. More specific information would be needed to quantify the impact on yearly operating costs.						
Energy Consumption	Vendor Result	Quantified by vendor.	Estimated from available information.	Quantified by vendor.	Quantified by vendor.	Not provided and insufficient information provided to quantify.	Estimated from available information.	Quantified by vendor.
	Data Gap	N/A	Quantify energy consumption.	N/A	N/A	Quantify energy consumption.	Quantify energy consumption.	N/A
Co-Fuel	Vendor Result	None required.	None required.	None required.	Trim and starter fuel common. IPA for the bench tests.	Can be used at full-scale, dependent on influent chemistry.	Diesel and propane.	None required.
Pre- or Post Treatment	Vendor Result	None required.	Dilution to improve UV transmittance prior to treatment.	None required.	None required.	None required.	None required.	RO to concentrate residual PFAS for additional plasma treatment. Final RO step for polishing.
	Data Gap	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.	Verify that no pre- or post-treatment is required for other Project 1007 influent sources.

Legend: N/A = not applicable to specific vendor.

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G7 Additional Tables

Table G.7: SAFF® Concentrate PFAS Composition by Vendor, Reported Detections in ng/L. ⁽¹⁾

Vendor	MPCA	374Water	Axine	Bay West	Claros	Enspired	Onvector	Revive
Lab	SGS AXYS	Eurofins	ALS Environmental Labs	Eurofins	Claros	Merit Laboratories	Pace	Pace
Method	533	1633	E745	1633	1633	1633	1633	1633
3:3 FTCA						4,000 U	30	
NEtFOSAA		134						
PFBA	463	315 J	<10,000			10,000	2,500	
PFBS	194	125	<2,000			2,000 U	700	
PFMBA						2,000 U	11	
PFMPA						2,000 U	18	
PFPeA	135		<2,000	<20,000		4,000 U	780	
PFPeS		6,690	6,800	11,000		8,100	9,500	8,280
HFPO-DA						2,000 U	220	
PFHxA	2,650	1,900	2,200	<10,000		2,200		2,830
PFHxS	149,000	98,400 E	137,000	170,000	40,000	140,000	160,000	138,000
PFHpA	84,800	53,400	71,400	100,000		7,200	85,000	70,900
PFHpS		99,800 E	36,000	52,000	15,000	39,000	53,000	64,600
PFOA	2,440,000	971,000 E	11,380,000	2,100,000	345,000	1,500,000	1,700,000	1,670,000
PFOS	4,670,000	3,660,000 E	4,160,000	4,600,000	1,050,000	2,400,000	3,200,000	3,510,000
PFOSA		604						
PfecHS			202,000					
PFNA	12,000	6,840	13,600	19,000		7,300	9,300	10,200
PFDA	14,700	6,920	16,800	12,000		5,500	7,700	7,320
PFUnA	28.1		<2,000	<10,000			31	
PFDoA	<33.3		<2,000				8.2	

⁽¹⁾ Blank cells indicate data not reported by vendor.

Legend: E = E Qualifier (detected compound's concentration exceeded the laboratory calibration curve; NEtFOSAA = N-ethylperfluorooctane sulfonamidoacetic acid; U = U Qualifier (Compound was analyzed for but not detected, values represent the detection limit).

Table G.8: Summary of Vendor Reported PFAS Degradation Results. ^(1,2)

Analyte		3:3 FTCA	5:3 FTCA	7:3 FTCA	NEtFOSAA	PFBA	PFBS	PFMBA	PFMPA	PFPeA	PFPeS	HFPO-DA	PFHxA	PFHxS	PFHpA	PFHpS	PFOA	PFOS	PFOSA	PfecHS	PFNA	PFDA	ADONA	PFUnA	PFDoA	PfTrDA	PFTeDA
374Water°																											
Run 1	Initial (ng/L)				134	315	125				6,690		1,900	98,400 E	53,400	99,800 E	971,000 E	3,660,000 E	604		6,840	6,920					
	Final (ng/L)													1.04 J				2.86									
	Result				ND	ND	ND				ND		ND		ND	ND	ND		ND			ND	ND				
Run 2	Initial (ng/L)				134	315	125				6,690		1,900	98,400 E	53,400	99,800 E	971,000 E	3,660,000 E	604		6,840	6,920					
	Final (ng/L)																	2.70									
	Result				ND	ND	ND				ND		ND	ND	ND	ND	ND		ND			ND	ND				
Axine																											
100% data	Initial (ng/L)					<10,000	<2,000			<2,000	6,800		2,200	137,000	71,400	36,000	1,380,000	4,160,000		202,000	13,600	16,800		<2,000	<2,000		
	Final (ng/L)					<20	<2			<2	<2		<2	<2	<2	<2	3.8	3.8		<2	<2	<2		<2	<2		
	Result					BDL	BDL			BDL	>99.971%		>99.909%	>99.999%	>99.997%	>99.994%	99.9997%	99.9999%		>99.999%	>99.985%	>99.988%		BDL	BDL		
General Atomics ⁽³⁾																											
Phase 1 - Test 1	Initial (ng/L)					97	360						500	4,000				33,000	120,000								
	Final (ng/L)					56	6.9						6.9	11				29	44								
	Result																										
Phase 1 - Test 2	Initial (ng/L)					96	330						450	4200				34,000	130,000								
	Final (ng/L)					<35	2.8						3.2	2.8				12	7.4								
	Result																										
Phase 1 - Test 3	Initial (ng/L)					100	590						650	4,300				36,000	150,000								
	Final (ng/L)					5	2.5						1.9	1.8				7.2	7.6								
	Result																										
Phase 2- Test 1	Initial (ng/L)					<400	1,236						1,162	12,524				132,146	341,070								
	Final (ng/L)					30	2.4						1.9	2.2				7.3	4.9								
	Result																										
Claros																											
Condition 1	Initial (ng/L)													36,500±3,160		13,500±1,720	338,100±12,710	930,700±114,600									
	Final (ng/L)													70 (LOQ)		0 (LOQ)	20 (LOQ)	230±100									
	Result																										

Analyte		3:3 FTCA	5:3 FTCA	7:3 FTCA	NEtFOSAA	PFBA	PFBS	PFMBA	PFMPA	PFPeA	PFPeS	HFPO-DA	PFHxA	PFHxS	PFHpA	PFHpS	PFOA	PFOS	PFOSA	PfecHS	PFNA	PFDA	ADONA	PFUnA	PFDoA	PFTrDA	PFTeDA
Condition 2	Initial (ng/L)													33,300±1,200		12,800±600	314,600±6,300	1,072,900±56,400									
	Final (ng/L)													2,790±500		160 (LOQ)	70 (LOQ)	2,400±500									
	Result																										
Ensired																											
5,400 kWh Result	Initial (ng/L)	<4,000				<10,000	<2,000	<2,000	<2,000	<4,000	8,100	<2,000	2,200	140,000	7,200	39,000	1,500,000	2,400,000			7,300	5,500					
	Final (ng/L)	480				12,000	<10	<10	230	1,500	<10	<10	54	15	12	<10	86	220			<10	<10					
	Result	N/A				N/A	N/A	N/A	N/A	N/A	>99%	N/A	98%	>99%	>99%	>99%	>99%	>99%			>99%	>99%					
Onvector																											
S7 pre-RO	Initial (ng/L)	30	310	1,500		2,500	700	11	18	780	9,500	220	0	160,000	85,000	53,000	1,700,000	3,200,000	0		9,300	7,700	71	31	8.2	0	1.1
	Final Plasma (ng/L)	0	0	0		18,000	93	0	23	4,500	49	0	730	57	140	16	290	2,100	6.5		21	20	0	3	2.6	2.7	4.4
	Final with RO (ng/L)	0	0	0		4.2	0	0	0	0	0	0	0	1.7	0	0.3	1.3	22	0		0.3	0	0	0	0	0	0
	Result - Plasma	100.00%	100.00%	100.00%		-620.00%	86.71%	100.00%	-27.78%	-476.92%	99.48%	100.00%	--	99.96%	99.84%	99.97%	99.98%	99.93%	--		99.77%	99.74%	100.00%	90.97%	68.29%	--	-300.00%
	Result - Post-RO	100.00%	100.00%	100.00%		99.83%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	--	100.00%	100.00%	100.00%	100.00%	100.00%	--		100.00%	100.00%	100.00%	100.00%	100.00%	--	100.00%
Revive																											
MPCA-03	Initial (ng/L)	<12500	<62500	<62500	<2500	<10000	<2500	<5000	<5000	<5000	8,280	<10000	2,830	138,000	70,900	64,600	1,670,000	3,510,000	<2500		10,200	7,320		<2500	<2500	<2500	<2500
	Final (ng/L)	<4.9	<24.7	<24.7	<0.99	<4.0	<0.99	<2.0	<2.0	<2.0	<0.99	<4.0	<0.99	<0.99	<0.99	<0.99	<0.99	<0.99	<0.99		<0.99	<0.99		<0.99	<0.99	<0.99	<0.99
	Result ⁽⁴⁾										>99.9%		>99.9%	>99.9%	>99.9%	>99.9%	>99.9%	>99.9%			>99.9%	>99.9%					

⁽¹⁾ Results are reported here as reported by vendors, including percent destruction.

⁽²⁾ Blank cells indicate data not reported by vendor.

⁽³⁾ Reported values reflect system dilution.

⁽⁴⁾ Percent reduction was not included in the vendor report and was calculated for analytes where at least the initial or final sample was about the detection limit based on the provided laboratory report.

Legend: BDL = Below Detection Limit; E = E Qualifier (detected compound's concentration exceeded the laboratory calibration curve; J = J Qualifier (Value is at the low end of the instrument range); LOQ = Limit of Quantitation; ND = Non-Detect; ng/L = nanograms per liter; RO = Reverse Osmosis; U = U Qualifier (Compound was analyzed for but not detected, values represent the detection limit).

G8 Vendor Reports

Attachment G1: 374Water° Final Report

374WATER°

374Water – MPCA

**Destructive technology test on perfluoroalkyl
substances (PFAS)**

pioneering a new era
in sustainability

Project Name	Destructive technology test on perfluoroalkyl substances (PFAS) concentrate	
Submitted to	Andri Dahlmeier	
Date	2/8/2024	3M Settlement Technical Workgroup Coordinator
Client	Minnesota Pollution Control Agency	
Revision	1	
Confidentiality	This document is confidential and may contain proprietary information and is shared under the covenant of an NDA. It is not to be disclosed to a third party without the written consent of 374Water Inc.	

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Executive Summary

In July of 2023, in collaboration with the Minnesota Pollution Control Agency (MPCA) and AECOM, 374Water received a 2-gallon sample of Surface Activated Foam Fractionate (SAFF) from a pilot PFAS treatment system operating in East Metro MSP. The SAFF sample was sent as part of a RFQ that provided vendors with PFAS destruction technologies the opportunity to receive and destroy a highly concentrated PFAS foam.

374Water received, prepared, treated, and disposed of the 2-gallon SAFF sample with its lab-based bench scale Supercritical Water Oxidation system. Samples for 40 PFAS analytes (EPA 1633), Total/Adsorbable Organofluorine by CIC (AOF), and a Total Oxidizable Precursor Assay (TOP) were collected and shipped to a 3rd party lab that could meet the reporting requirements and standards set forth by the MPCA.

Overall, the bench scale AirSCWO successfully destroyed 99.99996% of the PFAS contained in the samples according to the primary method used to confirm the technologies effectiveness (EPA 1633). Single digit part per trillion amounts were measured for two PFAS analytes in one of the four treated effluent samples taken while foam was being destroyed. A TOP Assay and a method to determine adsorbable TOF via CIC was used as a secondary confirmation of the destruction. Both AOF and TOP provide a measure of total organofluorine contents including PFAS analytes not targeted by 1633. Both the alternative methods showed PFAS was thoroughly destroyed by the supercritical water oxidation. Altogether, these results demonstrate that the SCWO reaction can destroy and subsequently transform all PFAS molecules and organofluorine compounds found in the SAFF into fully mineralized constituents.

Table 1: Summary of PFAS destruction per EPA 1633

	Sum PFAS Concentration FOAM (per 1633)	Detected SCWO Effluent PFAS concentration	Destruction and removal Efficiency (DRE)
1633-Run 1	4,906,128.00 ng/L	1.95 ng/L	99.99996%
1633 Run 2		No detections	100%

Introduction

As part of an 800-million-dollar USD settlement from 3M, the MPCA has commenced early-stage remediation efforts for PFAS contamination in the East Metro area. One project in process consisted of a two part treatment. First, a Australian built Surface Activated Foam Fractionation (SAFF) system injects air into a contaminated water source, thus concentrating PFAS in a liquid foam. Second, the foam is subjected to a technology or process that can destroy the PFAS, eliminating PFAS from the environment for good. As part of an exploration into the different destruction technologies on the market, the MPCA sought vendors that could destroy the resulting PFAS foam from the above-mentioned treatment.

Supercritical water oxidation (SCWO) is an advanced oxidation process that holds enormous potential for the treatment of a wide range of organic wastes, in particular concentrated wet wastes in slurries such as biosolids, sludges, agricultural wastes, chemical wastes with recalcitrant chemicals such as perfluoroalkyl and polyfluoroalkyl substances (PFAS), and many more. SCWO relies on the unique reactivity and transport properties that occur when an aqueous waste stream is brought above the critical point of water (374°C and 218 atm, or 704°F). Supercritical water is a dense single phase with transport properties like those of a gas, and solvent properties comparable to those of a non-polar solvent. Oxygen is fully soluble in supercritical water, resulting in extremely rapid and complete oxidation of all organics to carbon dioxide, clean water (that can be reused), and some non-leachable inorganic salts. [[https://www.enviro.wiki/index.php?title=Supercritical_Water_Oxidation_\(SCWO\)](https://www.enviro.wiki/index.php?title=Supercritical_Water_Oxidation_(SCWO))]

SCWO has several advantages over other treatment options: The organic components are destroyed rather than being concentrated or transferred to another medium. The SCWO reaction is “complete,” partially oxidized or unreacted harmful chemicals are not found in the effluents. SCWO reactions are extremely rapid, in the order of 8-10 seconds, which makes it possible to build extremely small and compact reactors. The high oxidative environment makes it possible to treat all sorts of organic contaminants.

Per- and polyfluoroalkyl substances (PFAS) are a group of chemicals used to make fluoropolymer coatings and products that resist heat, oil, stains, grease, and water. Fluoropolymer coatings can be in a variety of products. These include clothing, furniture, adhesives, food packaging, heat-resistant non-stick cooking surfaces, and the insulation of electrical wire. Many PFAS, including perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), are a concern because they:

- do not break down in the environment,
- can move through soils and contaminate drinking water sources,
- build up (bioaccumulate) in fish and wildlife.
- have been shown to negatively impact human health in limited anthropological studies at extremely low concentrations.

SCWO technologies can eliminate a broad spectrum of PFAS species, ionic and non-ionic, sulfonated, and non-sulfonated, long chain and short chain as well as PFAS precursors. Supercritical water oxidation facilitates the complete mineralization of all organic compounds, even recalcitrant ones such as PFAS, to minerals, CO₂, and H₂O.

The primary objectives of the tests reported herein were to demonstrate and quantify PFAS destruction in Surface Activated Foam Fractionate™ generated by the MPCA pilot project. Raw samples from the MPCA's pilot treatment facility at Lake Elmo were sent to the 374Water lab in Durham, NC and processed with a bench scale Supercritical Water Oxidation (SCWO) reactor. The resulting system effluents were tested for PFAS via a multitude of methods, including EPA 1633 and a Total Oxidizable Precursor Assay (TOP).

Methodology

Testing apparatus

The bench-scale AirSCWO system (see Figure 1) used for the treatability study is a scaled-down version of the larger commercial AirSCWO™ system and has been designed for technology development and treatability assessment. It is well suited for rapid and accurate assessment of waste mineralization, and determination of reaction kinetics. Unlike the commercial system offered by 374Water, the bench-scale system does not include an energy recovery system. Instead, it uses a furnace to provide the required heat for the SCWO process. However, the process mimics the composition and thermodynamics of the commercial system and yields treatment results that are representative of the performance expected by the commercial AirSCWO systems.

The continuous treatment bench-scale SCWO system includes dual piston pumps operating at 3500 PSI to drive water through an injection loop that is loaded with the target waste. The injection loops feed into a preheater and then furnace where the waste's temperature is brought up to 600 °C. The reaction time is controlled through the reactor length and waste feed rate. Typical flow of waste is 6 to 10 mL/min which covers the span of reaction times relevant to our commercial AirSCWO. For the MPCA treatability tests, the reactor residence time was approximately 10 seconds.

Like the commercial systems, the bench scale system uses an off the shelf trim and starter fuel (in this case isopropyl alcohol) fed during the initial heating of the apparatus to supercritical temperatures and prior to injecting the tested waste. For treatability assessment, the waste is typically treated continuously for a period of 1-3 hours during which steady state conditions are reached. Samples for in-house COD measurements and then external lab samples as specified by the testing plan are taken from the effluent for analysis.

Figure 1 shows the general system components and sampling ports from which samples were taken for all runs. All the liquid effluent samples are collected from the sampling port off the “Treated Effluent” stream.

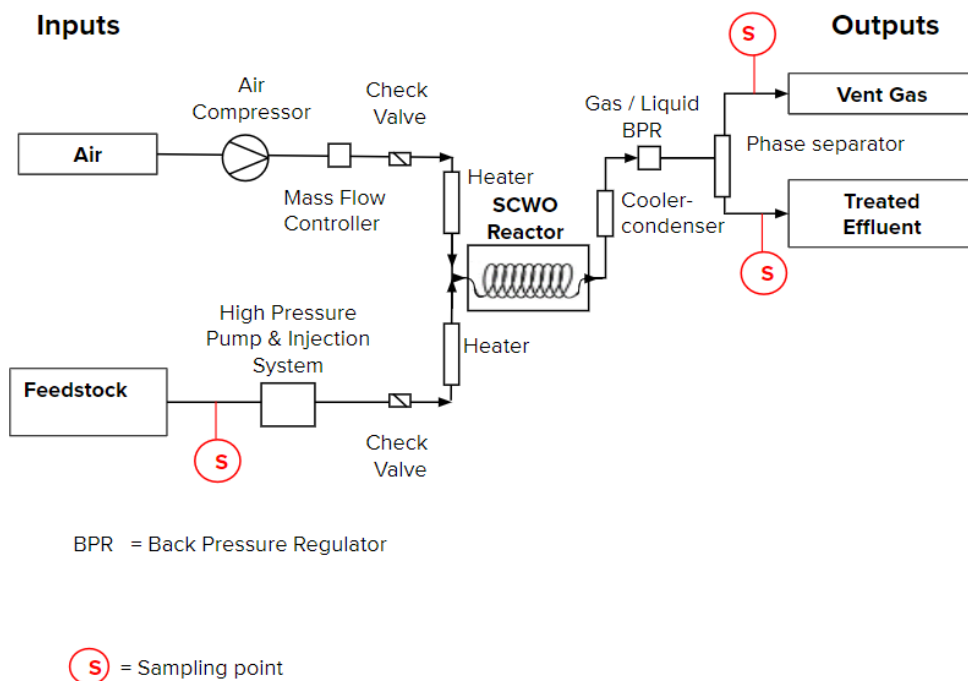


Figure 1: Schematic of the bench-scale SCWO system and sampling ports

Analytical Procedures

EPA 1633

The US EPA’s Office of Water, in partnership with the US Department of Defense’s (DoD) Strategic Environmental Research and Development Program, has published draft Method 1633, a single laboratory validated method to test for 40 PFAS compounds in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. This method is the first that covers matrices other than drinking water viz US EPA Methods 537.1 and 533 and is an isotope dilution liquid chromatography tandem mass spectrometry (LC-MS/MS) method that is the gold standard for PFAS determination. The extended range of PFAS are designed to cover traditional perfluoroalkyl acids (PFAAs), fluorotelomer sulfonic acids, perfluorooctane sulfonamides, perfluorooctane sulfonamidoacetic acids and perfluorooctane sulfonamide ethanols but additionally the replacement per- and polyfluoroether carboxylic acids such as GenX & ADONA as well as ether sulfonic acids (F53B) and fluorotelomer carboxylic acids that have been shown to be the major PFAS found in landfill leachates. This expanded list is more suitable to wider environmental

surveillance rather than just fire-fighting training areas traditionally investigated. (Description from Eurofins).

Adsorbable Organofluorine (AOF)

Adsorbable Organofluorine (AOF) analysis gives a quantitative assessment of both the same target PFAS compounds that are currently reported by LC/MS/MS and other fluoroorganic non-target compounds not readily determined by standard target PFAS testing. It reports a cumulative single parameter for water samples in µg/L or soil samples in µg/kg rather than individual components.

Using an automated sample preparation unit, up to 100 mL of aqueous sample is passed across two AOF charcoal tubes connected in series. After the sample is loaded, the charcoal tubes are flushed with a sodium nitrate solution to remove inorganic fluoride. After the charcoal tubes are flushed and the inorganic fluoride is removed, the contents of both AOF charcoal tubes are emptied into a single ceramic boat and analyzed using combustion ion chromatography.

This method provides a fast and accurate alternative to the existing standard methods by delivering greater coverage of concentration estimates for PFAS and organofluorine compounds. CIC-AOF is also an ideal complementary technique – with its simpler and more cost-effective method, it is a great pre-screening tool to identify samples which potentially contain additional compounds that were not included in the targeted analysis methods. [<https://enthalpy.com/blog/monitoring-pfas-impact-using-adsorbable-organic-fluorine-by-combustion-ion-chromatography/>]

Total Oxidizable Precursor (TOP) Assay

The Total Oxidizable Precursor (TOP) assay is a method used for analyzing the total concentration of oxidizable precursors of per- and polyfluoroalkyl substances (PFAS) in various samples. The TOP assay is particularly relevant when studying precursors of PFAS, which carry equal importance when considering the overall impact of a destruction technologies.

A TOP Assay involves subjecting the sample to an oxidation reaction using hot persulphate in an alkaline solution. Under these conditions hydroxyl radicals are formed reacting with both telomers and sulfonamide precursors. The oxidation is designed to convert all PFAS precursors into known PFCAs or other measurable end products. After the oxidation, the resulting products are analyzed for the 40 standard species from 1633 to quantify the total concentration of precursor in the sample. The assay provides a quantitative measure of the total oxidizable precursors present in the sample when compared before and after the oxidation reaction.

Other analysis

Halogens (SW846 9056) – Determination of inorganic anions by ion chromatography

Gross Calorific Value (ASTM D240)- Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter

Ash (ASTM D482)- Standard Test Method for Ash from Petroleum Products

Bench Scale Testing

Testing took place at 374Water's laboratory located in Durham, NC over the course of 2 days. Samples for analysis were transported to the chosen analytical lab via a company vehicle.

Waste Preparation and preliminary test results

The samples of PFAS foam sent to 374Water were initially sent to Eurofins for halogens, BTU, and ash contents measurements. The purpose of these tests is to help 374Water develop a SCWO "recipe" that is suitable for optimum treatment in the AirSCWO system. For the case of PFAS laden foam, the main operational parameters of interest are:

Halogens – Upon treatment in the AirSCWO™ reactor halogens form corrosive acids. This is of particular interest with PFAS wastes as the mineralized organofluorine can form hydrofluoric acid. pH mitigating compounds are added to the system depending on the measurements of both PFAS and other halogens. For the purposes of this study, sodium carbonate will be used to buffer acid formation.

BTU/Energy Content: The combined energy content of any waste mixture to be treated by the AirSCWO process must be between 1,000 and 1,200 BTU/lb. or 2.5-3 MJ/L, which corresponds roughly to a COD of about 160,000-200,000 mg/L. For treating a low energy feedstock like PFAS foam concentrate, we use isopropyl alcohol as trim fuel for its ease of use and high energy content.

Ash content is used as a surrogate for the combined dissolved and inorganic solids contained in the sample. Excessive ash content can cause salt deposition issues during treatment. An ash content under 10,000 mg/L indicates that combined the TDS and residual inorganic solids is well within our treatment criteria.

Table 2: Criteria of interest and methods and for Initial analysis of SAFF

Method and Parameter	Responsible Party
Method SW846-9056 – Total Bromine Total Chlorine Total Fluorine ASTM D240 – Gross Calorific Value ASTM D482 – Ash Content	374Water via 3 rd party lab (Eurofins)

Table 3: Results from the Initial analysis of the SAFF

Sample ID	Bromine (ppm)	Chlorine (ppm)	Fluorine (ppm)	Ash content (ppm)	BTU/lb.
MPCA SAFF Foam	0	240	0	278	ND

Based upon the chemical properties of the SAFF a 94.5% SAFF, 5% IPA, and 0.5% Sodium Carbonate recipe was developed:

Table 4: SAFF Recipe/mixtures created for the runs

Name	SAFF mass (g)	IPA mass (g)	Sodium Carbonate (20wt% sol) mass (g)	liquid flow rate (ml/min)	Air flow rate (g/min)	IPA%	Na ₂ CO ₃ %
MPCA SAFF 1	2964	159.6	80.5	9	8.33	5	0.5
MPCA SAFF 2	2964	159.6	80.5	6	5.55	5	0.5

Test Procedures

A single day test plan is dedicated to a single waste recipe and divided into seven segments:

1. Initial startup: Initial pressurization and heat input to the system using the electrical heaters. Waste is mixed and loaded into the high-pressure injection system.
2. Reaching steady state: Reaching full temperature via trim fuel and stabilization of the process conditions (sampling of the effluent as control prior to waste introduction occurs during this phase).
3. Test: Feeding and continuous SCWO reaction using the tested waste (sampling of the effluent occurs during this phase).
4. Flush: Transition to IPA from the tested compound to begin clearing the system. (The “After” sampling occurs during this phase of testing)
5. Cooldown: Feeding water without organics to cool the reactor below supercritical conditions.
6. Shutdown: Depressurization and final cooldown of the system
7. Cleaning: Contacted pieces of equipment are either cleaned or replaced in kind

Two samples of SAFF, IPA, and sodium carbonate were prepared identically to be treated at different pumping rates. Starting PFAS concentrations were determined by EPA 1633 and AOF. Samples for analysis using EPA Method 1633 were collected for analysis before injecting SAFF (i.e., blanks designated as PRE), during SAFF injection, and after switching from SAFF back to co-fuel mix. Samples for AOF and TOP assays were collected for one operating condition.

Table 5: Sample matrix/Collected samples from the runs.

Name	Date	time	1633	AOF	TOP
Run 1					
MPCA-SAFF-111523-PRE	11/15/2023	10:53	x		
MPCA-SAFF-111523-OP1	11/15/2023	11:22	x	x	x
MPCA-SAFF-111523-OP2	11/15/2023	13:40	x		
MPCA-SAFF-111523-Post	11/15/2023	14:15	x		
MPCA-SAFF-111523-Stock	11/15/2023	12:00	x	x	
Run 2					
MPCA-SAFF-111623-Pre	11/16/2023	10:24	x		
MPCA-SAFF-111623-OP1	11/16/2023	11:13	x		
MPCA-SAFF-111623-OP2	11/16/2023	11:34	x		
MPCA-SAFF-111623-Post	11/16/2023	12:15	x		

Process conditions

Table 6: Bench scale AirSCWO process conditions during the runs

Name	Liquid Flow rate (ml/min)	Reactor Residence Time (s)	Initial Reactor Temperature (C)
MPCA SAFF 1	9	~11	600
MPCA SAFF 2	6	~17	600

Results

PFAS Detected in the Foam Fractionate sample.

Two separate methods were used to determine the total concentration of PFAS in the Foam Fractionate provided by the MPCA:

PFAS Results SAFF - EPA 1633

Samples were submitted to Eurofins to re-validate the starting concentration of PFAS in the sample, of the 40 analytes surveyed 13 came back detected:

Table 7: EPA 1633 analysis on the SAFF samples provided by MPCA

Sample ID	Date	Time	Detected PFAS (ng/L)
MPCA-SAFF-111523-Stock	11/15/2023	12:00	SUM: 4,906,128.00 ng/L
Perfluorobutanesulfonic acid (PFBS)			125
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)			134
Perfluorohexanoic acid (PFHxA)			1,900
Perfluorobutanoic acid (PFBA)			315
Perfluorooctanesulfonic acid (PFOS)			3,660,000
Perfluoroheptanoic acid (PFHpA)			53,400
Perfluorooctanesulfonamide (PFOSA)			604
Perfluoropentanesulfonic acid (PFPeS)			6,690
Perfluorononanoic acid (PFNA)			6,840
Perfluorodecanoic acid (PFDA)			6,920
Perfluorooctanoic acid (PFOA)			971,000
Perfluorohexanesulfonic acid (PFHxS)			98,400
Perfluoroheptanesulfonic acid (PFHpS)			99,800

PFAS Results SAFF - Adsorbable Organofluorine (AOF)

A sample of the foam was sent to Eurofins to determine organofluorine via CIC. The results were the same magnitude and similar to the totals determined with EPA 1633.

Table 8: AOF via CIC on the SAFF sample provided by MPCA.

Sample ID	Date	Time	Total sum Organofluorine
MPCA-SAFF-111523-Stock	11/15/2023	12:00	4,720 ug/L (ppb)

PFAS Results SCWO effluent - EPA 1633

Of the 4 samples taken from the system, two had part per trillion detections of PFAS compounds. The complete results of EPA 1633 analyses performed during the study are attached in the appendix. The full tests including QA are attached separately from this report. The detected PFAS from the samples did not exceed single digit ppt.

Summary of detected PFAS by sample:

Table 9: EPA 1633 results from AirSCWO Effluent samples collected during the runs.

Sample ID	Date	Time	Detected PFAS
Run 1			
MPCA-SAFF-111523-PRE	11/15/2023	10:53	No Detections
MPCA-SAFF-111523-OP1	11/15/2023	11:22	No Detections
MPCA-SAFF-111523-OP2	11/15/2023	13:40	3.9 ppt
Perfluorooctanesulfonic acid (PFOS)			2.86 ppt
Perfluorohexanesulfonic acid (PFHxS)			1.04 ppt
MPCA-SAFF-111523-Post	11/15/2023	14:15	No Detections
Run 2			
MPCA-SAFF-111623-Pre	11/16/2023	10:24	2.69 ppt
Perfluorooctanesulfonic acid (PFOS)			2.69 ppt
MPCA-SAFF-111623-OP1	11/16/2023	11:13	No Detections
MPCA-SAFF-111623-OP2	11/16/2023	11:34	No Detections
MPCA-SAFF-111623-Post	11/16/2023	12:15	No Detections

PFAS Results SCWO Effluent - AOF

AOF measurements for the SCWO effluent came back several orders of magnitude higher than the amounts detected via EPA 1633 and the TOP Assay.

Upon consultation with the lab testing vendors, and considering the results collected by PVSC from the SCWO effluent, 374Water reached the following conclusions regarding the AOF/TOF results from this experiment. Current state-of-the-art TOF tests rely on the

difference between a total fluorine measurement and a total inorganic fluorine measurement. These measurements are subject to two key limitations: background effects from free fluoride ions, which limit the resolution of TOF to no less than 20% of the inorganic fluorine levels; and complexation of free fluoride with matrix ions, which lowers the measurable free fluoride and increases the calculated TOF.

In the case of treated waste samples considered in this study, both limitations introduce uncertainties to the TOF measurement that are several orders of magnitude larger than the expected TOF values of low part per trillion. Since the TOF values for treated samples have method uncertainties much greater than the expected TOF, and since the compound-specific EPA Method 1633 and TOP results show non-detect or low ppt values for all compounds of interest, we believe that the EPA Method 1633 and TOP results are a more representative analysis for TOF than the AOF/TOF-specific lab methods.

Table 10: Total sum organofluorine per AOF

Sample ID	Date	Time	Total sum Organofluorine
MPCA-SAFF-111523-OP1	11/15/2023	12:00	56.9 ug/L (ppb)

PFAS Results SCWO Effluent – Total Oxidizable Precursor Assay

The TOP Assay results from the SCWO effluent both returned single digit ppt detections of PFAS compounds. The pre assay samples returned detections of PFDA, PFOA, and PFHxA and the post assay only showed PFHxA and PFOA. The post detection samples had almost the same total sum, 9.13 and 8.65 ppt, before and after the assay respectively.

Table 11: Pre and post TOP assay measurements from run 1 AirSCWO effluents.

Sample ID [Run 1]	Date	Time	Assay Detections
			Pre assay
MPCA-SAFF-111523-OP1	11/15/2023	11:22	9.13 ppt
		Perfluorodecanoic acid (PFDA)	2.76 ppt
		Perfluorooctanoic acid (PFOA)	3.4 ppt
		Perfluorohexanoic acid (PFHxA)	2.97 ppt
			Post Assay
MPCA-SAFF-111523-OP1	11/15/2023	11:22	8.65 ppt
		Perfluorohexanoic acid (PFHxA)	6.12 ppt
		Perfluorooctanoic acid (PFOA)	2.53 ppt

Results Discussions

Discussions 1633

Throughout the analytes measured with EPA 1633 we saw comprehensive destruction of PFAS in all the samples. A few of the data points exhibited single digit part per trillion PFAS concentration. Considering the starting concentrations, we considered even the low single digit detections as a strong indicator of success.

Discussions TOP Assay

The products of the post oxidized PFAS adding to 8.65 ppt was extremely encouraging and further validated the destruction calculations made with EPA 1633. The lack of oxidizable precursors is a good indication that the PFAS destroyed by AirSCWO is completely mineralized and extremely limited amounts of oxidizable precursors remain in the effluents that were not detected with EPA 1633.

Energy projections per gallon of PFAS foam

For the purposes of this discussion, the energy considerations are provided for a commercial scale AirSCWO 6 destroying 1,500 gallons of SAFFF concentrate per day. There are two main components for consideration when discussing the energy consumption of AirSCWO to destroy PFAS foam concentrate.

- A. Electricity – Heating the influent wastes before destruction and the compression of ambient air requires 1,680 kwh of electricity per day. Of this 1,680 kwh there is the potential to recover a substantial portion (up to 90%) as metered electricity.
- B. Co-fuel – The destruction of PFAS in the reaction is, in some capacity, a product of the energy intensive oxidation of organic content aside from the organic fluorine/PFAS. In the case of destroying 1,500 gallons of foam in a single day we would also require ~90 gallons of Isopropyl Alcohol or another fuel like diesel.

To destroy 1,500 gallons of foam concentrate an operating AirSCWO 6 would require 1,680 kwh of electricity along with 90 gallons of IPA. On a per gallon basis, 1.12 kwh and .06 gallons of IPA.

Final Thoughts

Overall, the work performed showed that the PFAS in the SAFF can be destroyed when subjected to supercritical water oxidation. The SAFF was easy to work with and posed no issues during any part of the treatment process. Process conditions utilized during the bench scale experiment are representative of the commercial scale product being brought to market by 374Water. Finally, with both the bench and commercial scale systems we maintain the ability to tweak concentrations and residence times to adjust the final DRE towards whatever criteria is set forth by a potential use case. We thank the MPCA for the opportunity to demonstrate AirSCWO to destroy the SAFF and look forward to working together in the future.

Appendices

Appendix 1 – Physical and chemical characteristics of the SAFF for the purpose of recipe generation

ANALYTICAL REPORT

PREPARED FOR

Attn: Russ Schmitz
374Water Inc
3710 Shannon Rd
Suite 51877
Durham, North Carolina 27717

Generated 11/17/2023 7:23:11 AM

JOB DESCRIPTION

Waste - MNPCA-FF

JOB NUMBER

140-34231-1

Eurofins Knoxville

Job Notes

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Authorization



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Definitions/Glossary

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
□	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Job ID: 140-34231-1

Laboratory: Eurofins Knoxville

Narrative

Job Narrative 140-34231-1

Receipt

The sample was received on 11/3/2023 12:00 PM. Unless otherwise noted below, the sample arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 18.9° C.

General Chemistry

Gross Calorific Value: The heat of combustion (gross calorific value) of the samples was determined using SOP number KNOX-WC-0010 (based on ASTM Method D5865 for solids and ASTM Method D240 for liquids). A waste feed sample is combusted in an oxygen bomb that has been placed in a bomb calorimeter. The energy released during this combustion process is captured in the calorimeter, and the temperature rise of a water bath surrounding the bomb is measured. The temperature rise is proportional to the heat liberated during the combustion in calories. The gross calorific value is calculated from the temperature rise, the sample weight, and the calibration coefficient of the calorimeter. Certain extraneous sources of heat are assessed, and the effect of these heat sources is accounted for in the calculation, as well as the effect of various accelerants that are added to enhance combustion of the sample. The gross heat of combustion is calculated in units of cal/g using the following equation:

$$Q \text{ (gross)} = [(\Delta TEE) - (e1+e2+e3+e4)] / m$$

Where:

Q (gross) = Gross calorific value at constant volume as determined, cal/g

EE = Heat capacity of the calorimeter, cal/ ° C

Δt = Corrected temperature rise as measured by the calorimeter, ° C

e1 = Correction for heat of formation of nitric acid in calories, calculated by the calorimeter based on the energy released by the sample

e2 = Correction for sulfur, which is usually 0

e3 = Correction for fuse wire

e4 = Correction for spike addition that is calculated by the calorimeter using the spike weight benzoic acid equivalent (grams) times the benzoic acid heat of combustion (6318 cal/g)

m = Mass of the sample, g

The results are converted to Btu/lb, as necessary using the following conversion factor: 1 cal/g = 1.8 Btu/lb.

Total Halogens: The samples were prepared for total fluorine, chlorine, bromine and/or iodine using SOP number KNOX-WC-0016 (based on ASTM Method E442 and SW-846 Method 5050). The sample is oxidized by combustion in an oxygen flask at atmospheric pressure or a bomb containing oxygen under pressure. The liberated halogen compounds are absorbed primarily as halides in a sodium carbonate/sodium bicarbonate buffer solution. The combustion products are collected by repeated rinsing of the combustion apparatus, and analyzed by ion chromatography in accordance with SOP KNOX-WC-0005 (based on SW-846 Method 9056). The results are calculated using the following equation:

$$C = [(Ccom \times Vcom) / W] \times 1000 \text{ g/Kg}$$

Where:

C = Concentration of analyte in the sample, mg/Kg

Ccom = Concentration of analyte in the combustate, mg/L

Vcom = Total volume of combustate, L

W = Weight of sample combusted, g

Ash Content: The ash content of the samples was determined using SOP number KNOX-WC-0013 (based on ASTM Methods A4422, D482, and E830). A ten gram aliquot of sample is fired in a pre-tared crucible at 750° ± 25°C in a forced-draft muffle furnace. The total weight of ash residue and the crucible is measured on a 4-place analytical balance, and the residue weight is determined by difference. The ratio of the residue weight (mg) and the initial sample weight (kg) is used to calculate the ash content of the sample.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Client Sample Results

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Client Sample ID: MNPCA-FF

Lab Sample ID: 140-34231-1

Date Collected: 10/31/23 12:00

Matrix: Waste

Date Received: 11/03/23 12:00

Method: SW846 9056 - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Bromine	ND		44	26	mg/Kg		11/06/23 09:34	11/09/23 00:15	1
Total Chlorine	240		89	80	mg/Kg		11/06/23 09:34	11/09/23 00:15	1
Total Fluorine	ND		89	78	mg/Kg		11/06/23 09:34	11/09/23 00:15	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Gross Calorific Value (ASTM D240)	ND		1700	341	BTU/lb			11/09/23 11:07	1
Ash Content (ASTM D482)	278		198	97.2	mg/Kg			11/13/23 08:10	1

Default Detection Limits

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Method: 9056 - Anions, Ion Chromatography

Prep: 5050

Leach: MeOH Prep

Analyte	RL	MDL	Units
Total Bromine	50	29	mg/Kg
Total Chlorine	100	90	mg/Kg
Total Fluorine	100	88	mg/Kg

General Chemistry

Analyte	RL	MDL	Units
Gross Calorific Value	1800	360	BTU/lb
Ash Content	200	98.0	mg/Kg

QC Sample Results

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Method: 9056 - Anions, Ion Chromatography

Lab Sample ID: MB 140-79908/1-B

Matrix: Waste

Analysis Batch: 80119

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 79910

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Bromine	ND		50	29	mg/Kg		11/06/23 09:34	11/08/23 22:29	1
Total Chlorine	ND		100	91	mg/Kg		11/06/23 09:34	11/08/23 22:29	1
Total Fluorine	ND		100	89	mg/Kg		11/06/23 09:34	11/08/23 22:29	1

Lab Sample ID: LCS 140-79908/2-B

Matrix: Waste

Analysis Batch: 80119

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 79910

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Total Bromine	2490	2250		mg/Kg		90	70 - 130
Total Chlorine	10300	9380		mg/Kg		91	80 - 120
Total Fluorine	10000	9510		mg/Kg		95	80 - 120

Lab Sample ID: LCSD 140-79908/3-B

Matrix: Waste

Analysis Batch: 80119

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 79910

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Bromine	2490	2130		mg/Kg		86	70 - 130	5	10
Total Chlorine	10300	9360		mg/Kg		91	80 - 120	0	10
Total Fluorine	10000	9590		mg/Kg		96	80 - 120	1	10

Method: D240 - Heat of Combustion

Lab Sample ID: LCS 140-80075/3

Matrix: Waste

Analysis Batch: 80075

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Gross Calorific Value	20600	20330		BTU/lb		99	98 - 102

Lab Sample ID: LCSD 140-80075/4

Matrix: Waste

Analysis Batch: 80075

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Gross Calorific Value	20600	20260		BTU/lb		98	98 - 102	0	2.0

Method: D482 - Ash Content

Lab Sample ID: MB 140-80165/1

Matrix: Waste

Analysis Batch: 80165

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Ash Content	ND		200	98.0	mg/Kg			11/13/23 08:10	1

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QC Sample Results

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Method: D482 - Ash Content (Continued)

Lab Sample ID: LCS 140-80165/2
Matrix: Waste
Analysis Batch: 80165

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Ash Content	1000000	997800		mg/Kg		100	90 - 110

Lab Sample ID: LCSD 140-80165/3
Matrix: Waste
Analysis Batch: 80165

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Ash Content	1000000	999100		mg/Kg		100	90 - 110	0	10

QC Association Summary

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

HPLC/IC

Leach Batch: 79908

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-34231-1	MNPCA-FF	Total/NA	Waste	MeOH Prep	
MB 140-79908/1-B	Method Blank	Total/NA	Waste	MeOH Prep	
LCS 140-79908/2-B	Lab Control Sample	Total/NA	Waste	MeOH Prep	
LCSD 140-79908/3-B	Lab Control Sample Dup	Total/NA	Waste	MeOH Prep	

Prep Batch: 79910

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-34231-1	MNPCA-FF	Total/NA	Waste	5050	79908
MB 140-79908/1-B	Method Blank	Total/NA	Waste	5050	79908
LCS 140-79908/2-B	Lab Control Sample	Total/NA	Waste	5050	79908
LCSD 140-79908/3-B	Lab Control Sample Dup	Total/NA	Waste	5050	79908

Analysis Batch: 80119

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-34231-1	MNPCA-FF	Total/NA	Waste	9056	79910
MB 140-79908/1-B	Method Blank	Total/NA	Waste	9056	79910
LCS 140-79908/2-B	Lab Control Sample	Total/NA	Waste	9056	79910
LCSD 140-79908/3-B	Lab Control Sample Dup	Total/NA	Waste	9056	79910

General Chemistry

Analysis Batch: 80075

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-34231-1	MNPCA-FF	Total/NA	Waste	D240	
LCS 140-80075/3	Lab Control Sample	Total/NA	Waste	D240	
LCSD 140-80075/4	Lab Control Sample Dup	Total/NA	Waste	D240	

Analysis Batch: 80165

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
140-34231-1	MNPCA-FF	Total/NA	Waste	D482	
MB 140-80165/1	Method Blank	Total/NA	Waste	D482	
LCS 140-80165/2	Lab Control Sample	Total/NA	Waste	D482	
LCSD 140-80165/3	Lab Control Sample Dup	Total/NA	Waste	D482	

Lab Chronicle

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Client Sample ID: MNPCA-FF

Lab Sample ID: 140-34231-1

Date Collected: 10/31/23 12:00

Matrix: Waste

Date Received: 11/03/23 12:00

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Leach	MeOH Prep			1 g	1 g	79908	11/06/23 09:14	ACW	EET KNX
Total/NA	Prep	5050			1.1251 g	100.0884 mL	79910	11/06/23 09:34	ACW	EET KNX
Total/NA	Analysis	9056		1	10 mL	10 mL	80119	11/09/23 00:15	JXP	EET KNX
Instrument ID: IC4										
Total/NA	Analysis	D240		1	0.5285 g	0.5 g	80075	11/09/23 11:07	TMB	EET KNX
Instrument ID: NOEQUIP										
Total/NA	Analysis	D482		1	10.0846 g	10 g	80165	11/13/23 08:10	SJF	EET KNX
Instrument ID: NOEQUIP										

Client Sample ID: Method Blank

Lab Sample ID: MB 140-79908/1-B

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Leach	MeOH Prep			1 g	1 g	79908	11/06/23 09:14	ACW	EET KNX
Total/NA	Prep	5050			1 g	100.7499 mL	79910	11/06/23 09:34	ACW	EET KNX
Total/NA	Analysis	9056		1	10 mL	10 mL	80119	11/08/23 22:29	JXP	EET KNX
Instrument ID: IC4										

Client Sample ID: Method Blank

Lab Sample ID: MB 140-80165/1

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	D482		1	10 g	10 g	80165	11/13/23 08:10	SJF	EET KNX
Instrument ID: NOEQUIP										

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-79908/2-B

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Leach	MeOH Prep			1 g	1 g	79908	11/06/23 09:14	ACW	EET KNX
Total/NA	Prep	5050			1 g	105.1699 mL	79910	11/06/23 09:34	ACW	EET KNX
Total/NA	Analysis	9056		20	10 mL	10 mL	80119	11/08/23 22:51	JXP	EET KNX
Instrument ID: IC4										

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-80075/3

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	D240		1	0.4948 g	0.5 g	80075	11/09/23 11:07	TMB	EET KNX
Instrument ID: NOEQUIP										

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Lab Chronicle

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Client Sample ID: Lab Control Sample

Lab Sample ID: LCS 140-80165/2

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	D482		1	0.4129 g	10 g	80165	11/13/23 08:10	SJF	EET KNX
Instrument ID: NOEQUIP										

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-79908/3-B

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Leach	MeOH Prep			1 g	1 g	79908	11/06/23 09:14	ACW	EET KNX
Total/NA	Prep	5050			1 g	102.6637 mL	79910	11/06/23 09:34	ACW	EET KNX
Total/NA	Analysis	9056		20	10 mL	10 mL	80119	11/08/23 23:12	JXP	EET KNX
Instrument ID: IC4										

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-80075/4

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	D240		1	0.5079 g	0.5 g	80075	11/09/23 11:07	TMB	EET KNX
Instrument ID: NOEQUIP										

Client Sample ID: Lab Control Sample Dup

Lab Sample ID: LCSD 140-80165/3

Date Collected: N/A

Matrix: Waste

Date Received: N/A

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	D482		1	0.4303 g	10 g	80165	11/13/23 08:10	SJF	EET KNX
Instrument ID: NOEQUIP										

Laboratory References:

EET KNX = Eurofins Knoxville, 5815 Middlebrook Pike, Knoxville, TN 37921, TEL (865)291-3000

Accreditation/Certification Summary

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Laboratory: Eurofins Knoxville

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
	AFCEE	N/A	
ANAB	Dept. of Defense ELAP	L2311	02-13-25
ANAB	Dept. of Energy	L2311.01	02-13-25
ANAB	ISO/IEC 17025	L2311	02-13-25
Arkansas DEQ	State	88-0688	06-16-24
Colorado	State	TN00009	02-29-24
Connecticut	State	PH-0223	09-30-25
Florida	NELAP	E87177	06-30-24
Georgia (DW)	State	906	07-27-25
Hawaii	State	NA	07-27-24
Kansas	NELAP	E-10349	10-31-24
Kentucky (DW)	State	90101	12-31-23
Louisiana (All)	NELAP	83979	06-30-24
Louisiana (DW)	State	LA019	12-31-23
Maryland	State	277	03-31-24
Michigan	State	9933	07-27-25
Nevada	State	TN00009	07-31-24
New Hampshire	NELAP	2999	01-17-24
New Jersey	NELAP	TN001	07-01-24
New York	NELAP	10781	03-31-24
North Carolina (DW)	State	21705	07-31-24
North Carolina (WW/SW)	State	64	12-31-23
Oklahoma	State	9415	12-31-23
Oregon	NELAP	TNI0189	01-01-24
Pennsylvania	NELAP	68-00576	12-01-23
Tennessee	State	02014	07-27-25
Texas	NELAP	T104704380-23-18	08-31-24
US Fish & Wildlife	US Federal Programs	058448	07-31-24
USDA	US Federal Programs	525-22-279-18762	10-06-25
Utah	NELAP	TN00009	07-31-24
Virginia	NELAP	460176	09-14-24
Washington	State	C593	01-19-24
West Virginia (DW)	State	9955C	12-31-23
West Virginia DEP	State	345	04-30-24
Wisconsin	State	998044300	08-31-24

Method Summary

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Method	Method Description	Protocol	Laboratory
9056	Anions, Ion Chromatography	SW846	EET KNX
D240	Heat of Combustion	ASTM	EET KNX
D482	Ash Content	ASTM	EET KNX
5050	Bomb Preparation Method for Solid Waste	SW846	EET KNX
MeOH Prep	Methanol Preparation	None	EET KNX

Protocol References:

ASTM = ASTM International

None = None

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

EET KNX = Eurofins Knoxville, 5815 Middlebrook Pike, Knoxville, TN 37921, TEL (865)291-3000

Sample Summary

Client: 374Water Inc
Project/Site: Waste - MNPCA-FF

Job ID: 140-34231-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
140-34231-1	MNPCA-FF	Waste	10/31/23 12:00	11/03/23 12:00

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13

Chain of Custody Record

Project Manager: David Garb Email: <u>DS@374water.com</u> Tel/Fax:		Client Contact Your Company Name here <u>374 water systems inc.</u> Address <u>510 Pylon Drive</u> City/State/Zip <u> Raleigh, NC 27606</u> (xxx) xxx-xxxx <u>919-452-4980</u> Phone FAX (xxx) xxx-xxxx Project Name: <u>MNPCHA Farm Finc</u> Site: <u>MNPCHA</u> P O #		Site Contact: <u>Russell Schmitz</u> Date: <u>10/31/2023</u> Carrier: <u>FedEx</u> Lab Contact: <u>Courtney Adams</u> COC No: <u>10312223-3</u> of <u>1</u> COCs							
Analysis Turnaround Time ☐ CALENDAR DAYS ☐ WORKING DAYS TAT if different from Below ☒ 2 weeks ☐ 1 week ☐ 2 days ☐ 1 day		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <u>12:00</u>		Sample Type (C=Comp, G=Grab) <u>G</u>		Matrix <u>WW</u>		# of Cont. <u>1</u>	
Sample Identification <u>MNPCHA -FF</u>		Sample Date <u>10/31/2023</u>		Sample Time <							

Log In Number:

QA026R32.doc, 062719

Appendix B – PFAS testing by Eurofins; EPA 1633

ANALYTICAL REPORT

PREPARED FOR

Attn: Russ Schmitz
374Water Inc
3710 Shannon Rd
Suite 51877
Durham, North Carolina 27717

Generated 1/24/2024 4:55:57 PM

JOB DESCRIPTION

PFAs (MPCA-SAFF)

JOB NUMBER

752-13791-1

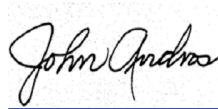
Eurofins Raleigh

Job Notes

This report may not be reproduced except in full, and with written approval from the laboratory. The results relate only to the samples tested. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

The test results in this report relate only to the samples as received by the laboratory and will meet all requirements of the methodology, with any exceptions noted. This report shall not be reproduced except in full, without the express written approval of the laboratory. All questions should be directed to the Eurofins Environment Testing Southeast, LLC Project Manager.

Authorization



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Authorized for release by
John Andros, Project Manager I
John.Andros@et.eurofinsus.com
(404)944-4744

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Definitions/Glossary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Qualifiers

LCMS

Qualifier	Qualifier Description
*-	LCS and/or LCSD is outside acceptance limits, low biased.
*+	LCS and/or LCSD is outside acceptance limits, high biased.
*5-	Isotope dilution analyte is outside acceptance limits, low biased.
*5+	Isotope dilution analyte is outside acceptance limits, high biased.
E	Result exceeded calibration range.
I	Value is EMPC (estimated maximum possible concentration).
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
α	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: 374Water Inc
Project: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Job ID: 752-13791-1

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Job Narrative 752-13791-1

Receipt

The samples were received on 11/16/2023 3:20 PM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved and on ice. The temperature of the cooler at receipt time was 5.5°C

PFAS

Method 1633: The laboratory control sample (LCS) for preparation batch 680-809669 and 680-809669 and analytical batch 680-810043 recovered outside control limits for the following analytes: N-ethylperfluorooctane sulfonamide (NEtFOSA) and N-methylperfluorooctane sulfonamidoethanol (NMeFOSE). A low-level LCS (LLCS), spiked at the reporting limit (RL), was prepared with this batch. The affected target analytes recovered within acceptance limits; therefore, the LLCS demonstrates the analytical system had sufficient sensitivity to detect the compounds had they been present. Since the affected target compounds were either not detected or below the RL in the samples, the data have been reported and qualified.

Method 1633: The laboratory control sample (LCS) for preparation batch 680-809669 and 680-809669 and analytical batch 680-810043 recovered outside control limits for the following analytes: N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE). A low-level LCS (LLCS), spiked at the reporting limit (RL), was prepared with this batch. The affected target analytes were detected; therefore, the LLCS demonstrates the analytical system had sufficient sensitivity to detect the compounds had they been present. Since the affected target compounds were either not detected or below the RL in the samples, the data have been reported and qualified.

Method 1633: The low-level laboratory control sample (LLCS) associated with preparation batch 680-809669 and 680-809669 and analytical batch 680-810043 was outside acceptance criteria for the following analyte(s): Perfluorononanoic acid (PFNA) and N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE). The analyte was detected, therefore, the LLCS demonstrates the analytical system had sufficient sensitivity to detect the compounds had they been present. Since the affected target compounds were either not detected or below the RL in the samples, the data have been reported and qualified. Perfluorononanoic acid recovered within range in both the LCS and LCSD.

Method 1633: The Isotope Dilution Analyte (IDA) recovery associated with the following samples is below the method recommended limit: MPCA-SAFF-111523-PRE (752-13791-1), MPCA-SAFF-111523-OP1 (752-13791-2), MPCA-SAFF-111523-OP2 (752-13791-3), MPCA-SAFF-111623-PRE (752-13791-6), MPCA-SAFF-111623-OP1 (752-13791-7), MPCA-SAFF-111623-OP2 (752-13791-8) and MPCA-SAFF-111623-Post (752-13791-9). Generally, data quality is not considered affected if the IDA signal-to-noise ratio is greater than 10:1, which is achieved for all IDA in the sample(s).

Method 1633: The following sample was re-prepared outside of preparation holding time due to exceedances for multiple analytes: MPCA-SAFF-111523-Stock (752-13791-5).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

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Detection Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-PRE

Lab Sample ID: 752-13791-1

No Detections.

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Total PFCA	6.37	J	500	0.200	ng/L	1		Total PFCA-Sum	Pre-Treatment
Total PFCA	8.65	J	500	0.200	ng/L	1		Total PFCA-Sum	Post-Treatment

Client Sample ID: MPCA-SAFF-111523-OP2

Lab Sample ID: 752-13791-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanesulfonic acid (PFHxS)	1.04	J	1.13	0.800	ng/L	1		1633	Total/NA
Perfluorooctanesulfonic acid (PFOS)	2.86		1.05	0.719	ng/L	1		1633	Total/NA

Client Sample ID: MPCA-SAFF-111523-Post

Lab Sample ID: 752-13791-4

No Detections.

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorobutanoic acid (PFBA)	315	J	2000	240	ng/L	1		1633	Total/NA
Perfluorohexanoic acid (PFHxA)	1900		150	78.0	ng/L	1		1633	Total/NA
Perfluoroheptanoic acid (PFHpA)	53400		170	66.0	ng/L	1		1633	Total/NA
Perfluorooctanoic acid (PFOA)	971000	E	180	140	ng/L	1		1633	Total/NA
Perfluorononanoic acid (PFNA)	6840	*	150	84.0	ng/L	1		1633	Total/NA
Perfluorodecanoic acid (PFDA)	6920		160	51.0	ng/L	1		1633	Total/NA
Perfluorobutanesulfonic acid (PFBS)	125		120	50.0	ng/L	1		1633	Total/NA
Perfluoropentanesulfonic acid (PFPeS)	6690		140	96.0	ng/L	1		1633	Total/NA
Perfluorohexanesulfonic acid (PFHxS)	98400	E	140	99.0	ng/L	1		1633	Total/NA
Perfluoroheptanesulfonic acid (PFHpS)	99800	E	140	120	ng/L	1		1633	Total/NA
Perfluorooctanesulfonic acid (PFOS)	3660000	E	130	89.0	ng/L	1		1633	Total/NA
Perfluorooctanesulfonamide (PFOSA)	604		150	56.0	ng/L	1		1633	Total/NA
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	134		130	91.0	ng/L	1		1633	Total/NA

Client Sample ID: MPCA-SAFF-111623-PRE

Lab Sample ID: 752-13791-6

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorooctanesulfonic acid (PFOS)	2.69		0.964	0.660	ng/L	1		1633	Total/NA

Client Sample ID: MPCA-SAFF-111623-OP1

Lab Sample ID: 752-13791-7

No Detections.

Client Sample ID: MPCA-SAFF-111623-OP2

Lab Sample ID: 752-13791-8

No Detections.

Client Sample ID: MPCA-SAFF-111623-Post

Lab Sample ID: 752-13791-9

No Detections.

This Detection Summary does not include radiochemical test results.

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-PRE

Lab Sample ID: 752-13791-1

Date Collected: 11/15/23 10:53

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		17.4	2.09	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoropentanoic acid (PFPeA)	ND		2.79	1.39	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorohexanoic acid (PFHxA)	ND		1.31	0.679	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoroheptanoic acid (PFHpA)	ND		1.48	0.575	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorooctanoic acid (PFOA)	ND		1.57	1.22	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorononanoic acid (PFNA)	ND	*-	1.31	0.732	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorodecanoic acid (PFDA)	ND		1.39	0.444	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoroundecanoic acid (PFUnA)	ND		1.66	0.531	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorododecanoic acid (PFDoA)	ND		1.31	0.627	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorotridecanoic acid (PFTriDA)	ND		1.48	0.793	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorotetradecanoic acid (PFTA)	ND		1.39	0.523	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.05	0.436	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.22	0.836	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.22	0.862	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.22	1.05	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.13	0.775	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorononanesulfonic acid (PFNS)	ND		1.22	0.862	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.31	1.13	ng/L		11/22/23 10:18	11/29/23 22:14	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		5.40	1.05	ng/L		11/22/23 10:18	11/29/23 22:14	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		5.14	1.22	ng/L		11/22/23 10:18	11/29/23 22:14	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.66	2.18	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.31	0.488	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.39	0.479	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.39	0.618	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.48	0.714	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.13	0.793	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	35.7	5.05	ng/L		11/22/23 10:18	11/29/23 22:14	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	6.27	3.14	ng/L		11/22/23 10:18	11/29/23 22:14	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		5.57	2.26	ng/L		11/22/23 10:18	11/29/23 22:14	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		4.88	1.48	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.79	1.13	ng/L		11/22/23 10:18	11/29/23 22:14	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		2.87	2.70	ng/L		11/22/23 10:18	11/29/23 22:14	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		5.05	1.74	ng/L		11/22/23 10:18	11/29/23 22:14	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		5.31	2.09	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.35	0.488	ng/L		11/22/23 10:18	11/29/23 22:14	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-PRE

Lab Sample ID: 752-13791-1

Date Collected: 11/15/23 10:53

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		34.8	3.14	ng/L		11/22/23 10:18	11/29/23 22:14	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		35.7	11.3	ng/L		11/22/23 10:18	11/29/23 22:14	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		34.8	13.9	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.13	0.958	ng/L		11/22/23 10:18	11/29/23 22:14	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.70	1.22	ng/L		11/22/23 10:18	11/29/23 22:14	1
Isotope Dilution	%Recovery	Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C4 PFBA	89.8		10 - 130				11/22/23 10:18	11/29/23 22:14	1
13C5 PFPeA	79.2		40 - 150				11/22/23 10:18	11/29/23 22:14	1
13C5 PFHxA	83.2		40 - 150				11/22/23 10:18	11/29/23 22:14	1
13C4 PFHpA	79.4		40 - 150				11/22/23 10:18	11/29/23 22:14	1
13C8 PFOA	67.7		30 - 140				11/22/23 10:18	11/29/23 22:14	1
13C9 PFNA	75.7		30 - 140				11/22/23 10:18	11/29/23 22:14	1
13C6 PFDA	80.9		20 - 140				11/22/23 10:18	11/29/23 22:14	1
13C7 PFUnA	75.2		20 - 140				11/22/23 10:18	11/29/23 22:14	1
13C2 PFDoA	61.7		10 - 150				11/22/23 10:18	11/29/23 22:14	1
13C2 PFTeDA	60.9		10 - 130				11/22/23 10:18	11/29/23 22:14	1
13C3 PFBS	93.5		25 - 150				11/22/23 10:18	11/29/23 22:14	1
13C3 PFHxS	78.8		25 - 150				11/22/23 10:18	11/29/23 22:14	1
13C8 PFOS	70.6		20 - 140				11/22/23 10:18	11/29/23 22:14	1
13C8 FOSA	65.6		10 - 130				11/22/23 10:18	11/29/23 22:14	1
d3-NMeFOSAA	42.4		10 - 200				11/22/23 10:18	11/29/23 22:14	1
d5-NEtFOSAA	44.4		10 - 200				11/22/23 10:18	11/29/23 22:14	1
M2-4:2 FTS	24.1	*5-	25 - 200				11/22/23 10:18	11/29/23 22:14	1
M2-6:2 FTS	31.3		25 - 200				11/22/23 10:18	11/29/23 22:14	1
M2-8:2 FTS	32.1		25 - 200				11/22/23 10:18	11/29/23 22:14	1
13C3 HFPO-DA	85.2		25 - 160				11/22/23 10:18	11/29/23 22:14	1
d7-N-MeFOSE-M	58.1		10 - 150				11/22/23 10:18	11/29/23 22:14	1
d9-N-EtFOSE-M	106		10 - 150				11/22/23 10:18	11/29/23 22:14	1
d5-NEtPFOSA	62.9		10 - 130				11/22/23 10:18	11/29/23 22:14	1
d3-NMePFOSA	66.7		10 - 130				11/22/23 10:18	11/29/23 22:14	1

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		17.2	2.07	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoropentanoic acid (PFPeA)	ND		2.75	1.38	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorohexanoic acid (PFHxA)	ND		1.29	0.671	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoroheptanoic acid (PFHpA)	ND		1.46	0.568	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorooctanoic acid (PFOA)	ND		1.55	1.20	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorononanoic acid (PFNA)	ND	*-	1.29	0.723	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorodecanoic acid (PFDA)	ND		1.38	0.439	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoroundecanoic acid (PFUnA)	ND		1.64	0.525	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorododecanoic acid (PFDoA)	ND		1.29	0.620	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorotridecanoic acid (PFTeDA)	ND		1.46	0.783	ng/L		11/22/23 10:18	11/29/23 22:29	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorotetradecanoic acid (PFTA)	ND		1.38	0.516	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.03	0.430	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.20	0.826	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.20	0.852	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.20	1.03	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.12	0.766	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorononanesulfonic acid (PFNS)	ND		1.20	0.852	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.29	1.12	ng/L		11/22/23 10:18	11/29/23 22:29	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		5.34	1.03	ng/L		11/22/23 10:18	11/29/23 22:29	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		5.08	1.20	ng/L		11/22/23 10:18	11/29/23 22:29	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.59	2.15	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.29	0.482	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.38	0.473	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.38	0.611	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.46	0.706	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.12	0.783	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	35.3	4.99	ng/L		11/22/23 10:18	11/29/23 22:29	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	6.20	3.10	ng/L		11/22/23 10:18	11/29/23 22:29	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		5.51	2.24	ng/L		11/22/23 10:18	11/29/23 22:29	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		4.82	1.46	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.75	1.12	ng/L		11/22/23 10:18	11/29/23 22:29	1
Nonfluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		2.84	2.67	ng/L		11/22/23 10:18	11/29/23 22:29	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		4.99	1.72	ng/L		11/22/23 10:18	11/29/23 22:29	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		5.25	2.07	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.32	0.482	ng/L		11/22/23 10:18	11/29/23 22:29	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		34.4	3.10	ng/L		11/22/23 10:18	11/29/23 22:29	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		35.3	11.2	ng/L		11/22/23 10:18	11/29/23 22:29	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		34.4	13.8	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.12	0.947	ng/L		11/22/23 10:18	11/29/23 22:29	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.67	1.20	ng/L		11/22/23 10:18	11/29/23 22:29	1
Isotope Dilution	%Recovery	Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C4 PFBA	75.9		10 - 130				11/22/23 10:18	11/29/23 22:29	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFPeA	66.9		40 - 150	11/22/23 10:18	11/29/23 22:29	1
13C5 PFHxA	72.8		40 - 150	11/22/23 10:18	11/29/23 22:29	1
13C4 PFHpA	68.6		40 - 150	11/22/23 10:18	11/29/23 22:29	1
13C8 PFOA	69.6		30 - 140	11/22/23 10:18	11/29/23 22:29	1
13C9 PFNA	70.6		30 - 140	11/22/23 10:18	11/29/23 22:29	1
13C6 PFDA	76.1		20 - 140	11/22/23 10:18	11/29/23 22:29	1
13C7 PFUnA	76.0		20 - 140	11/22/23 10:18	11/29/23 22:29	1
13C2 PFDoA	61.1		10 - 150	11/22/23 10:18	11/29/23 22:29	1
13C2 PFTeDA	73.1		10 - 130	11/22/23 10:18	11/29/23 22:29	1
13C3 PFBS	77.7		25 - 150	11/22/23 10:18	11/29/23 22:29	1
13C3 PFHxS	66.9		25 - 150	11/22/23 10:18	11/29/23 22:29	1
13C8 PFOS	65.4		20 - 140	11/22/23 10:18	11/29/23 22:29	1
13C8 FOSA	58.4		10 - 130	11/22/23 10:18	11/29/23 22:29	1
d3-NMeFOSAA	39.9		10 - 200	11/22/23 10:18	11/29/23 22:29	1
d5-NEtFOSAA	41.5		10 - 200	11/22/23 10:18	11/29/23 22:29	1
M2-4:2 FTS	22.2	*5-	25 - 200	11/22/23 10:18	11/29/23 22:29	1
M2-6:2 FTS	28.6		25 - 200	11/22/23 10:18	11/29/23 22:29	1
M2-8:2 FTS	30.8		25 - 200	11/22/23 10:18	11/29/23 22:29	1
13C3 HFPO-DA	74.5		25 - 160	11/22/23 10:18	11/29/23 22:29	1
d7-N-MeFOSE-M	52.2		10 - 150	11/22/23 10:18	11/29/23 22:29	1
d9-N-EtFOSE-M	97.6		10 - 150	11/22/23 10:18	11/29/23 22:29	1
d5-NEtPFOSA	53.0		10 - 130	11/22/23 10:18	11/29/23 22:29	1
d3-NMePFOSA	65.1		10 - 130	11/22/23 10:18	11/29/23 22:29	1

Method: TAL SOP Total PFCA-Sum - Total PFCA (Summary) - Pre-Treatment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total PFCA	6.37	J	500	0.200	ng/L			01/09/24 16:32	1

Method: TAL SOP Total PFCA-Sum - Total PFCA (Summary) - Post-Treatment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total PFCA	8.65	J	500	0.200	ng/L			12/05/23 19:05	1

Client Sample ID: MPCA-SAFF-111523-OP2

Lab Sample ID: 752-13791-3

Date Collected: 11/15/23 13:40

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		16.2	1.94	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoropentanoic acid (PFPeA)	ND		2.58	1.29	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorohexanoic acid (PFHxA)	ND		1.21	0.630	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoroheptanoic acid (PFHpA)	ND		1.37	0.533	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorooctanoic acid (PFOA)	ND		1.45	1.13	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorononanoic acid (PFNA)	ND	*-	1.21	0.679	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorodecanoic acid (PFDA)	ND		1.29	0.412	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoroundecanoic acid (PFUnA)	ND		1.53	0.493	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorododecanoic acid (PFDoA)	ND		1.21	0.582	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorotridecanoic acid (PFTTrDA)	ND		1.37	0.735	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorotetradecanoic acid (PFTA)	ND		1.29	0.485	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.969	0.404	ng/L		11/22/23 10:18	11/29/23 23:15	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-OP2

Lab Sample ID: 752-13791-3

Date Collected: 11/15/23 13:40

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluoropentanesulfonic acid (PFPeS)	ND		1.13	0.775	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorohexanesulfonic acid (PFHxS)	1.04	J	1.13	0.800	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.13	0.969	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorooctanesulfonic acid (PFOS)	2.86		1.05	0.719	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorononanesulfonic acid (PFNS)	ND		1.13	0.800	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.21	1.05	ng/L		11/22/23 10:18	11/29/23 23:15	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		5.01	0.969	ng/L		11/22/23 10:18	11/29/23 23:15	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		4.77	1.13	ng/L		11/22/23 10:18	11/29/23 23:15	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.25	2.02	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.21	0.452	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.29	0.444	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.29	0.574	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.37	0.662	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.05	0.735	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	33.1	4.68	ng/L		11/22/23 10:18	11/29/23 23:15	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	5.82	2.91	ng/L		11/22/23 10:18	11/29/23 23:15	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		5.17	2.10	ng/L		11/22/23 10:18	11/29/23 23:15	1
4,8-Dioxo-3H-perfluorononanoic acid (ADONA)	ND		4.52	1.37	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.58	1.05	ng/L		11/22/23 10:18	11/29/23 23:15	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		2.67	2.50	ng/L		11/22/23 10:18	11/29/23 23:15	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		4.68	1.62	ng/L		11/22/23 10:18	11/29/23 23:15	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		4.93	1.94	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.18	0.452	ng/L		11/22/23 10:18	11/29/23 23:15	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		32.3	2.91	ng/L		11/22/23 10:18	11/29/23 23:15	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		33.1	10.5	ng/L		11/22/23 10:18	11/29/23 23:15	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		32.3	12.9	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.05	0.889	ng/L		11/22/23 10:18	11/29/23 23:15	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.50	1.13	ng/L		11/22/23 10:18	11/29/23 23:15	1
Isotope Dilution	%Recovery	Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C4 PFBA	90.6		10 - 130				11/22/23 10:18	11/29/23 23:15	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-OP2

Lab Sample ID: 752-13791-3

Date Collected: 11/15/23 13:40

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFPeA	80.3		40 - 150	11/22/23 10:18	11/29/23 23:15	1
13C5 PFHxA	84.7		40 - 150	11/22/23 10:18	11/29/23 23:15	1
13C4 PFHpA	81.2		40 - 150	11/22/23 10:18	11/29/23 23:15	1
13C8 PFOA	64.2		30 - 140	11/22/23 10:18	11/29/23 23:15	1
13C9 PFNA	70.2		30 - 140	11/22/23 10:18	11/29/23 23:15	1
13C6 PFDA	73.0		20 - 140	11/22/23 10:18	11/29/23 23:15	1
13C7 PFUnA	65.4		20 - 140	11/22/23 10:18	11/29/23 23:15	1
13C2 PFDoA	53.2		10 - 150	11/22/23 10:18	11/29/23 23:15	1
13C2 PFTeDA	61.5		10 - 130	11/22/23 10:18	11/29/23 23:15	1
13C3 PFBS	80.6		25 - 150	11/22/23 10:18	11/29/23 23:15	1
13C3 PFHxS	76.4		25 - 150	11/22/23 10:18	11/29/23 23:15	1
13C8 PFOS	68.0		20 - 140	11/22/23 10:18	11/29/23 23:15	1
13C8 FOSA	60.0		10 - 130	11/22/23 10:18	11/29/23 23:15	1
d3-NMeFOSAA	33.2		10 - 200	11/22/23 10:18	11/29/23 23:15	1
d5-NEtFOSAA	35.0		10 - 200	11/22/23 10:18	11/29/23 23:15	1
M2-4:2 FTS	21.7	*5-	25 - 200	11/22/23 10:18	11/29/23 23:15	1
M2-6:2 FTS	26.5		25 - 200	11/22/23 10:18	11/29/23 23:15	1
M2-8:2 FTS	26.7		25 - 200	11/22/23 10:18	11/29/23 23:15	1
13C3 HFPO-DA	90.7		25 - 160	11/22/23 10:18	11/29/23 23:15	1
d7-N-MeFOSE-M	51.4		10 - 150	11/22/23 10:18	11/29/23 23:15	1
d9-N-EtFOSE-M	94.8		10 - 150	11/22/23 10:18	11/29/23 23:15	1
d5-NEtPFOSA	51.0		10 - 130	11/22/23 10:18	11/29/23 23:15	1
d3-NMePFOSA	59.0		10 - 130	11/22/23 10:18	11/29/23 23:15	1

Client Sample ID: MPCA-SAFF-111523-Post

Lab Sample ID: 752-13791-4

Date Collected: 11/15/23 14:15

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		17.3	2.08	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoropentanoic acid (PFPeA)	ND		2.77	1.38	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorohexanoic acid (PFHxA)	ND		1.30	0.675	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoroheptanoic acid (PFHpA)	ND		1.47	0.571	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorooctanoic acid (PFOA)	ND		1.56	1.21	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorononanoic acid (PFNA)	ND	*-	1.30	0.727	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorodecanoic acid (PFDA)	ND		1.38	0.441	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoroundecanoic acid (PFUnA)	ND		1.64	0.528	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorododecanoic acid (PFDoA)	ND		1.30	0.623	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorotridecanoic acid (PFTeDA)	ND		1.47	0.787	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorotetradecanoic acid (PFTA)	ND		1.38	0.519	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.04	0.433	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.21	0.830	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.21	0.856	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.21	1.04	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.12	0.770	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorononanesulfonic acid (PFNS)	ND		1.21	0.856	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.30	1.12	ng/L		11/22/23 10:18	11/29/23 23:31	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-Post

Lab Sample ID: 752-13791-4

Date Collected: 11/15/23 14:15

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		5.36	1.04	ng/L		11/22/23 10:18	11/29/23 23:31	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		5.10	1.21	ng/L		11/22/23 10:18	11/29/23 23:31	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.62	2.16	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.30	0.484	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.38	0.476	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.38	0.614	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.47	0.709	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.12	0.787	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	35.5	5.02	ng/L		11/22/23 10:18	11/29/23 23:31	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	6.23	3.11	ng/L		11/22/23 10:18	11/29/23 23:31	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		5.54	2.25	ng/L		11/22/23 10:18	11/29/23 23:31	1
4,8-Dioxo-3H-perfluorononanoic acid (ADONA)	ND		4.84	1.47	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.77	1.12	ng/L		11/22/23 10:18	11/29/23 23:31	1
Nonafluoro-3,6-dioxahexanoic acid (NFDHA)	ND		2.85	2.68	ng/L		11/22/23 10:18	11/29/23 23:31	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		5.02	1.73	ng/L		11/22/23 10:18	11/29/23 23:31	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		5.28	2.08	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.34	0.484	ng/L		11/22/23 10:18	11/29/23 23:31	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		34.6	3.11	ng/L		11/22/23 10:18	11/29/23 23:31	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		35.5	11.2	ng/L		11/22/23 10:18	11/29/23 23:31	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		34.6	13.8	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.12	0.952	ng/L		11/22/23 10:18	11/29/23 23:31	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.68	1.21	ng/L		11/22/23 10:18	11/29/23 23:31	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	88.0		10 - 130	11/22/23 10:18	11/29/23 23:31	1
13C5 PFPeA	76.9		40 - 150	11/22/23 10:18	11/29/23 23:31	1
13C5 PFHxA	80.1		40 - 150	11/22/23 10:18	11/29/23 23:31	1
13C4 PFHpA	79.6		40 - 150	11/22/23 10:18	11/29/23 23:31	1
13C8 PFOA	67.0		30 - 140	11/22/23 10:18	11/29/23 23:31	1
13C9 PFNA	79.2		30 - 140	11/22/23 10:18	11/29/23 23:31	1
13C6 PFDA	85.1		20 - 140	11/22/23 10:18	11/29/23 23:31	1
13C7 PFUnA	82.7		20 - 140	11/22/23 10:18	11/29/23 23:31	1
13C2 PFDoA	62.1		10 - 150	11/22/23 10:18	11/29/23 23:31	1
13C2 PFTeDA	67.8		10 - 130	11/22/23 10:18	11/29/23 23:31	1
13C3 PFBS	91.3		25 - 150	11/22/23 10:18	11/29/23 23:31	1

Eurofins Raleigh

Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-Post

Lab Sample ID: 752-13791-4

Date Collected: 11/15/23 14:15

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C3 PFHxS	81.3		25 - 150	11/22/23 10:18	11/29/23 23:31	1
13C8 PFOS	82.7		20 - 140	11/22/23 10:18	11/29/23 23:31	1
13C8 FOSA	64.0		10 - 130	11/22/23 10:18	11/29/23 23:31	1
d3-NMeFOSAA	39.8		10 - 200	11/22/23 10:18	11/29/23 23:31	1
d5-NEtFOSAA	41.9		10 - 200	11/22/23 10:18	11/29/23 23:31	1
M2-4:2 FTS	25.0		25 - 200	11/22/23 10:18	11/29/23 23:31	1
M2-6:2 FTS	31.8		25 - 200	11/22/23 10:18	11/29/23 23:31	1
M2-8:2 FTS	33.6		25 - 200	11/22/23 10:18	11/29/23 23:31	1
13C3 HFPO-DA	87.8		25 - 160	11/22/23 10:18	11/29/23 23:31	1
d7-N-MeFOSE-M	60.8		10 - 150	11/22/23 10:18	11/29/23 23:31	1
d9-N-EtFOSE-M	111		10 - 150	11/22/23 10:18	11/29/23 23:31	1
d5-NEtPFOSA	54.3		10 - 130	11/22/23 10:18	11/29/23 23:31	1
d3-NMePFOSA	63.7		10 - 130	11/22/23 10:18	11/29/23 23:31	1

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	315	J	2000	240	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoropentanoic acid (PFPeA)	ND		320	160	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorohexanoic acid (PFHxA)	1900		150	78.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoroheptanoic acid (PFHpA)	53400		170	66.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorooctanoic acid (PFOA)	971000	E	180	140	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorononanoic acid (PFNA)	6840	*-	150	84.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorodecanoic acid (PFDA)	6920		160	51.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoroundecanoic acid (PFUnA)	ND		190	61.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorododecanoic acid (PFDoA)	ND		150	72.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorotridecanoic acid (PFTrDA)	ND		170	91.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorotetradecanoic acid (PFTA)	ND		160	60.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorobutanesulfonic acid (PFBS)	125		120	50.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoropentanesulfonic acid (PFPeS)	6690		140	96.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorohexanesulfonic acid (PFHxS)	98400	E	140	99.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoroheptanesulfonic acid (PFHpS)	99800	E	140	120	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorooctanesulfonic acid (PFOS)	3660000	E	130	89.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorononanesulfonic acid (PFNS)	ND		140	99.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorododecanesulfonic acid (PFDoS)	ND		150	130	ng/L		11/22/23 10:18	11/29/23 23:46	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		620	120	ng/L		11/22/23 10:18	11/29/23 23:46	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		590	140	ng/L		11/22/23 10:18	11/29/23 23:46	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		650	250	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorooctanesulfonamide (PFOSA)	604		150	56.0	ng/L		11/22/23 10:18	11/29/23 23:46	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		160	55.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	160	71.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		170	82.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	134		130	91.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	4100	580	ng/L		11/22/23 10:18	11/29/23 23:46	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	720	360	ng/L		11/22/23 10:18	11/29/23 23:46	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		640	260	ng/L		11/22/23 10:18	11/29/23 23:46	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		560	170	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		320	130	ng/L		11/22/23 10:18	11/29/23 23:46	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		330	310	ng/L		11/22/23 10:18	11/29/23 23:46	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9Cl-PF3ONS)	ND		580	200	ng/L		11/22/23 10:18	11/29/23 23:46	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		610	240	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		270	56.0	ng/L		11/22/23 10:18	11/29/23 23:46	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		4000	360	ng/L		11/22/23 10:18	11/29/23 23:46	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		4100	1300	ng/L		11/22/23 10:18	11/29/23 23:46	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		4000	1600	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluorodecanesulfonic acid (PFDS)	ND		130	110	ng/L		11/22/23 10:18	11/29/23 23:46	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		310	140	ng/L		11/22/23 10:18	11/29/23 23:46	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	84.9		10 - 130	11/22/23 10:18	11/29/23 23:46	1
13C5 PFPeA	76.0		40 - 150	11/22/23 10:18	11/29/23 23:46	1
13C5 PFHxA	82.4		40 - 150	11/22/23 10:18	11/29/23 23:46	1
13C4 PFHpA	74.6		40 - 150	11/22/23 10:18	11/29/23 23:46	1
13C8 PFOA	54.3		30 - 140	11/22/23 10:18	11/29/23 23:46	1
13C9 PFNA	78.5		30 - 140	11/22/23 10:18	11/29/23 23:46	1
13C6 PFDA	88.5		20 - 140	11/22/23 10:18	11/29/23 23:46	1
13C7 PFUnA	89.0		20 - 140	11/22/23 10:18	11/29/23 23:46	1
13C2 PFDoA	63.2		10 - 150	11/22/23 10:18	11/29/23 23:46	1
13C2 PFTeDA	65.5		10 - 130	11/22/23 10:18	11/29/23 23:46	1
13C3 PFBS	107		25 - 150	11/22/23 10:18	11/29/23 23:46	1
13C3 PFHxS	82.6		25 - 150	11/22/23 10:18	11/29/23 23:46	1
13C8 PFOS	70.2		20 - 140	11/22/23 10:18	11/29/23 23:46	1
13C8 FOSA	175	*5+	10 - 130	11/22/23 10:18	11/29/23 23:46	1
d3-NMeFOSAA	147		10 - 200	11/22/23 10:18	11/29/23 23:46	1
d5-NEtFOSAA	122		10 - 200	11/22/23 10:18	11/29/23 23:46	1
M2-4:2 FTS	65.7		25 - 200	11/22/23 10:18	11/29/23 23:46	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
M2-6:2 FTS	61.0		25 - 200	11/22/23 10:18	11/29/23 23:46	1
M2-8:2 FTS	49.3		25 - 200	11/22/23 10:18	11/29/23 23:46	1
13C3 HFPO-DA	83.5		25 - 160	11/22/23 10:18	11/29/23 23:46	1
d7-N-MeFOSE-M	144		10 - 150	11/22/23 10:18	11/29/23 23:46	1
d9-N-EtFOSE-M	274	*5+	10 - 150	11/22/23 10:18	11/29/23 23:46	1
d5-NEtPFOSA	146	*5+	10 - 130	11/22/23 10:18	11/29/23 23:46	1
d3-NMePFOSA	169	*5+	10 - 130	11/22/23 10:18	11/29/23 23:46	1

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS - DL

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	98.1		25 - 130	12/14/23 10:49	12/15/23 13:06	3
13C5 PFPeA	75.8		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C5 PFHxA	83.3		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C4 PFHpA	76.3		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C8 PFOA	71.8		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C9 PFNA	75.2		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C6 PFDA	67.4		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C7 PFUnA	77.4		30 - 130	12/14/23 10:49	12/15/23 13:06	3
13C2 PFDoA	63.6		10 - 130	12/14/23 10:49	12/15/23 13:06	3
13C2 PFTeDA	36.4		10 - 130	12/14/23 10:49	12/15/23 13:06	3
13C3 PFBS	78.7		40 - 135	12/14/23 10:49	12/15/23 13:06	3
13C3 PFHxS	68.4		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C8 PFOS	58.5		40 - 130	12/14/23 10:49	12/15/23 13:06	3
13C8 FOSA	53.9		40 - 130	12/14/23 10:49	12/15/23 13:06	3
d3-NMeFOSAA	57.2		40 - 170	12/14/23 10:49	12/15/23 13:06	3
d5-NEtFOSAA	49.8		25 - 135	12/14/23 10:49	12/15/23 13:06	3
M2-4:2 FTS	102		40 - 200	12/14/23 10:49	12/15/23 13:06	3
M2-6:2 FTS	84.8		40 - 200	12/14/23 10:49	12/15/23 13:06	3
M2-8:2 FTS	81.9		40 - 300	12/14/23 10:49	12/15/23 13:06	3
13C3 HFPO-DA	77.9		40 - 130	12/14/23 10:49	12/15/23 13:06	3
d7-N-MeFOSE-M	42.2		10 - 130	12/14/23 10:49	12/15/23 13:06	3
d9-N-EtFOSE-M	66.6		10 - 130	12/14/23 10:49	12/15/23 13:06	3
d5-NEtPFOSA	34.5		10 - 130	12/14/23 10:49	12/15/23 13:06	3
d3-NMePFOSA	40.0		10 - 130	12/14/23 10:49	12/15/23 13:06	3

Client Sample ID: MPCA-SAFF-111623-PRE

Lab Sample ID: 752-13791-6

Date Collected: 11/16/23 10:24

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		14.8	1.78	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoropentanoic acid (PFPeA)	ND		2.37	1.19	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorohexanoic acid (PFHxA)	ND		1.11	0.579	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoroheptanoic acid (PFHpA)	ND		1.26	0.490	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorooctanoic acid (PFOA)	ND		1.34	1.04	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorononanoic acid (PFNA)	ND	*-	1.11	0.623	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorodecanoic acid (PFDA)	ND		1.19	0.378	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoroundecanoic acid (PFUnA)	ND		1.41	0.453	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorododecanoic acid (PFDoA)	ND		1.11	0.534	ng/L		11/22/23 10:18	11/30/23 00:01	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-PRE

Lab Sample ID: 752-13791-6

Date Collected: 11/16/23 10:24

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorotridecanoic acid (PFTrDA)	ND		1.26	0.675	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorotetradecanoic acid (PFTA)	ND		1.19	0.445	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.890	0.371	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.04	0.712	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.04	0.734	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.04	0.890	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorooctanesulfonic acid (PFOS)	2.69		0.964	0.660	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorononanesulfonic acid (PFNS)	ND		1.04	0.734	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.11	0.964	ng/L		11/22/23 10:18	11/30/23 00:01	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		4.60	0.890	ng/L		11/22/23 10:18	11/30/23 00:01	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		4.38	1.04	ng/L		11/22/23 10:18	11/30/23 00:01	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		4.82	1.85	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.11	0.415	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.19	0.408	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.19	0.527	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.26	0.608	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		0.964	0.675	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	30.4	4.30	ng/L		11/22/23 10:18	11/30/23 00:01	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	5.34	2.67	ng/L		11/22/23 10:18	11/30/23 00:01	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		4.75	1.93	ng/L		11/22/23 10:18	11/30/23 00:01	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		4.15	1.26	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.37	0.964	ng/L		11/22/23 10:18	11/30/23 00:01	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		2.45	2.30	ng/L		11/22/23 10:18	11/30/23 00:01	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9Cl-PF3ONS)	ND		4.30	1.48	ng/L		11/22/23 10:18	11/30/23 00:01	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		4.53	1.78	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.00	0.415	ng/L		11/22/23 10:18	11/30/23 00:01	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		29.7	2.67	ng/L		11/22/23 10:18	11/30/23 00:01	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		30.4	9.64	ng/L		11/22/23 10:18	11/30/23 00:01	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		29.7	11.9	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluorodecanesulfonic acid (PFDS)	ND		0.964	0.816	ng/L		11/22/23 10:18	11/30/23 00:01	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.30	1.04	ng/L		11/22/23 10:18	11/30/23 00:01	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-PRE

Lab Sample ID: 752-13791-6

Date Collected: 11/16/23 10:24

Matrix: Water

Date Received: 11/16/23 15:20

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	83.7		10 - 130	11/22/23 10:18	11/30/23 00:01	1
13C5 PFPeA	81.5		40 - 150	11/22/23 10:18	11/30/23 00:01	1
13C5 PFHxA	80.7		40 - 150	11/22/23 10:18	11/30/23 00:01	1
13C4 PFHpA	79.7		40 - 150	11/22/23 10:18	11/30/23 00:01	1
13C8 PFOA	68.9		30 - 140	11/22/23 10:18	11/30/23 00:01	1
13C9 PFNA	72.0		30 - 140	11/22/23 10:18	11/30/23 00:01	1
13C6 PFDA	76.6		20 - 140	11/22/23 10:18	11/30/23 00:01	1
13C7 PFUnA	69.1		20 - 140	11/22/23 10:18	11/30/23 00:01	1
13C2 PFDoA	56.8		10 - 150	11/22/23 10:18	11/30/23 00:01	1
13C2 PFTeDA	80.2		10 - 130	11/22/23 10:18	11/30/23 00:01	1
13C3 PFBS	96.2		25 - 150	11/22/23 10:18	11/30/23 00:01	1
13C3 PFHxS	78.2		25 - 150	11/22/23 10:18	11/30/23 00:01	1
13C8 PFOS	71.6		20 - 140	11/22/23 10:18	11/30/23 00:01	1
13C8 FOSA	62.3		10 - 130	11/22/23 10:18	11/30/23 00:01	1
d3-NMeFOSAA	35.8		10 - 200	11/22/23 10:18	11/30/23 00:01	1
d5-NEtFOSAA	38.3		10 - 200	11/22/23 10:18	11/30/23 00:01	1
M2-4:2 FTS	21.2	*5-	25 - 200	11/22/23 10:18	11/30/23 00:01	1
M2-6:2 FTS	26.0		25 - 200	11/22/23 10:18	11/30/23 00:01	1
M2-8:2 FTS	29.0		25 - 200	11/22/23 10:18	11/30/23 00:01	1
13C3 HFPO-DA	90.3		25 - 160	11/22/23 10:18	11/30/23 00:01	1
d7-N-MeFOSE-M	56.5		10 - 150	11/22/23 10:18	11/30/23 00:01	1
d9-N-EtFOSE-M	102		10 - 150	11/22/23 10:18	11/30/23 00:01	1
d5-NEtPFOSA	50.8		10 - 130	11/22/23 10:18	11/30/23 00:01	1
d3-NMePFOSA	61.8		10 - 130	11/22/23 10:18	11/30/23 00:01	1

Client Sample ID: MPCA-SAFF-111623-OP1

Lab Sample ID: 752-13791-7

Date Collected: 11/16/23 11:13

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		15.5	1.85	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoropentanoic acid (PFPeA)	ND		2.47	1.24	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorohexanoic acid (PFHxA)	ND		1.16	0.603	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoroheptanoic acid (PFHpA)	ND		1.31	0.510	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorooctanoic acid (PFOA)	ND		1.39	1.08	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorononanoic acid (PFNA)	ND	*-	1.16	0.649	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorodecanoic acid (PFDA)	ND		1.24	0.394	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoroundecanoic acid (PFUnA)	ND		1.47	0.471	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorododecanoic acid (PFDoA)	ND		1.16	0.556	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorotridecanoic acid (PFTeDA)	ND		1.31	0.703	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorotetradecanoic acid (PFTA)	ND		1.24	0.464	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.927	0.386	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.08	0.742	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.08	0.765	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.08	0.927	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.00	0.688	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorononanesulfonic acid (PFNS)	ND		1.08	0.765	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.16	1.00	ng/L		11/22/23 10:18	11/30/23 00:17	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-OP1

Lab Sample ID: 752-13791-7

Date Collected: 11/16/23 11:13

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		4.79	0.927	ng/L		11/22/23 10:18	11/30/23 00:17	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		4.56	1.08	ng/L		11/22/23 10:18	11/30/23 00:17	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.02	1.93	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.16	0.433	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.24	0.425	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.24	0.549	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.31	0.634	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.00	0.703	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	31.7	4.48	ng/L		11/22/23 10:18	11/30/23 00:17	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	5.56	2.78	ng/L		11/22/23 10:18	11/30/23 00:17	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		4.95	2.01	ng/L		11/22/23 10:18	11/30/23 00:17	1
4,8-Dioxo-3H-perfluorononanoic acid (ADONA)	ND		4.33	1.31	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.47	1.00	ng/L		11/22/23 10:18	11/30/23 00:17	1
Nonafluoro-3,6-dioxahexanoic acid (NFDHA)	ND		2.55	2.40	ng/L		11/22/23 10:18	11/30/23 00:17	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		4.48	1.55	ng/L		11/22/23 10:18	11/30/23 00:17	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		4.71	1.85	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.09	0.433	ng/L		11/22/23 10:18	11/30/23 00:17	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		30.9	2.78	ng/L		11/22/23 10:18	11/30/23 00:17	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		31.7	10.0	ng/L		11/22/23 10:18	11/30/23 00:17	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		30.9	12.4	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.00	0.850	ng/L		11/22/23 10:18	11/30/23 00:17	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.40	1.08	ng/L		11/22/23 10:18	11/30/23 00:17	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	83.0		10 - 130	11/22/23 10:18	11/30/23 00:17	1
13C5 PFPeA	83.9		40 - 150	11/22/23 10:18	11/30/23 00:17	1
13C5 PFHxA	83.2		40 - 150	11/22/23 10:18	11/30/23 00:17	1
13C4 PFHpA	84.5		40 - 150	11/22/23 10:18	11/30/23 00:17	1
13C8 PFOA	64.4		30 - 140	11/22/23 10:18	11/30/23 00:17	1
13C9 PFNA	73.0		30 - 140	11/22/23 10:18	11/30/23 00:17	1
13C6 PFDA	77.1		20 - 140	11/22/23 10:18	11/30/23 00:17	1
13C7 PFUnA	67.7		20 - 140	11/22/23 10:18	11/30/23 00:17	1
13C2 PFDoA	51.9		10 - 150	11/22/23 10:18	11/30/23 00:17	1
13C2 PFTeDA	63.2		10 - 130	11/22/23 10:18	11/30/23 00:17	1
13C3 PFBS	84.4		25 - 150	11/22/23 10:18	11/30/23 00:17	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-OP1

Lab Sample ID: 752-13791-7

Date Collected: 11/16/23 11:13

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C3 PFHxS	79.3		25 - 150	11/22/23 10:18	11/30/23 00:17	1
13C8 PFOS	72.5		20 - 140	11/22/23 10:18	11/30/23 00:17	1
13C8 FOSA	61.9		10 - 130	11/22/23 10:18	11/30/23 00:17	1
d3-NMeFOSAA	33.8		10 - 200	11/22/23 10:18	11/30/23 00:17	1
d5-NEtFOSAA	34.1		10 - 200	11/22/23 10:18	11/30/23 00:17	1
M2-4:2 FTS	22.0	*5-	25 - 200	11/22/23 10:18	11/30/23 00:17	1
M2-6:2 FTS	25.8		25 - 200	11/22/23 10:18	11/30/23 00:17	1
M2-8:2 FTS	25.5		25 - 200	11/22/23 10:18	11/30/23 00:17	1
13C3 HFPO-DA	95.2		25 - 160	11/22/23 10:18	11/30/23 00:17	1
d7-N-MeFOSE-M	54.4		10 - 150	11/22/23 10:18	11/30/23 00:17	1
d9-N-EtFOSE-M	101		10 - 150	11/22/23 10:18	11/30/23 00:17	1
d5-NEtPFOSA	54.0		10 - 130	11/22/23 10:18	11/30/23 00:17	1
d3-NMePFOSA	64.8		10 - 130	11/22/23 10:18	11/30/23 00:17	1

Client Sample ID: MPCA-SAFF-111623-OP2

Lab Sample ID: 752-13791-8

Date Collected: 11/16/23 11:34

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		15.6	1.87	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoropentanoic acid (PFPeA)	ND		2.49	1.25	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorohexanoic acid (PFHxA)	ND		1.17	0.607	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoroheptanoic acid (PFHpA)	ND		1.32	0.514	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorooctanoic acid (PFOA)	ND		1.40	1.09	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorononanoic acid (PFNA)	ND	*-	1.17	0.654	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorodecanoic acid (PFDA)	ND		1.25	0.397	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoroundecanoic acid (PFUnA)	ND		1.48	0.475	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorododecanoic acid (PFDoA)	ND		1.17	0.561	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorotridecanoic acid (PFTrDA)	ND		1.32	0.709	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorotetradecanoic acid (PFTA)	ND		1.25	0.467	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.935	0.389	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.09	0.748	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.09	0.771	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.09	0.935	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.01	0.693	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorononanesulfonic acid (PFNS)	ND		1.09	0.771	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.17	1.01	ng/L		11/22/23 10:18	11/30/23 00:32	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		4.83	0.935	ng/L		11/22/23 10:18	11/30/23 00:32	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		4.60	1.09	ng/L		11/22/23 10:18	11/30/23 00:32	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		5.06	1.95	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.17	0.436	ng/L		11/22/23 10:18	11/30/23 00:32	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.25	0.428	ng/L		11/22/23 10:18	11/30/23 00:32	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	*-	1.25	0.553	ng/L		11/22/23 10:18	11/30/23 00:32	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-OP2

Lab Sample ID: 752-13791-8

Date Collected: 11/16/23 11:34

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.32	0.639	ng/L		11/22/23 10:18	11/30/23 00:32	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.01	0.709	ng/L		11/22/23 10:18	11/30/23 00:32	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	*-	31.9	4.52	ng/L		11/22/23 10:18	11/30/23 00:32	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	*-	5.61	2.80	ng/L		11/22/23 10:18	11/30/23 00:32	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		4.98	2.02	ng/L		11/22/23 10:18	11/30/23 00:32	1
4,8-Dioxo-3H-perfluorononanoic acid (ADONA)	ND		4.36	1.32	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.49	1.01	ng/L		11/22/23 10:18	11/30/23 00:32	1
Nonafluoro-3,6-dioxahexanoic acid (NFDHA)	ND		2.57	2.41	ng/L		11/22/23 10:18	11/30/23 00:32	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND		4.52	1.56	ng/L		11/22/23 10:18	11/30/23 00:32	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND		4.75	1.87	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.10	0.436	ng/L		11/22/23 10:18	11/30/23 00:32	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		31.2	2.80	ng/L		11/22/23 10:18	11/30/23 00:32	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		31.9	10.1	ng/L		11/22/23 10:18	11/30/23 00:32	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		31.2	12.5	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.01	0.857	ng/L		11/22/23 10:18	11/30/23 00:32	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.41	1.09	ng/L		11/22/23 10:18	11/30/23 00:32	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	89.2		10 - 130	11/22/23 10:18	11/30/23 00:32	1
13C5 PFPeA	84.7		40 - 150	11/22/23 10:18	11/30/23 00:32	1
13C5 PFHxA	90.5		40 - 150	11/22/23 10:18	11/30/23 00:32	1
13C4 PFHpA	84.1		40 - 150	11/22/23 10:18	11/30/23 00:32	1
13C8 PFOA	66.8		30 - 140	11/22/23 10:18	11/30/23 00:32	1
13C9 PFNA	78.9		30 - 140	11/22/23 10:18	11/30/23 00:32	1
13C6 PFDA	89.6		20 - 140	11/22/23 10:18	11/30/23 00:32	1
13C7 PFUnA	78.8		20 - 140	11/22/23 10:18	11/30/23 00:32	1
13C2 PFDoA	65.9		10 - 150	11/22/23 10:18	11/30/23 00:32	1
13C2 PFTeDA	70.5		10 - 130	11/22/23 10:18	11/30/23 00:32	1
13C3 PFBS	95.9		25 - 150	11/22/23 10:18	11/30/23 00:32	1
13C3 PFHxS	81.8		25 - 150	11/22/23 10:18	11/30/23 00:32	1
13C8 PFOS	74.0		20 - 140	11/22/23 10:18	11/30/23 00:32	1
13C8 FOSA	72.1		10 - 130	11/22/23 10:18	11/30/23 00:32	1
d3-NMeFOSAA	34.8		10 - 200	11/22/23 10:18	11/30/23 00:32	1
d5-NEtFOSAA	36.0		10 - 200	11/22/23 10:18	11/30/23 00:32	1
M2-4:2 FTS	22.2	*5-	25 - 200	11/22/23 10:18	11/30/23 00:32	1
M2-6:2 FTS	25.9		25 - 200	11/22/23 10:18	11/30/23 00:32	1
M2-8:2 FTS	29.9		25 - 200	11/22/23 10:18	11/30/23 00:32	1
13C3 HFPO-DA	97.4		25 - 160	11/22/23 10:18	11/30/23 00:32	1
d7-N-MeFOSE-M	66.7		10 - 150	11/22/23 10:18	11/30/23 00:32	1

Eurofins Raleigh

Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-OP2

Lab Sample ID: 752-13791-8

Date Collected: 11/16/23 11:34

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
d9-N-EtFOSE-M	120		10 - 150	11/22/23 10:18	11/30/23 00:32	1
d5-NEtPFOSA	61.8		10 - 130	11/22/23 10:18	11/30/23 00:32	1
d3-NMePFOSA	71.9		10 - 130	11/22/23 10:18	11/30/23 00:32	1

Client Sample ID: MPCA-SAFF-111623-Post

Lab Sample ID: 752-13791-9

Date Collected: 11/16/23 12:15

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		14.2	1.71	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoropentanoic acid (PFPeA)	ND		2.28	1.14	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorohexanoic acid (PFHxA)	ND		1.07	0.555	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoroheptanoic acid (PFHpA)	ND		1.21	0.469	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorooctanoic acid (PFOA)	ND		1.28	0.996	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorononanoic acid (PFNA)	ND	-	1.07	0.597	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorodecanoic acid (PFDA)	ND		1.14	0.363	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoroundecanoic acid (PFUnA)	ND		1.35	0.434	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorododecanoic acid (PFDoA)	ND		1.07	0.512	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorotridecanoic acid (PFTTrDA)	ND		1.21	0.647	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorotetradecanoic acid (PFTA)	ND		1.14	0.427	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.853	0.356	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoropentanesulfonic acid (PFPeS)	ND		0.996	0.683	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorohexanesulfonic acid (PFHxS)	ND		0.996	0.704	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		0.996	0.853	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorooctanesulfonic acid (PFOS)	ND		0.925	0.633	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorononanesulfonic acid (PFNS)	ND		0.996	0.704	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.07	0.925	ng/L		11/22/23 10:18	11/30/23 00:47	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		4.41	0.853	ng/L		11/22/23 10:18	11/30/23 00:47	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		4.20	0.996	ng/L		11/22/23 10:18	11/30/23 00:47	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		4.62	1.78	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.07	0.398	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.14	0.391	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND	-	1.14	0.505	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.21	0.583	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		0.925	0.647	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND	-	29.2	4.13	ng/L		11/22/23 10:18	11/30/23 00:47	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND	-	5.12	2.56	ng/L		11/22/23 10:18	11/30/23 00:47	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		4.55	1.85	ng/L		11/22/23 10:18	11/30/23 00:47	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-Post

Lab Sample ID: 752-13791-9

Date Collected: 11/16/23 12:15

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		3.98	1.21	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		2.28	0.925	ng/L		11/22/23 10:18	11/30/23 00:47	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		2.35	2.20	ng/L		11/22/23 10:18	11/30/23 00:47	1
9-Chlorohexadecafluoro-3-oxanonan e-1-sulfonic acid(9Cl-PF3ONS)	ND		4.13	1.42	ng/L		11/22/23 10:18	11/30/23 00:47	1
11-Chloroeicosafluoro-3-oxaundecan e-1-sulfonic acid (11Cl-PF3OUdS)	ND		4.34	1.71	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		1.92	0.398	ng/L		11/22/23 10:18	11/30/23 00:47	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		28.4	2.56	ng/L		11/22/23 10:18	11/30/23 00:47	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		29.2	9.25	ng/L		11/22/23 10:18	11/30/23 00:47	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		28.4	11.4	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluorodecanesulfonic acid (PFDS)	ND		0.925	0.782	ng/L		11/22/23 10:18	11/30/23 00:47	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		2.20	0.996	ng/L		11/22/23 10:18	11/30/23 00:47	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	94.7		10 - 130	11/22/23 10:18	11/30/23 00:47	1
13C5 PFPeA	94.2		40 - 150	11/22/23 10:18	11/30/23 00:47	1
13C5 PFHxA	97.9		40 - 150	11/22/23 10:18	11/30/23 00:47	1
13C4 PFHpA	91.0		40 - 150	11/22/23 10:18	11/30/23 00:47	1
13C8 PFOA	71.9		30 - 140	11/22/23 10:18	11/30/23 00:47	1
13C9 PFNA	83.3		30 - 140	11/22/23 10:18	11/30/23 00:47	1
13C6 PFDA	94.0		20 - 140	11/22/23 10:18	11/30/23 00:47	1
13C7 PFUnA	81.7		20 - 140	11/22/23 10:18	11/30/23 00:47	1
13C2 PFDoA	68.6		10 - 150	11/22/23 10:18	11/30/23 00:47	1
13C2 PFTeDA	86.3		10 - 130	11/22/23 10:18	11/30/23 00:47	1
13C3 PFBS	98.8		25 - 150	11/22/23 10:18	11/30/23 00:47	1
13C3 PFHxS	84.5		25 - 150	11/22/23 10:18	11/30/23 00:47	1
13C8 PFOS	67.3		20 - 140	11/22/23 10:18	11/30/23 00:47	1
13C8 FOSA	64.1		10 - 130	11/22/23 10:18	11/30/23 00:47	1
d3-NMeFOSAA	31.6		10 - 200	11/22/23 10:18	11/30/23 00:47	1
d5-NEtFOSAA	33.1		10 - 200	11/22/23 10:18	11/30/23 00:47	1
M2-4:2 FTS	23.6	*5-	25 - 200	11/22/23 10:18	11/30/23 00:47	1
M2-6:2 FTS	26.1		25 - 200	11/22/23 10:18	11/30/23 00:47	1
M2-8:2 FTS	24.7	*5-	25 - 200	11/22/23 10:18	11/30/23 00:47	1
13C3 HFPO-DA	108		25 - 160	11/22/23 10:18	11/30/23 00:47	1
d7-N-MeFOSE-M	58.6		10 - 150	11/22/23 10:18	11/30/23 00:47	1
d9-N-EtFOSE-M	108		10 - 150	11/22/23 10:18	11/30/23 00:47	1
d5-NEtPFOSA	58.5		10 - 130	11/22/23 10:18	11/30/23 00:47	1
d3-NMePFOSA	66.8		10 - 130	11/22/23 10:18	11/30/23 00:47	1

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Isotope Dilution Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Matrix: Water

Prep Type: Total/NA

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFBA (10-130)	PFPeA (40-150)	13C5PHA (40-150)	C4PFHA (40-150)	C8PFOA (30-140)	C9PFNA (30-140)	C6PFDA (20-140)	13C7PUA (20-140)
752-13791-1	MPCA-SAFF-111523-PRE	89.8	79.2	83.2	79.4	67.7	75.7	80.9	75.2
752-13791-2	MPCA-SAFF-111523-OP1	75.9	66.9	72.8	68.6	69.6	70.6	76.1	76.0
752-13791-3	MPCA-SAFF-111523-OP2	90.6	80.3	84.7	81.2	64.2	70.2	73.0	65.4
752-13791-4	MPCA-SAFF-111523-Post	88.0	76.9	80.1	79.6	67.0	79.2	85.1	82.7
752-13791-5	MPCA-SAFF-111523-Stock	84.9	76.0	82.4	74.6	54.3	78.5	88.5	89.0
752-13791-6	MPCA-SAFF-111623-PRE	83.7	81.5	80.7	79.7	68.9	72.0	76.6	69.1
752-13791-7	MPCA-SAFF-111623-OP1	83.0	83.9	83.2	84.5	64.4	73.0	77.1	67.7
752-13791-8	MPCA-SAFF-111623-OP2	89.2	84.7	90.5	84.1	66.8	78.9	89.6	78.8
752-13791-9	MPCA-SAFF-111623-Post	94.7	94.2	97.9	91.0	71.9	83.3	94.0	81.7
LCS 680-809669/2-A	Lab Control Sample	79.5	77.5	79.1	75.2	71.8	75.8	79.2	75.0
LCS 680-813392/2-A	Lab Control Sample	104	75.5	82.3	77.6	80.7	82.9	80.4	88.6
LCSD 680-809669/3-A	Lab Control Sample Dup	80.7	78.0	82.1	81.0	63.5	75.4	83.2	78.0
LCSD 680-813392/3-A	Lab Control Sample Dup	103	80.4	88.1	82.9	86.7	86.4	82.8	93.1
LLCS 680-809669/4-A	Lab Control Sample	78.4	78.4	73.8	76.6	66.4	76.5	84.3	73.1
LLCS 680-813392/4-A	Lab Control Sample	106	81.7	93.0	90.3	71.9	82.1	79.6	90.9
MB 680-809669/1-A	Method Blank	72.9	69.6	69.1	68.3	62.9	69.0	75.3	67.2
		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFDaA (10-150)	PFTDA (10-130)	C3PFBS (25-150)	C3PFHS (25-150)	C8PFOS (20-140)	PFOSA (10-130)	d3NMFOS (10-200)	d5NEFOS (10-200)
752-13791-1	MPCA-SAFF-111523-PRE	61.7	60.9	93.5	78.8	70.6	65.6	42.4	44.4
752-13791-2	MPCA-SAFF-111523-OP1	61.1	73.1	77.7	66.9	65.4	58.4	39.9	41.5
752-13791-3	MPCA-SAFF-111523-OP2	53.2	61.5	80.6	76.4	68.0	60.0	33.2	35.0
752-13791-4	MPCA-SAFF-111523-Post	62.1	67.8	91.3	81.3	82.7	64.0	39.8	41.9
752-13791-5	MPCA-SAFF-111523-Stock	63.2	65.5	107	82.6	70.2	175 *5+	147	122
752-13791-6	MPCA-SAFF-111623-PRE	56.8	80.2	96.2	78.2	71.6	62.3	35.8	38.3
752-13791-7	MPCA-SAFF-111623-OP1	51.9	63.2	84.4	79.3	72.5	61.9	33.8	34.1
752-13791-8	MPCA-SAFF-111623-OP2	65.9	70.5	95.9	81.8	74.0	72.1	34.8	36.0
752-13791-9	MPCA-SAFF-111623-Post	68.6	86.3	98.8	84.5	67.3	64.1	31.6	33.1
LCS 680-809669/2-A	Lab Control Sample	58.3	60.7	90.7	69.6	67.9	64.4	55.7	58.6
LCS 680-813392/2-A	Lab Control Sample	84.2	70.3	95.9	81.3	90.7	79.6	81.6	79.8
LCSD 680-809669/3-A	Lab Control Sample Dup	62.8	58.6	92.6	73.1	68.8	60.1	57.4	56.2
LCSD 680-813392/3-A	Lab Control Sample Dup	92.0	79.7	104	84.8	91.2	81.8	86.1	83.6
LLCS 680-809669/4-A	Lab Control Sample	57.2	63.8	85.1	70.0	71.2	63.6	56.9	58.6
LLCS 680-813392/4-A	Lab Control Sample	89.2	73.1	100	84.9	87.9	80.9	85.9	82.5
MB 680-809669/1-A	Method Blank	52.9	56.3	77.9	64.3	67.2	60.1	49.1	51.6
		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	M242FTS (25-200)	M262FTS (25-200)	M282FTS (25-200)	HFPODA (25-160)	NMFM (10-150)	NEFM (10-150)	d5NPFSA (10-130)	d3NMFSA (10-130)
752-13791-1	MPCA-SAFF-111523-PRE	24.1 *5-	31.3	32.1	85.2	58.1	106	62.9	66.7
752-13791-2	MPCA-SAFF-111523-OP1	22.2 *5-	28.6	30.8	74.5	52.2	97.6	53.0	65.1
752-13791-3	MPCA-SAFF-111523-OP2	21.7 *5-	26.5	26.7	90.7	51.4	94.8	51.0	59.0
752-13791-4	MPCA-SAFF-111523-Post	25.0	31.8	33.6	87.8	60.8	111	54.3	63.7
752-13791-5	MPCA-SAFF-111523-Stock	65.7	61.0	49.3	83.5	144	274 *5+	146 *5+	169 *5+
752-13791-6	MPCA-SAFF-111623-PRE	21.2 *5-	26.0	29.0	90.3	56.5	102	50.8	61.8
752-13791-7	MPCA-SAFF-111623-OP1	22.0 *5-	25.8	25.5	95.2	54.4	101	54.0	64.8
752-13791-8	MPCA-SAFF-111623-OP2	22.2 *5-	25.9	29.9	97.4	66.7	120	61.8	71.9
752-13791-9	MPCA-SAFF-111623-Post	23.6 *5-	26.1	24.7 *5-	108	58.6	108	58.5	66.8
LCS 680-809669/2-A	Lab Control Sample	57.1	52.3	49.5	78.8	56.5	102	50.2	58.6
LCS 680-813392/2-A	Lab Control Sample	97.7	96.6	84.4	78.8	60.1	118	62.5	65.8

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Isotope Dilution Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Matrix: Water

Prep Type: Total/NA

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	M242FTS (25-200)	M262FTS (25-200)	M282FTS (25-200)	HFPODA (25-160)	NMFM (10-150)	NEFM (10-150)	d5NPFSA (10-130)	d3NMFSA (10-130)
LCSD 680-809669/3-A	Lab Control Sample Dup	68.2	65.1	60.5	81.4	53.6	95.0	43.6	50.8
LCSD 680-813392/3-A	Lab Control Sample Dup	95.9	91.4	90.0	81.6	64.7	120	60.6	70.2
LLCS 680-809669/4-A	Lab Control Sample	60.4	60.0	53.7	77.0	52.7	91.3	47.5	53.7
LLCS 680-813392/4-A	Lab Control Sample	114	96.6	92.9	91.7	60.5	120	59.3	67.3
MB 680-809669/1-A	Method Blank	49.4	47.8	41.5	74.5	53.3	92.6	50.9	52.1
Surrogate Legend									
PFBA = 13C4 PFBA									
PFPeA = 13C5 PFPeA									
13C5PHA = 13C5 PFHxA									
C4PFHA = 13C4 PFHpA									
C8PFOA = 13C8 PFOA									
C9PFNA = 13C9 PFNA									
C6PFDA = 13C6 PFDA									
13C7PUA = 13C7 PFUnA									
PFDaA = 13C2 PFDaA									
PFTDA = 13C2 PFTeDA									
C3PFBS = 13C3 PFBS									
C3PFHS = 13C3 PFHxS									
C8PFOS = 13C8 PFOS									
PFOSA = 13C8 FOSA									
d3NMFOS = d3-NMeFOSAA									
d5NEFOS = d5-NEtFOSAA									
M242FTS = M2-4:2 FTS									
M262FTS = M2-6:2 FTS									
M282FTS = M2-8:2 FTS									
HFPODA = 13C3 HFPO-DA									
NMFM = d7-N-MeFOSE-M									
NEFM = d9-N-EtFOSE-M									
d5NPFSA = d5-NEtPFOSA									
d3NMFSA = d3-NMePFOSA									

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Matrix: Water

Prep Type: Total/NA

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFBA (25-130)	PFPeA (40-130)	13C5PHA (40-130)	C4PFHA (40-130)	C8PFOA (40-130)	C9PFNA (40-130)	C6PFDA (40-130)	13C7PUA (30-130)
752-13791-5 - DL	MPCA-SAFF-111523-Stock	98.1	75.8	83.3	76.3	71.8	75.2	67.4	77.4
MB 680-813392/1-A	Method Blank	99.6	70.3	81.0	72.5	75.9	79.6	79.2	86.0
		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFDaA (10-130)	PFTDA (10-130)	C3PFBS (40-135)	C3PFHS (40-130)	C8PFOS (40-130)	PFOSA (40-130)	d3NMFOS (40-170)	d5NEFOS (25-135)
752-13791-5 - DL	MPCA-SAFF-111523-Stock	63.6	36.4	78.7	68.4	58.5	53.9	57.2	49.8
MB 680-813392/1-A	Method Blank	82.5	61.5	98.2	79.9	80.8	77.7	76.9	74.9
		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	M242FTS (40-200)	M262FTS (40-200)	M282FTS (40-300)	HFPODA (40-130)	NMFM (10-130)	NEFM (10-130)	d5NPFSA (10-130)	d3NMFSA (10-130)
752-13791-5 - DL	MPCA-SAFF-111523-Stock	102	84.8	81.9	77.9	42.2	66.6	34.5	40.0
MB 680-813392/1-A	Method Blank	104	96.6	100	79.4	58.3	106	57.3	60.6

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Isotope Dilution Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Surrogate Legend

PFBA = 13C4 PFBA
PFPeA = 13C5 PFPeA
13C5PHA = 13C5 PFHxA
C4PFHA = 13C4 PFHpA
C8PFOA = 13C8 PFOA
C9PFNA = 13C9 PFNA
C6PFDA = 13C6 PFDA
13C7PUA = 13C7 PFUnA
PFDaA = 13C2 PFDaA
PFTDA = 13C2 PFTeDA
C3PFBS = 13C3 PFBS
C3PFHS = 13C3 PFHxS
C8PFOS = 13C8 PFOS
PFOSA = 13C8 FOSA
d3NMFOS = d3-NMeFOSAA
d5NEFOS = d5-NEtFOSAA
M242FTS = M2-4:2 FTS
M262FTS = M2-6:2 FTS
M282FTS = M2-8:2 FTS
HFPODA = 13C3 HFPO-DA
NMFM = d7-N-MeFOSE-M
NEFM = d9-N-EtFOSE-M
d5NPFSA = d5-NEtPFOSA
d3NMFSA = d3-NMePFOSA

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS

Lab Sample ID: MB 680-809669/1-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 809669

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		20.0	2.40	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoropentanoic acid (PFPeA)	ND		3.20	1.60	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorohexanoic acid (PFHxA)	ND		1.50	0.780	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoroheptanoic acid (PFHpA)	ND		1.70	0.660	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorooctanoic acid (PFOA)	ND		1.80	1.40	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorononanoic acid (PFNA)	ND		1.50	0.840	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorodecanoic acid (PFDA)	ND		1.60	0.510	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoroundecanoic acid (PFUnA)	ND		1.90	0.610	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorododecanoic acid (PFDoA)	ND		1.50	0.720	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorotridecanoic acid (PFTriDA)	ND		1.70	0.910	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorotetradecanoic acid (PFTA)	ND		1.60	0.600	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.20	0.500	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.40	0.960	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.40	0.990	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.40	1.20	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.30	0.890	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorononanesulfonic acid (PFNS)	ND		1.40	0.990	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.50	1.30	ng/L		11/22/23 10:18	11/29/23 20:11	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		6.20	1.20	ng/L		11/22/23 10:18	11/29/23 20:11	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		5.90	1.40	ng/L		11/22/23 10:18	11/29/23 20:11	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		6.50	2.50	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.50	0.560	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.60	0.550	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND		1.60	0.710	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.70	0.820	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.30	0.910	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND		41.0	5.80	ng/L		11/22/23 10:18	11/29/23 20:11	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND		7.20	3.60	ng/L		11/22/23 10:18	11/29/23 20:11	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		6.40	2.60	ng/L		11/22/23 10:18	11/29/23 20:11	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		5.60	1.70	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		3.20	1.30	ng/L		11/22/23 10:18	11/29/23 20:11	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		3.30	3.10	ng/L		11/22/23 10:18	11/29/23 20:11	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9CI-PF3ONS)	ND		5.80	2.00	ng/L		11/22/23 10:18	11/29/23 20:11	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)	ND		6.10	2.40	ng/L		11/22/23 10:18	11/29/23 20:11	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: MB 680-809669/1-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 809669

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluoro (2-ethoxyethane) sulfonic acid (PFEEA)	ND		2.70	0.560	ng/L		11/22/23 10:18	11/29/23 20:11	1
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		40.0	3.60	ng/L		11/22/23 10:18	11/29/23 20:11	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		41.0	13.0	ng/L		11/22/23 10:18	11/29/23 20:11	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		40.0	16.0	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.30	1.10	ng/L		11/22/23 10:18	11/29/23 20:11	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		3.10	1.40	ng/L		11/22/23 10:18	11/29/23 20:11	1

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	72.9		10 - 130	11/22/23 10:18	11/29/23 20:11	1
13C5 PFPeA	69.6		40 - 150	11/22/23 10:18	11/29/23 20:11	1
13C5 PFHxA	69.1		40 - 150	11/22/23 10:18	11/29/23 20:11	1
13C4 PFHpA	68.3		40 - 150	11/22/23 10:18	11/29/23 20:11	1
13C8 PFOA	62.9		30 - 140	11/22/23 10:18	11/29/23 20:11	1
13C9 PFNA	69.0		30 - 140	11/22/23 10:18	11/29/23 20:11	1
13C6 PFDA	75.3		20 - 140	11/22/23 10:18	11/29/23 20:11	1
13C7 PFUnA	67.2		20 - 140	11/22/23 10:18	11/29/23 20:11	1
13C2 PFDoA	52.9		10 - 150	11/22/23 10:18	11/29/23 20:11	1
13C2 PFTeDA	56.3		10 - 130	11/22/23 10:18	11/29/23 20:11	1
13C3 PFBS	77.9		25 - 150	11/22/23 10:18	11/29/23 20:11	1
13C3 PFHxS	64.3		25 - 150	11/22/23 10:18	11/29/23 20:11	1
13C8 PFOS	67.2		20 - 140	11/22/23 10:18	11/29/23 20:11	1
13C8 FOSA	60.1		10 - 130	11/22/23 10:18	11/29/23 20:11	1
d3-NMeFOSAA	49.1		10 - 200	11/22/23 10:18	11/29/23 20:11	1
d5-NEtFOSAA	51.6		10 - 200	11/22/23 10:18	11/29/23 20:11	1
M2-4:2 FTS	49.4		25 - 200	11/22/23 10:18	11/29/23 20:11	1
M2-6:2 FTS	47.8		25 - 200	11/22/23 10:18	11/29/23 20:11	1
M2-8:2 FTS	41.5		25 - 200	11/22/23 10:18	11/29/23 20:11	1
13C3 HFPO-DA	74.5		25 - 160	11/22/23 10:18	11/29/23 20:11	1
d7-N-MeFOSE-M	53.3		10 - 150	11/22/23 10:18	11/29/23 20:11	1
d9-N-EtFOSE-M	92.6		10 - 150	11/22/23 10:18	11/29/23 20:11	1
d5-NEtPFOSA	50.9		10 - 130	11/22/23 10:18	11/29/23 20:11	1
d3-NMePFOSA	52.1		10 - 130	11/22/23 10:18	11/29/23 20:11	1

Lab Sample ID: LCS 680-809669/2-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorobutanoic acid (PFBA)	128	124.8		ng/L		98	58 - 148
Perfluoropentanoic acid (PFPeA)	64.0	56.03		ng/L		88	54 - 152
Perfluorohexanoic acid (PFHxA)	32.0	31.03		ng/L		97	55 - 152
Perfluoroheptanoic acid (PFHpA)	32.0	30.18		ng/L		94	54 - 154
Perfluorooctanoic acid (PFOA)	32.0	27.86		ng/L		87	52 - 161
Perfluorononanoic acid (PFNA)	32.0	22.25		ng/L		70	59 - 149
Perfluorodecanoic acid (PFDA)	32.0	26.89		ng/L		84	52 - 147

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCS 680-809669/2-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluoroundecanoic acid (PFUnA)	32.0	24.44		ng/L		76	48 - 159
Perfluorododecanoic acid (PFDoA)	32.0	30.47		ng/L		95	64 - 142
Perfluorotridecanoic acid (PFTrDA)	32.0	30.43		ng/L		95	49 - 148
Perfluorotetradecanoic acid (PFTA)	32.0	28.19		ng/L		88	47 - 161
Perfluorobutanesulfonic acid (PFBS)	28.4	21.35		ng/L		75	62 - 144
Perfluoropentanesulfonic acid (PFPeS)	30.0	29.92		ng/L		100	59 - 151
Perfluorohexanesulfonic acid (PFHxS)	29.2	26.59		ng/L		91	57 - 146
Perfluoroheptanesulfonic acid (PFHpS)	30.5	29.49		ng/L		97	55 - 152
Perfluorooctanesulfonic acid (PFOS)	29.8	29.93		ng/L		101	58 - 149
Perfluorononanesulfonic acid (PFNS)	30.7	28.06		ng/L		91	52 - 148
Perfluorododecanesulfonic acid (PFDoS)	31.0	16.51		ng/L		53	36 - 145
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	120	106.8		ng/L		89	67 - 146
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	122	117.4		ng/L		96	61 - 151
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	123	105.7		ng/L		86	63 - 152
Perfluorooctanesulfonamide (PFOSA)	32.0	32.46		ng/L		101	61 - 148
N-methylperfluorooctane sulfonamide (NMeFOSA)	32.0	29.26		ng/L		91	63 - 145
N-ethylperfluorooctane sulfonamide (NEtFOSA)	32.0	22.47		ng/L		70	65 - 139
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	32.0	27.35		ng/L		85	58 - 144
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	32.0	27.30		ng/L		85	59 - 146
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	320	254.7		ng/L		80	71 - 136
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	320	218.2	*-	ng/L		68	69 - 137
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	128	115.0		ng/L		90	63 - 144
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	121	107.4		ng/L		89	68 - 146
Perfluoro-4-methoxybutanoic acid (PFMBA)	64.0	55.33		ng/L		86	55 - 148
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	64.0	57.13		ng/L		89	48 - 161
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9Cl-PF3ONS)	120	103.1		ng/L		86	51 - 156
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	121	86.41		ng/L		72	46 - 156

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCS 680-809669/2-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	57.0	46.13		ng/L		81	56 - 151
3-Perfluoropropylpropanoic acid (3:3 FTCA)	160	147.0		ng/L		92	62 - 129
3-Perfluoropentylpropanoic acid (5:3 FTCA)	799	745.2		ng/L		93	63 - 134
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	799	561.4		ng/L		70	50 - 138
Perfluorodecanesulfonic acid (PFDS)	30.8	27.34		ng/L		89	51 - 147
Perfluoro-3-methoxypropanoic acid (PFMPA)	64.0	57.93		ng/L		91	51 - 145

Isotope Dilution	LCS %Recovery	LCS Qualifier	Limits
13C4 PFBA	79.5		10 - 130
13C5 PFPeA	77.5		40 - 150
13C5 PFHxA	79.1		40 - 150
13C4 PFHpA	75.2		40 - 150
13C8 PFOA	71.8		30 - 140
13C9 PFNA	75.8		30 - 140
13C6 PFDA	79.2		20 - 140
13C7 PFUnA	75.0		20 - 140
13C2 PFDoA	58.3		10 - 150
13C2 PFTeDA	60.7		10 - 130
13C3 PFBS	90.7		25 - 150
13C3 PFHxS	69.6		25 - 150
13C8 PFOS	67.9		20 - 140
13C8 FOSA	64.4		10 - 130
d3-NMeFOSAA	55.7		10 - 200
d5-NEtFOSAA	58.6		10 - 200
M2-4:2 FTS	57.1		25 - 200
M2-6:2 FTS	52.3		25 - 200
M2-8:2 FTS	49.5		25 - 200
13C3 HFPO-DA	78.8		25 - 160
d7-N-MeFOSE-M	56.5		10 - 150
d9-N-EtFOSE-M	102		10 - 150
d5-NEtPFOSA	50.2		10 - 130
d3-NMePFOSA	58.6		10 - 130

Lab Sample ID: LCSD 680-809669/3-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorobutanoic acid (PFBA)	128	102.6		ng/L		80	58 - 148	20	30
Perfluoropentanoic acid (PFPeA)	64.0	49.37		ng/L		77	54 - 152	13	30
Perfluorohexanoic acid (PFHxA)	32.0	26.23		ng/L		82	55 - 152	17	30
Perfluoroheptanoic acid (PFHpA)	32.0	27.43		ng/L		86	54 - 154	10	30
Perfluorooctanoic acid (PFOA)	32.0	26.29		ng/L		82	52 - 161	6	30
Perfluorononanoic acid (PFNA)	32.0	19.49		ng/L		61	59 - 149	13	30

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCSD 680-809669/3-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorodecanoic acid (PFDA)	32.0	22.51		ng/L		70	52 - 147	18	30
Perfluoroundecanoic acid (PFUnA)	32.0	21.23		ng/L		66	48 - 159	14	30
Perfluorododecanoic acid (PFDoA)	32.0	27.42		ng/L		86	64 - 142	11	30
Perfluorotridecanoic acid (PFTrDA)	32.0	29.47		ng/L		92	49 - 148	3	30
Perfluorotetradecanoic acid (PFTA)	32.0	25.94		ng/L		81	47 - 161	8	30
Perfluorobutanesulfonic acid (PFBS)	28.4	19.88		ng/L		70	62 - 144	7	30
Perfluoropentanesulfonic acid (PFPeS)	30.0	25.20		ng/L		84	59 - 151	17	30
Perfluorohexanesulfonic acid (PFHxS)	29.2	22.20		ng/L		76	57 - 146	18	30
Perfluoroheptanesulfonic acid (PFHpS)	30.5	26.05		ng/L		85	55 - 152	12	30
Perfluorooctanesulfonic acid (PFOS)	29.8	25.09		ng/L		84	58 - 149	18	30
Perfluorononanesulfonic acid (PFNS)	30.7	25.19		ng/L		82	52 - 148	11	30
Perfluorododecanesulfonic acid (PFDoS)	31.0	13.45		ng/L		43	36 - 145	20	30
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	120	98.94		ng/L		82	67 - 146	8	30
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	122	97.46		ng/L		80	61 - 151	19	30
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	123	91.40		ng/L		74	63 - 152	14	30
Perfluorooctanesulfonamide (PFOSA)	32.0	28.79		ng/L		90	61 - 148	12	30
N-methylperfluorooctane sulfonamide (NMeFOSA)	32.0	24.98		ng/L		78	63 - 145	16	30
N-ethylperfluorooctane sulfonamide (NEtFOSA)	32.0	18.79	*-	ng/L		59	65 - 139	18	30
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	32.0	22.85		ng/L		71	58 - 144	18	30
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	32.0	23.31		ng/L		73	59 - 146	16	30
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	320	211.7	*-	ng/L		66	71 - 136	18	30
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	320	180.3	*-	ng/L		56	69 - 137	19	30
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	128	105.2		ng/L		82	63 - 144	9	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	121	92.51	I	ng/L		77	68 - 146	15	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	64.0	48.84		ng/L		76	55 - 148	12	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	64.0	51.39		ng/L		80	48 - 161	11	30
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9CI-PF3ONS)	120	87.52		ng/L		73	51 - 156	16	30

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCSD 680-809669/3-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	121	80.93		ng/L		67	46 - 156	7	30
Perfluoro (2-ethoxyethane) sulfonic acid (PFEEA)	57.0	40.47		ng/L		71	56 - 151	13	30
3-Perfluoropropylpropanoic acid (3:3 FTCA)	160	132.7		ng/L		83	62 - 129	10	30
3-Perfluoropentylpropanoic acid (5:3 FTCA)	799	634.4		ng/L		79	63 - 134	16	30
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	799	493.5		ng/L		62	50 - 138	13	30
Perfluorodecanesulfonic acid (PFDS)	30.8	22.54		ng/L		73	51 - 147	19	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	64.0	52.91		ng/L		83	51 - 145	9	30

Isotope Dilution	LCSD %Recovery	LCSD Qualifier	Limits
13C4 PFBA	80.7		10 - 130
13C5 PFPeA	78.0		40 - 150
13C5 PFHxA	82.1		40 - 150
13C4 PFHpA	81.0		40 - 150
13C8 PFOA	63.5		30 - 140
13C9 PFNA	75.4		30 - 140
13C6 PFDA	83.2		20 - 140
13C7 PFUnA	78.0		20 - 140
13C2 PFDoA	62.8		10 - 150
13C2 PFTeDA	58.6		10 - 130
13C3 PFBS	92.6		25 - 150
13C3 PFHxS	73.1		25 - 150
13C8 PFOS	68.8		20 - 140
13C8 FOSA	60.1		10 - 130
d3-NMeFOSAA	57.4		10 - 200
d5-NEtFOSAA	56.2		10 - 200
M2-4:2 FTS	68.2		25 - 200
M2-6:2 FTS	65.1		25 - 200
M2-8:2 FTS	60.5		25 - 200
13C3 HFPO-DA	81.4		25 - 160
d7-N-MeFOSE-M	53.6		10 - 150
d9-N-EtFOSE-M	95.0		10 - 150
d5-NEtPFOSA	43.6		10 - 130
d3-NMePFOSA	50.8		10 - 130

Lab Sample ID: LLCS 680-809669/4-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorobutanoic acid (PFBA)	12.8	8.810	J	ng/L		69	44 - 157
Perfluoropentanoic acid (PFPeA)	6.40	4.321		ng/L		68	57 - 148
Perfluorohexanoic acid (PFHxA)	3.20	2.571		ng/L		80	62 - 149
Perfluoroheptanoic acid (PFHpA)	3.20	2.519		ng/L		79	56 - 150

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LLCS 680-809669/4-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorooctanoic acid (PFOA)	3.20	2.410		ng/L		75	57 - 161
Perfluorononanoic acid (PFNA)	3.20	1.578	*-	ng/L		49	53 - 157
Perfluorodecanoic acid (PFDA)	3.20	1.903		ng/L		59	43 - 158
Perfluoroundecanoic acid (PFUnA)	3.20	1.985		ng/L		62	50 - 155
Perfluorododecanoic acid (PFDoA)	3.20	2.496		ng/L		78	60 - 141
Perfluorotridecanoic acid (PFTrDA)	3.20	2.170		ng/L		68	52 - 140
Perfluorotetradecanoic acid (PFTA)	3.20	2.375		ng/L		74	52 - 156
Perfluorobutanesulfonic acid (PFBS)	2.84	1.787		ng/L		63	63 - 145
Perfluoropentanesulfonic acid (PFPeS)	3.00	2.458		ng/L		82	58 - 144
Perfluorohexanesulfonic acid (PFHxS)	2.92	1.691		ng/L		58	44 - 158
Perfluoroheptanesulfonic acid (PFHpS)	3.05	2.792		ng/L		91	51 - 150
Perfluorooctanesulfonic acid (PFOS)	2.98	1.539		ng/L		52	43 - 162
Perfluorononanesulfonic acid (PFNS)	3.07	1.882		ng/L		61	46 - 151
Perfluorododecanesulfonic acid (PFDoS)	3.10	1.518	I	ng/L		49	30 - 138
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	12.0	10.89		ng/L		91	52 - 158
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	12.2	10.28		ng/L		84	48 - 158
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	12.3	8.687		ng/L		71	46 - 165
Perfluorooctanesulfonamide (PFOSA)	3.20	2.379		ng/L		74	47 - 163
N-methylperfluorooctane sulfonamide (NMeFOSA)	3.20	2.409		ng/L		75	54 - 155
N-ethylperfluorooctane sulfonamide (NEtFOSA)	3.20	1.770		ng/L		55	49 - 156
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	3.20	1.609	J	ng/L		50	32 - 160
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	3.20	1.947		ng/L		61	51 - 154
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	32.0	20.37	J	ng/L		64	56 - 151
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	32.0	17.38	*-	ng/L		54	60 - 147
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	12.8	9.567		ng/L		75	58 - 154
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	12.1	7.752		ng/L		64	61 - 148
Perfluoro-4-methoxybutanoic acid (PFMBA)	6.40	4.359		ng/L		68	49 - 154
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	6.40	4.791		ng/L		75	47 - 160

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LLCS 680-809669/4-A

Matrix: Water

Analysis Batch: 810043

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 809669

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
9-Chlorohexadecafluoro-3-oxan onane-1-sulfonic acid(9Cl-PF3ONS)	12.0	7.571	I	ng/L		63	44 - 167
11-Chloroeicosafluoro-3-oxaund ecane-1-sulfonic acid (11Cl-PF3OUdS)	12.1	7.198		ng/L		60	36 - 158
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	5.70	3.668		ng/L		64	56 - 144
3-Perfluoropropylpropanoic acid (3:3 FTCA)	16.0	10.57	J	ng/L		66	32 - 161
3-Perfluoropentylpropanoic acid (5:3 FTCA)	79.9	63.86		ng/L		80	39 - 156
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	79.9	44.58		ng/L		56	36 - 149
Perfluorodecanesulfonic acid (PFDS)	3.08	2.000		ng/L		65	50 - 144
Perfluoro-3-methoxypropanoic acid (PFMPA)	6.40	4.306		ng/L		67	48 - 150

Isotope Dilution	LLCS %Recovery	LLCS Qualifier	Limits
13C4 PFBA	78.4		10 - 130
13C5 PFPeA	78.4		40 - 150
13C5 PFHxA	73.8		40 - 150
13C4 PFHpA	76.6		40 - 150
13C8 PFOA	66.4		30 - 140
13C9 PFNA	76.5		30 - 140
13C6 PFDA	84.3		20 - 140
13C7 PFUnA	73.1		20 - 140
13C2 PFDoA	57.2		10 - 150
13C2 PFTeDA	63.8		10 - 130
13C3 PFBS	85.1		25 - 150
13C3 PFHxS	70.0		25 - 150
13C8 PFOS	71.2		20 - 140
13C8 FOSA	63.6		10 - 130
d3-NMeFOSAA	56.9		10 - 200
d5-NEtFOSAA	58.6		10 - 200
M2-4:2 FTS	60.4		25 - 200
M2-6:2 FTS	60.0		25 - 200
M2-8:2 FTS	53.7		25 - 200
13C3 HFPO-DA	77.0		25 - 160
d7-N-MeFOSE-M	52.7		10 - 150
d9-N-EtFOSE-M	91.3		10 - 150
d5-NEtPFOSA	47.5		10 - 130
d3-NMePFOSA	53.7		10 - 130

Lab Sample ID: MB 680-813392/1-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 813392

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		20.0	2.40	ng/L		12/14/23 10:48	12/14/23 15:28	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: MB 680-813392/1-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 813392

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluoropentanoic acid (PFPeA)	ND		3.20	1.60	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorohexanoic acid (PFHxA)	ND		1.50	0.780	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoroheptanoic acid (PFHpA)	ND		1.70	0.660	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorooctanoic acid (PFOA)	ND		1.80	1.40	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorononanoic acid (PFNA)	ND		1.50	0.840	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorodecanoic acid (PFDA)	ND		1.60	0.510	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoroundecanoic acid (PFUnA)	ND		1.90	0.610	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorododecanoic acid (PFDoA)	ND		1.50	0.720	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorotridecanoic acid (PFTTrDA)	ND		1.70	0.910	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorotetradecanoic acid (PFTA)	ND		1.60	0.600	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.20	0.500	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoropentanesulfonic acid (PFPeS)	ND		1.40	0.960	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorohexanesulfonic acid (PFHxS)	ND		1.40	0.990	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoroheptanesulfonic acid (PFHpS)	ND		1.40	1.20	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorooctanesulfonic acid (PFOS)	ND		1.30	0.890	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorononanesulfonic acid (PFNS)	ND		1.40	0.990	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorododecanesulfonic acid (PFDoS)	ND		1.50	1.30	ng/L		12/14/23 10:48	12/14/23 15:28	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	ND		6.20	1.20	ng/L		12/14/23 10:48	12/14/23 15:28	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	ND		5.90	1.40	ng/L		12/14/23 10:48	12/14/23 15:28	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	ND		6.50	2.50	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorooctanesulfonamide (PFOSA)	ND		1.50	0.560	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-methylperfluorooctane sulfonamide (NMeFOSA)	ND		1.60	0.550	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-ethylperfluorooctane sulfonamide (NEtFOSA)	ND		1.60	0.710	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND		1.70	0.820	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND		1.30	0.910	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	ND		41.0	5.80	ng/L		12/14/23 10:48	12/14/23 15:28	1
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	ND		7.20	3.60	ng/L		12/14/23 10:48	12/14/23 15:28	1
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	ND		6.40	2.60	ng/L		12/14/23 10:48	12/14/23 15:28	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		5.60	1.70	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND		3.20	1.30	ng/L		12/14/23 10:48	12/14/23 15:28	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND		3.30	3.10	ng/L		12/14/23 10:48	12/14/23 15:28	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)	ND		5.80	2.00	ng/L		12/14/23 10:48	12/14/23 15:28	1
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)	ND		6.10	2.40	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ND		2.70	0.560	ng/L		12/14/23 10:48	12/14/23 15:28	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: MB 680-813392/1-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 813392

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ND		40.0	3.60	ng/L		12/14/23 10:48	12/14/23 15:28	1
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ND		41.0	13.0	ng/L		12/14/23 10:48	12/14/23 15:28	1
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ND		40.0	16.0	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.30	1.10	ng/L		12/14/23 10:48	12/14/23 15:28	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND		3.10	1.40	ng/L		12/14/23 10:48	12/14/23 15:28	1

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFBA	99.6		25 - 130	12/14/23 10:48	12/14/23 15:28	1
13C5 PFPeA	70.3		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C5 PFHxA	81.0		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C4 PFHpA	72.5		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C8 PFOA	75.9		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C9 PFNA	79.6		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C6 PFDA	79.2		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C7 PFUnA	86.0		30 - 130	12/14/23 10:48	12/14/23 15:28	1
13C2 PFDoA	82.5		10 - 130	12/14/23 10:48	12/14/23 15:28	1
13C2 PFTeDA	61.5		10 - 130	12/14/23 10:48	12/14/23 15:28	1
13C3 PFBS	98.2		40 - 135	12/14/23 10:48	12/14/23 15:28	1
13C3 PFHxS	79.9		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C8 PFOS	80.8		40 - 130	12/14/23 10:48	12/14/23 15:28	1
13C8 FOSA	77.7		40 - 130	12/14/23 10:48	12/14/23 15:28	1
d3-NMeFOSAA	76.9		40 - 170	12/14/23 10:48	12/14/23 15:28	1
d5-NEtFOSAA	74.9		25 - 135	12/14/23 10:48	12/14/23 15:28	1
M2-4:2 FTS	104		40 - 200	12/14/23 10:48	12/14/23 15:28	1
M2-6:2 FTS	96.6		40 - 200	12/14/23 10:48	12/14/23 15:28	1
M2-8:2 FTS	100		40 - 300	12/14/23 10:48	12/14/23 15:28	1
13C3 HFPO-DA	79.4		40 - 130	12/14/23 10:48	12/14/23 15:28	1
d7-N-MeFOSE-M	58.3		10 - 130	12/14/23 10:48	12/14/23 15:28	1
d9-N-EtFOSE-M	106		10 - 130	12/14/23 10:48	12/14/23 15:28	1
d5-NEtPFOSA	57.3		10 - 130	12/14/23 10:48	12/14/23 15:28	1
d3-NMePFOSA	60.6		10 - 130	12/14/23 10:48	12/14/23 15:28	1

Lab Sample ID: LCS 680-813392/2-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorobutanoic acid (PFBA)	128	124.6		ng/L		97	58 - 148
Perfluoropentanoic acid (PFPeA)	64.0	69.35		ng/L		108	54 - 152
Perfluorohexanoic acid (PFHxA)	32.0	37.40		ng/L		117	55 - 152
Perfluoroheptanoic acid (PFHpA)	32.0	41.64		ng/L		130	54 - 154
Perfluorooctanoic acid (PFOA)	32.0	34.47		ng/L		108	52 - 161
Perfluorononanoic acid (PFNA)	32.0	27.55		ng/L		86	59 - 149
Perfluorodecanoic acid (PFDA)	32.0	36.52		ng/L		114	52 - 147
Perfluoroundecanoic acid (PFUnA)	32.0	30.28		ng/L		95	48 - 159

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCS 680-813392/2-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorododecanoic acid (PFDoA)	32.0	35.55		ng/L		111	64 - 142
Perfluorotridecanoic acid (PFTTrDA)	32.0	51.33	*+	ng/L		160	49 - 148
Perfluorotetradecanoic acid (PFTA)	32.0	37.72		ng/L		118	47 - 161
Perfluorobutanesulfonic acid (PFBS)	28.4	29.53		ng/L		104	62 - 144
Perfluoropentanesulfonic acid (PFPeS)	30.0	37.41		ng/L		125	59 - 151
Perfluorohexanesulfonic acid (PFHxS)	29.2	31.22		ng/L		107	57 - 146
Perfluoroheptanesulfonic acid (PFHpS)	30.5	33.28		ng/L		109	55 - 152
Perfluorooctanesulfonic acid (PFOS)	29.8	28.59		ng/L		96	58 - 149
Perfluorononanesulfonic acid (PFNS)	30.7	31.33		ng/L		102	52 - 148
Perfluorododecanesulfonic acid (PFDoS)	31.0	24.15		ng/L		78	36 - 145
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	120	129.5		ng/L		108	67 - 146
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	122	134.6		ng/L		110	61 - 151
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	123	134.7		ng/L		110	63 - 152
Perfluorooctanesulfonamide (PFOSA)	32.0	42.68		ng/L		133	61 - 148
N-methylperfluorooctane sulfonamide (NMeFOSA)	32.0	32.42		ng/L		101	63 - 145
N-ethylperfluorooctane sulfonamide (NEtFOSA)	32.0	25.70		ng/L		80	65 - 139
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	32.0	33.71		ng/L		105	58 - 144
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	32.0	33.24		ng/L		104	59 - 146
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	320	340.0		ng/L		106	71 - 136
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	320	260.8		ng/L		82	69 - 137
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	128	129.2		ng/L		101	63 - 144
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	121	141.4		ng/L		117	68 - 146
Perfluoro-4-methoxybutanoic acid (PFMBA)	64.0	70.78		ng/L		111	55 - 148
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	64.0	73.61		ng/L		115	48 - 161
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9Cl-PF3ONS)	120	128.2		ng/L		107	51 - 156
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	121	120.5		ng/L		100	46 - 156
Perfluoro (2-ethoxyethane) sulfonic acid (PFEEESA)	57.0	57.84		ng/L		102	56 - 151

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCS 680-813392/2-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
3-Perfluoropropylpropanoic acid (3:3 FTCA)	160	189.4		ng/L		119	62 - 129
3-Perfluoropentylpropanoic acid (5:3 FTCA)	799	885.1		ng/L		111	63 - 134
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	799	736.7		ng/L		92	50 - 138
Perfluorodecanesulfonic acid (PFDS)	30.8	30.60		ng/L		99	51 - 147
Perfluoro-3-methoxypropanoic acid (PFMPA)	64.0	75.77		ng/L		118	51 - 145

Isotope Dilution	LCS %Recovery	LCS Qualifier	Limits
13C4 PFBA	104		10 - 130
13C5 PFPeA	75.5		40 - 150
13C5 PFHxA	82.3		40 - 150
13C4 PFHpA	77.6		40 - 150
13C8 PFOA	80.7		30 - 140
13C9 PFNA	82.9		30 - 140
13C6 PFDA	80.4		20 - 140
13C7 PFUnA	88.6		20 - 140
13C2 PFDoA	84.2		10 - 150
13C2 PFTeDA	70.3		10 - 130
13C3 PFBS	95.9		25 - 150
13C3 PFHxS	81.3		25 - 150
13C8 PFOS	90.7		20 - 140
13C8 FOSA	79.6		10 - 130
d3-NMeFOSAA	81.6		10 - 200
d5-NEtFOSAA	79.8		10 - 200
M2-4:2 FTS	97.7		25 - 200
M2-6:2 FTS	96.6		25 - 200
M2-8:2 FTS	84.4		25 - 200
13C3 HFPO-DA	78.8		25 - 160
d7-N-MeFOSE-M	60.1		10 - 150
d9-N-EtFOSE-M	118		10 - 150
d5-NEtPFOSA	62.5		10 - 130
d3-NMePFOSA	65.8		10 - 130

Lab Sample ID: LCSD 680-813392/3-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorobutanoic acid (PFBA)	128	124.7		ng/L		97	58 - 148	0	30
Perfluoropentanoic acid (PFPeA)	64.0	71.71		ng/L		112	54 - 152	3	30
Perfluorohexanoic acid (PFHxA)	32.0	38.85		ng/L		121	55 - 152	4	30
Perfluoroheptanoic acid (PFHpA)	32.0	41.71		ng/L		130	54 - 154	0	30
Perfluorooctanoic acid (PFOA)	32.0	36.67		ng/L		115	52 - 161	6	30
Perfluorononanoic acid (PFNA)	32.0	29.82		ng/L		93	59 - 149	8	30
Perfluorodecanoic acid (PFDA)	32.0	38.43		ng/L		120	52 - 147	5	30

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCSD 680-813392/3-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluoroundecanoic acid (PFUnA)	32.0	33.94		ng/L		106	48 - 159	11	30
Perfluorododecanoic acid (PFDoA)	32.0	34.95		ng/L		109	64 - 142	2	30
Perfluorotridecanoic acid (PFTrDA)	32.0	47.97	*+	ng/L		150	49 - 148	7	30
Perfluorotetradecanoic acid (PFTA)	32.0	37.44		ng/L		117	47 - 161	1	30
Perfluorobutanesulfonic acid (PFBS)	28.4	28.17		ng/L		99	62 - 144	5	30
Perfluoropentanesulfonic acid (PFPeS)	30.0	38.56		ng/L		128	59 - 151	3	30
Perfluorohexanesulfonic acid (PFHxS)	29.2	31.20		ng/L		107	57 - 146	0	30
Perfluoroheptanesulfonic acid (PFHpS)	30.5	35.50		ng/L		116	55 - 152	6	30
Perfluorooctanesulfonic acid (PFOS)	29.8	32.27		ng/L		108	58 - 149	12	30
Perfluorononanesulfonic acid (PFNS)	30.7	33.50		ng/L		109	52 - 148	7	30
Perfluorododecanesulfonic acid (PFDoS)	31.0	23.76		ng/L		77	36 - 145	2	30
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	120	145.9		ng/L		121	67 - 146	12	30
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	122	144.6		ng/L		119	61 - 151	7	30
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	123	134.9		ng/L		110	63 - 152	0	30
Perfluorooctanesulfonamide (PFOSA)	32.0	46.17		ng/L		144	61 - 148	8	30
N-methylperfluorooctane sulfonamide (NMeFOSA)	32.0	34.30		ng/L		107	63 - 145	6	30
N-ethylperfluorooctane sulfonamide (NEtFOSA)	32.0	24.64		ng/L		77	65 - 139	4	30
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	32.0	33.24		ng/L		104	58 - 144	1	30
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	32.0	30.92		ng/L		97	59 - 146	7	30
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	320	304.7		ng/L		95	71 - 136	11	30
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	320	254.1		ng/L		79	69 - 137	3	30
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	128	147.4		ng/L		115	63 - 144	13	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	121	129.0		ng/L		107	68 - 146	9	30
Perfluoro-4-methoxybutanoic acid (PFMBA)	64.0	73.69		ng/L		115	55 - 148	4	30
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	64.0	73.36		ng/L		115	48 - 161	0	30
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	120	143.8		ng/L		120	51 - 156	11	30
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	121	134.8		ng/L		112	46 - 156	11	30

Eurofins Raleigh

QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LCSD 680-813392/3-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	57.0	57.91		ng/L		102	56 - 151	0	30
3-Perfluoropropylpropanoic acid (3:3 FTCA)	160	201.7		ng/L		126	62 - 129	6	30
3-Perfluoropentylpropanoic acid (5:3 FTCA)	799	900.3		ng/L		113	63 - 134	2	30
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	799	756.9		ng/L		95	50 - 138	3	30
Perfluorodecanesulfonic acid (PFDS)	30.8	33.42		ng/L		108	51 - 147	9	30
Perfluoro-3-methoxypropanoic acid (PFMPA)	64.0	79.05		ng/L		124	51 - 145	4	30

Isotope Dilution	LCSD %Recovery	LCSD Qualifier	Limits
13C4 PFBA	103		10 - 130
13C5 PFPeA	80.4		40 - 150
13C5 PFHxA	88.1		40 - 150
13C4 PFHpA	82.9		40 - 150
13C8 PFOA	86.7		30 - 140
13C9 PFNA	86.4		30 - 140
13C6 PFDA	82.8		20 - 140
13C7 PFUnA	93.1		20 - 140
13C2 PFDoA	92.0		10 - 150
13C2 PFTeDA	79.7		10 - 130
13C3 PFBS	104		25 - 150
13C3 PFHxS	84.8		25 - 150
13C8 PFOS	91.2		20 - 140
13C8 FOSA	81.8		10 - 130
d3-NMeFOSAA	86.1		10 - 200
d5-NEtFOSAA	83.6		10 - 200
M2-4:2 FTS	95.9		25 - 200
M2-6:2 FTS	91.4		25 - 200
M2-8:2 FTS	90.0		25 - 200
13C3 HFPO-DA	81.6		25 - 160
d7-N-MeFOSE-M	64.7		10 - 150
d9-N-EtFOSE-M	120		10 - 150
d5-NEtPFOSA	60.6		10 - 130
d3-NMePFOSA	70.2		10 - 130

Lab Sample ID: LLCS 680-813392/4-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorobutanoic acid (PFBA)	12.8	7.741	J	ng/L		60	44 - 157
Perfluoropentanoic acid (PFPeA)	6.40	6.224		ng/L		97	57 - 148
Perfluorohexanoic acid (PFHxA)	3.20	3.140		ng/L		98	62 - 149
Perfluoroheptanoic acid (PFHpA)	3.20	3.253		ng/L		102	56 - 150
Perfluorooctanoic acid (PFOA)	3.20	2.329		ng/L		73	57 - 161
Perfluorononanoic acid (PFNA)	3.20	2.350		ng/L		73	53 - 157

Eurofins Raleigh

QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LLCS 680-813392/4-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorodecanoic acid (PFDA)	3.20	2.605		ng/L		81	43 - 158
Perfluoroundecanoic acid (PFUnA)	3.20	2.620		ng/L		82	50 - 155
Perfluorododecanoic acid (PFDoA)	3.20	2.989		ng/L		93	60 - 141
Perfluorotridecanoic acid (PFTrDA)	3.20	4.257		ng/L		133	52 - 140
Perfluorotetradecanoic acid (PFTA)	3.20	3.006		ng/L		94	52 - 156
Perfluorobutanesulfonic acid (PFBS)	2.84	2.434		ng/L		86	63 - 145
Perfluoropentanesulfonic acid (PFPeS)	3.00	2.861		ng/L		95	58 - 144
Perfluorohexanesulfonic acid (PFHxS)	2.92	2.784		ng/L		95	44 - 158
Perfluoroheptanesulfonic acid (PFHpS)	3.05	2.854		ng/L		93	51 - 150
Perfluorooctanesulfonic acid (PFOS)	2.98	2.805		ng/L		94	43 - 162
Perfluorononanesulfonic acid (PFNS)	3.07	2.595		ng/L		84	46 - 151
Perfluorododecanesulfonic acid (PFDoS)	3.10	1.860		ng/L		60	30 - 138
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	12.0	12.33		ng/L		103	52 - 158
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	12.2	12.30		ng/L		101	48 - 158
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	12.3	10.89		ng/L		89	46 - 165
Perfluorooctanesulfonamide (PFOSA)	3.20	3.421		ng/L		107	47 - 163
N-methylperfluorooctane sulfonamide (NMeFOSA)	3.20	2.761		ng/L		86	54 - 155
N-ethylperfluorooctane sulfonamide (NEtFOSA)	3.20	2.136		ng/L		67	49 - 156
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	3.20	2.451		ng/L		77	32 - 160
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	3.20	2.391		ng/L		75	51 - 154
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	32.0	29.99	J	ng/L		94	56 - 151
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	32.0	20.61		ng/L		64	60 - 147
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	12.8	10.37		ng/L		81	58 - 154
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	12.1	11.92		ng/L		99	61 - 148
Perfluoro-4-methoxybutanoic acid (PFMBA)	6.40	6.178		ng/L		97	49 - 154
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	6.40	6.073		ng/L		95	47 - 160
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9CI-PF3ONS)	12.0	10.09		ng/L		84	44 - 167

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method: 1633 - Per- and Polyfluoroalkyl Substances by LC/MS/MS (Continued)

Lab Sample ID: LLCS 680-813392/4-A

Matrix: Water

Analysis Batch: 813506

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 813392

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	12.1	10.76		ng/L		89	36 - 158
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	5.70	4.072		ng/L		71	56 - 144
3-Perfluoropropylpropanoic acid (3:3 FTCA)	16.0	18.10	J	ng/L		113	32 - 161
3-Perfluoropentylpropanoic acid (5:3 FTCA)	79.9	80.97		ng/L		101	39 - 156
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	79.9	59.05		ng/L		74	36 - 149
Perfluorodecanesulfonic acid (PFDS)	3.08	2.693		ng/L		87	50 - 144
Perfluoro-3-methoxypropanoic acid (PFMPA)	6.40	6.803		ng/L		106	48 - 150

Isotope Dilution	LLCS %Recovery	LLCS Qualifier	LLCS Limits
13C4 PFBA	106		10 - 130
13C5 PFPeA	81.7		40 - 150
13C5 PFHxA	93.0		40 - 150
13C4 PFHpA	90.3		40 - 150
13C8 PFOA	71.9		30 - 140
13C9 PFNA	82.1		30 - 140
13C6 PFDA	79.6		20 - 140
13C7 PFUnA	90.9		20 - 140
13C2 PFDoA	89.2		10 - 150
13C2 PFTeDA	73.1		10 - 130
13C3 PFBS	100		25 - 150
13C3 PFHxS	84.9		25 - 150
13C8 PFOS	87.9		20 - 140
13C8 FOSA	80.9		10 - 130
d3-NMeFOSAA	85.9		10 - 200
d5-NEtFOSAA	82.5		10 - 200
M2-4:2 FTS	114		25 - 200
M2-6:2 FTS	96.6		25 - 200
M2-8:2 FTS	92.9		25 - 200
13C3 HFPO-DA	91.7		25 - 160
d7-N-MeFOSE-M	60.5		10 - 150
d9-N-EtFOSE-M	120		10 - 150
d5-NEtPFOSA	59.3		10 - 130
d3-NMePFOSA	67.3		10 - 130

QC Association Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

LCMS

Analysis Batch: 465807

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	Total PFCA-Sum	

Analysis Batch: 465809

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Post-Treatment	Water	Total PFCA-Sum	

Prep Batch: 809669

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-1	MPCA-SAFF-111523-PRE	Total/NA	Water	1633	
752-13791-2	MPCA-SAFF-111523-OP1	Total/NA	Water	1633	
752-13791-3	MPCA-SAFF-111523-OP2	Total/NA	Water	1633	
752-13791-4	MPCA-SAFF-111523-Post	Total/NA	Water	1633	
752-13791-5	MPCA-SAFF-111523-Stock	Total/NA	Water	1633	
752-13791-6	MPCA-SAFF-111623-PRE	Total/NA	Water	1633	
752-13791-7	MPCA-SAFF-111623-OP1	Total/NA	Water	1633	
752-13791-8	MPCA-SAFF-111623-OP2	Total/NA	Water	1633	
752-13791-9	MPCA-SAFF-111623-Post	Total/NA	Water	1633	
MB 680-809669/1-A	Method Blank	Total/NA	Water	1633	
LCS 680-809669/2-A	Lab Control Sample	Total/NA	Water	1633	
LCSD 680-809669/3-A	Lab Control Sample Dup	Total/NA	Water	1633	
LLCS 680-809669/4-A	Lab Control Sample	Total/NA	Water	1633	

Analysis Batch: 810043

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-1	MPCA-SAFF-111523-PRE	Total/NA	Water	1633	809669
752-13791-2	MPCA-SAFF-111523-OP1	Total/NA	Water	1633	809669
752-13791-3	MPCA-SAFF-111523-OP2	Total/NA	Water	1633	809669
752-13791-4	MPCA-SAFF-111523-Post	Total/NA	Water	1633	809669
752-13791-5	MPCA-SAFF-111523-Stock	Total/NA	Water	1633	809669
752-13791-6	MPCA-SAFF-111623-PRE	Total/NA	Water	1633	809669
752-13791-7	MPCA-SAFF-111623-OP1	Total/NA	Water	1633	809669
752-13791-8	MPCA-SAFF-111623-OP2	Total/NA	Water	1633	809669
752-13791-9	MPCA-SAFF-111623-Post	Total/NA	Water	1633	809669
MB 680-809669/1-A	Method Blank	Total/NA	Water	1633	809669
LCS 680-809669/2-A	Lab Control Sample	Total/NA	Water	1633	809669
LCSD 680-809669/3-A	Lab Control Sample Dup	Total/NA	Water	1633	809669
LLCS 680-809669/4-A	Lab Control Sample	Total/NA	Water	1633	809669

Prep Batch: 813392

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-5 - DL	MPCA-SAFF-111523-Stock	Total/NA	Water	1633	
MB 680-813392/1-A	Method Blank	Total/NA	Water	1633	
LCS 680-813392/2-A	Lab Control Sample	Total/NA	Water	1633	
LCSD 680-813392/3-A	Lab Control Sample Dup	Total/NA	Water	1633	
LLCS 680-813392/4-A	Lab Control Sample	Total/NA	Water	1633	

Analysis Batch: 813506

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-5 - DL	MPCA-SAFF-111523-Stock	Total/NA	Water	1633	813392
MB 680-813392/1-A	Method Blank	Total/NA	Water	1633	813392
LCS 680-813392/2-A	Lab Control Sample	Total/NA	Water	1633	813392

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QC Association Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

LCMS (Continued)

Analysis Batch: 813506 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCSD 680-813392/3-A	Lab Control Sample Dup	Total/NA	Water	1633	813392
LLCS 680-813392/4-A	Lab Control Sample	Total/NA	Water	1633	813392

Analysis Batch: 813661

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-5 - DL	MPCA-SAFF-111523-Stock	Total/NA	Water	1633	813392

Lab Chronicle

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111523-PRE

Lab Sample ID: 752-13791-1

Date Collected: 11/15/23 10:53

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/29/23 22:14

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/29/23 22:29
Post-Treatment	Analysis	Total PFCA-Sum		1	465809	V3JD	ELLE	12/05/23 19:05
Pre-Treatment	Analysis	Total PFCA-Sum		1	465807	V3JD	ELLE	01/09/24 16:32

Client Sample ID: MPCA-SAFF-111523-OP2

Lab Sample ID: 752-13791-3

Date Collected: 11/15/23 13:40

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/29/23 23:15

Client Sample ID: MPCA-SAFF-111523-Post

Lab Sample ID: 752-13791-4

Date Collected: 11/15/23 14:15

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/29/23 23:31

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/29/23 23:46
Total/NA	Prep	1633	DL		813392	CC	EET SAV	12/14/23 10:49
Total/NA	Analysis	1633	DL	1	813506	SW	EET SAV	12/14/23 22:08
Total/NA	Prep	1633	DL		813392	CC	EET SAV	12/14/23 10:49
Total/NA	Analysis	1633	DL	3	813661	SW	EET SAV	12/15/23 13:06

Lab Chronicle

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Client Sample ID: MPCA-SAFF-111623-PRE

Lab Sample ID: 752-13791-6

Date Collected: 11/16/23 10:24

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/30/23 00:01

Client Sample ID: MPCA-SAFF-111623-OP1

Lab Sample ID: 752-13791-7

Date Collected: 11/16/23 11:13

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/30/23 00:17

Client Sample ID: MPCA-SAFF-111623-OP2

Lab Sample ID: 752-13791-8

Date Collected: 11/16/23 11:34

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/30/23 00:32

Client Sample ID: MPCA-SAFF-111623-Post

Lab Sample ID: 752-13791-9

Date Collected: 11/16/23 12:15

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	1633			809669	MEW	EET SAV	11/22/23 10:18
Total/NA	Analysis	1633		1	810043	UI	EET SAV	11/30/23 00:47

Laboratory References:

EET SAV = Eurofins Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Accreditation/Certification Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
North Carolina (WW/SW)	State	521	12-31-24
The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.			
Analysis Method	Prep Method	Matrix	Analyte
Total PFCA-Sum		Water	Total PFCA

Laboratory: Eurofins Savannah

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
North Carolina (WW/SW)	State	269	12-31-23
The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.			
Analysis Method	Prep Method	Matrix	Analyte
1633	1633	Water	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)
1633	1633	Water	1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)
1633	1633	Water	1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)
1633	1633	Water	1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)
1633	1633	Water	3-Perfluoroheptylpropanoic acid (7:3 FTCA)
1633	1633	Water	3-Perfluoropentylpropanoic acid (5:3 FTCA)
1633	1633	Water	3-Perfluoropropylpropanoic acid (3:3 FTCA)
1633	1633	Water	4,8-Dioxa-3H-perfluorononanoic acid (ADONA)
1633	1633	Water	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid(9Cl-PF3ONS)
1633	1633	Water	Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)
1633	1633	Water	N-ethylperfluorooctane sulfonamide (NEtFOSA)
1633	1633	Water	N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)
1633	1633	Water	N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)
1633	1633	Water	N-methylperfluorooctane sulfonamide (NMeFOSA)
1633	1633	Water	N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)
1633	1633	Water	N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)
1633	1633	Water	Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)
1633	1633	Water	Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)
1633	1633	Water	Perfluoro-3-methoxypropanoic acid (PFMPA)
1633	1633	Water	Perfluoro-4-methoxybutanoic acid (PFMBA)

Eurofins Raleigh

Accreditation/Certification Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Laboratory: Eurofins Savannah (Continued)

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.			
Analysis Method	Prep Method	Matrix	Analyte
1633	1633	Water	Perfluorobutanesulfonic acid (PFBS)
1633	1633	Water	Perfluorobutanoic acid (PFBA)
1633	1633	Water	Perfluorodecanesulfonic acid (PFDS)
1633	1633	Water	Perfluorodecanoic acid (PFDA)
1633	1633	Water	Perfluorododecanesulfonic acid (PFDoS)
1633	1633	Water	Perfluorododecanoic acid (PFDoA)
1633	1633	Water	Perfluoroheptanesulfonic acid (PFHpS)
1633	1633	Water	Perfluoroheptanoic acid (PFHpA)
1633	1633	Water	Perfluorohexanesulfonic acid (PFHxS)
1633	1633	Water	Perfluorohexanoic acid (PFHxA)
1633	1633	Water	Perfluorononanesulfonic acid (PFNS)
1633	1633	Water	Perfluorononanoic acid (PFNA)
1633	1633	Water	Perfluorooctanesulfonamide (PFOSA)
1633	1633	Water	Perfluorooctanesulfonic acid (PFOS)
1633	1633	Water	Perfluorooctanoic acid (PFOA)
1633	1633	Water	Perfluoropentanesulfonic acid (PFPeS)
1633	1633	Water	Perfluoropentanoic acid (PFPeA)
1633	1633	Water	Perfluorotetradecanoic acid (PFTA)
1633	1633	Water	Perfluorotridecanoic acid (PFTTrDA)
1633	1633	Water	Perfluoroundecanoic acid (PFUnA)

Method Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Method	Method Description	Protocol	Laboratory
1633	Per- and Polyfluoroalkyl Substances by LC/MS/MS	EPA	EET SAV
Total PFCA-Sum	Total PFCA (Summary)	TAL SOP	ELLE
1633	Solid-Phase Extraction (SPE)	EPA	EET SAV

Protocol References:

- EPA = US Environmental Protection Agency
- TAL SOP = TestAmerica Laboratories, Standard Operating Procedure

Laboratory References:

- EET SAV = Eurofins Savannah, 5102 LaRoche Avenue, Savannah, GA 31404, TEL (912)354-7858
- ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

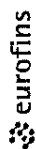
Sample Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
752-13791-1	MPCA-SAFF-111523-PRE	Water	11/15/23 10:53	11/16/23 15:20
752-13791-2	MPCA-SAFF-111523-OP1	Water	11/15/23 11:22	11/16/23 15:20
752-13791-3	MPCA-SAFF-111523-OP2	Water	11/15/23 13:40	11/16/23 15:20
752-13791-4	MPCA-SAFF-111523-Post	Water	11/15/23 14:15	11/16/23 15:20
752-13791-5	MPCA-SAFF-111523-Stock	Water	11/15/23 12:00	11/16/23 15:20
752-13791-6	MPCA-SAFF-111623-PRE	Water	11/16/23 10:24	11/16/23 15:20
752-13791-7	MPCA-SAFF-111623-OP1	Water	11/16/23 11:13	11/16/23 15:20
752-13791-8	MPCA-SAFF-111623-OP2	Water	11/16/23 11:34	11/16/23 15:20
752-13791-9	MPCA-SAFF-111623-Post	Water	11/16/23 12:15	11/16/23 15:20

Chain of Custody Record



Environment Testing

Client Information		Sampler		Lab Pmt:		Carrier Tracking No(s):		COC No:	
Client Contact: Russ Schmitz		Phone: 919 452 4980		Andros, John		State of Origin: NC		680-151309-54750.1	
Company: 374Water Inc		PWSID:		E-Mail: John.Andros@eurofins.com		Page: Page 1 of 2		Job #:	
Address: 3710 Shannon Rd Suite 51877		Due Date Requested:		Analysis Requested		Total Number of Containers		Preservation Codes:	
City: Durham		TAT Requested (days): Standard		1633 PFAS List of 40		CIC Fluorine Total Fluorine		A HCL B NaOH C Zn Acetate D Nitric Acid E NaHSO4 F MeOH G Antichlor H Ascorbic Acid I Ice J DI Water K EDTA L EDA Other	
State, Zip: NC, 27717		Compliance Project: ☐ Yes ☒ No		Field Filled Sample (Yes or No)		PFC, IDA, Total PFC, DHT		M Hexane N None O AsNaO2 P Na2OAS Q Na2SO3 R Na2SO4 S H2SO4 T TSP Dodecahydrate U V W Y Z	
Phone: 919-452-4980		PO #:		Perform MS/MSD (Yes or No)		1633 PFAS List of 40		752-13791 COC	
Email: rs@374water.com		Advance Payment Required		Matrix (Wet, Solid, On-site, Awa)		1633 PFAS List of 40		Special Instructions/Note: 13791	
Project Name: PFAS		WO #:		Sample Type (C=Comp, G=grab)		1633 PFAS List of 40			
Site: Raleigh Lab		Project #: 68030200		Sample Date		1633 PFAS List of 40			
		SSOW#:		Sample Time		1633 PFAS List of 40			
Sample Identification	MPCA - SAFF-111623 - PRE	11/15/2023	10:53	6	W	X	X	X	
	MPCA - SAFF-111623 - OPI	11/15/2023	11:22	6	W	X	X	X	
	MPCA - SAFF-111623 - OP2	11/15/2023	13:40	6	W	X	X	X	
	MPCA - SAFF-111623 - Post	11/15/2023	14:15	6	W	X	X	X	
	MPCA - SAFF-111623 - Stock	11/15/2023	12:00	6	W	X	X	X	
	MPCA - SAFF-111623 - PRE	11/16/2023	10:23	6	W	X	X	X	
	MPCA - SAFF-111623 - OPI	11/16/2023	11:13	6	W	X	X	X	
	MPCA - SAFF-111623 - OP2	11/16/2023	11:34	6	W	X	X	X	
	MPCA - SAFF-111623 - Post	11/16/2023	12:15	6	W	X	X	X	
Possible Hazard Identification ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐ Radiological ☒ PFAS									
Deliverable Requested: I, II, III, IV Other (specify)									
Empty Kit Relinquished by: _____ Date: _____									
Relinquished by: _____ Date/Time: _____ Company: _____									
Relinquished by: _____ Date/Time: _____ Company: _____									
Relinquished by: _____ Date/Time: _____ Company: _____									
Custody Seal No. _____ ☐ Yes ☒ No									

Chain of Custody Record

[illegible]

Eurofins Raleigh

102-A Woodwinds Industrial Court

Cary NC 27511

Phone: 919-677-1669

Chain of Custody Record



Environment Testing

Client Information (Sub Contract Lab)		Sampler		Lab PM: Andros, John		Carrier Tracking No(s):		COC No: 752-1861 1		
Client Contact: Shipping/Receiving		Phone:		E-Mail: John.Andros@et.eurofinsus.com		State of Origin: North Carolina		Page: Page 1 of 1		
Company: Eurofins Environment Testing Southeast,		Accreditations Required (See note): State North Carolina (WW/SW)		Job #: 752-13791 1						
Address: 5102 LaRoche Avenue,		Due Date Requested: 12/11/2023		Analysis Requested		Preservation Codes: A HCL M Hexane B NaOH N None C Zn Acetate O AsNaO2 D Nitric Acid P Na2O4S E NaHSO4 Q Na2SO3 F MeOH R Na2S2O3 G Amchlor S H2SO4 H Ascorbic Acid T TSP Dodecahydrate I Ice U Acetone J DI Water V MCAA K EDTA W pH 4-5 L EDA Y Trizma Z other (specify) Other:				
City: Savannah		TAT Requested (days):								
State, Zip: GA, 31404		PO #:								
Phone: 912-354-7858(Tel) 912-352-0165(Fax)		WO #:								
Email:										
Project Name: PFAs		Project #: 68030200								
Site:		SSOW#:								
Sample Identification Client ID (Lab ID)		Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=soil, BT=Tissue, Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	1633/1633_SPE 1633-PFAs-List of 40	Total Number of containers	Special Instructions/Note:
				Preservation Code:		X				
MPCA-SAFF-11523-Pre (752-13791 1)		11/15/23	10:53 Eastern		Water		X		2	
MPCA-SAFF-11523-OP1 (752-13791-2)		11/15/23	11:22 Eastern		Water		X		2	
MPCA-SAFF-11523-OP2 (752-13791-3)		11/15/23	13:40 Eastern		Water		X		2	
MPCA-SAFF-11523-Post (752-13791-4)		11/15/23	14:15 Eastern		Water		X		2	
MPCA-SAFF-11523-Stock (752-13791-5)		11/15/23	12:00 Eastern		Water		X		2	
MPCA-SAFF-111623-Pre (752-13791-6)		11/16/23	10:24 Eastern		Water		X		2	
MPCA-SAFF-111623-OP1 (752-13791 7)		11/16/23	11:13 Eastern		Water		X		2	
MPCA-SAFF-111623-OP2 (752-13791-8)		11/16/23	11:34 Eastern		Water		X		2	
MPCA-SAFF-111623-Post (752-13791-9)		11/16/23	12:15 Eastern		Water		X		2	
Note: Since laboratory accreditations are subject to change, Eurofins Environment Testing Southeast, LLC places the ownership of method, analyte & accreditation compliance upon our subcontract laboratories. This sample shipment is forwarded under chain-of-custody. If the laboratory does not currently maintain accreditation in the State of Origin listed above for analysis/tests/matrix being analyzed, the samples must be shipped back to the Eurofins Environment Testing Southeast, LLC laboratory or other instructions will be provided. Any changes to accreditation status should be brought to Eurofins Environment Testing Southeast, LLC attention immediately. If all requested accreditations are current to date, return the signed Chain of Custody attesting to said compliance to Eurofins Environment Testing Southeast, LLC.										
Possible Hazard Identification						Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)				
Unconfirmed						☐ Return To Client ☐ Disposal By Lab ☐ Archive For _____ Months				
Deliverable Requested: I II III IV Other (specify)						Primary Deliverable Rank: 2				
Special Instructions/QC Requirements:										
Empty Kit Relinquished by:			Date:		Time:		Method of Shipment:			
Relinquished by:			Date/Time: 11/16/23 10:17		Company:		Received by:		Date/Time: 11-17-23	
Relinquished by:			Date/Time:		Company:		Received by:		Date/Time: 11-14	
Relinquished by:			Date/Time:		Company:		Received by:		Date/Time:	
Custody Seals Intact: Δ Yes Δ No		Custody Seal No.				Cooler Temperature(s) °C and Other Remarks: 1.1-1.2				

Ver: 06/08/2021

Login Sample Receipt Checklist

Client: 374Water Inc

Job Number: 752-13791-1

Login Number: 13791

List Source: Eurofins Raleigh

List Number: 1

Creator: Hyatt, Samantha

Question	Answer	Comment
Radioactivity wasn't checked or is $\leq$ background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is $<6\text{mm}$ (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Login Sample Receipt Checklist

Client: 374Water Inc

Job Number: 752-13791-1

Login Number: 13791

List Number: 2

Creator: Arroyo, Haley

List Source: Eurofins Lancaster Laboratories Environment Testing, LLC

List Creation: 11/17/23 01:07 PM

Question	Answer	Comment
The cooler's custody seal is intact.	True	Seals on cooler but date and time not filled out.
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature acceptable,where thermal pres is required(</=6C, not frozen).	True	
Cooler Temperature is recorded.	True	
WV:Container Temp acceptable,where thermal pres is required (</=6C, not frozen).	N/A	
WV: Container Temperature is recorded.	N/A	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
There are no discrepancies between the containers received and the COC.	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
There is sufficient vol. for all requested analyses.	True	
Is the Field Sampler's name present on COC?	False	Received project as a subcontract.
Sample custody seals are intact.	N/A	
VOA sample vials do not have headspace >6mm in diameter (none, if from WV)?	N/A	

Login Sample Receipt Checklist

Client: 374Water Inc

Job Number: 752-13791-1

Login Number: 13791

List Number: 3

Creator: Harley, Tynisha

List Source: Eurofins Savannah

List Creation: 11/17/23 01:48 PM

Question	Answer	Comment
Radioactivity wasn't checked or is $\leq$ background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is $<6\text{mm}$ (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Appendix C – PFAS testing by Eurofins; AOF by CIC, TOP Assay

ANALYTICAL REPORT

PREPARED FOR

Attn: Russ Schmitz
374Water Inc
3710 Shannon Rd
Suite 51877
Durham, North Carolina 27717

Generated 1/24/2024 5:01:49 PM

JOB DESCRIPTION

PFAs (MPCA-SAFF)

JOB NUMBER

752-13791-2

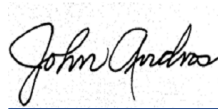
Eurofins Raleigh

Job Notes

This report may not be reproduced except in full, and with written approval from the laboratory. The results relate only to the samples tested. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

The test results in this report relate only to the samples as received by the laboratory and will meet all requirements of the methodology, with any exceptions noted. This report shall not be reproduced except in full, without the express written approval of the laboratory. All questions should be directed to the Eurofins Environment Testing Southeast, LLC Project Manager.

Authorization



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1/24/2024 5:01:49 PM

Authorized for release by
John Andros, Project Manager I
John.Andros@et.eurofinsus.com
(404)944-4744

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Definitions/Glossary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Qualifiers

LCMS

Qualifier	Qualifier Description
*5-	Isotope dilution analyte is outside acceptance limits, low biased.
B	Compound was found in the blank and sample.
H	Sample was prepped or analyzed beyond the specified holding time. This does not meet regulatory requirements.
I	Value is EMPC (estimated maximum possible concentration).
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
α	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: 374Water Inc
Project: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Job ID: 752-13791-2

Eurofins Raleigh

Job Narrative 752-13791-2

Receipt

The samples were received on 11/16/2023 3:20 PM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved and on ice. The temperature of the cooler at receipt time was 5.5°C

PFAS

Method 537_IDA_TOPS: Target analyte(s) Perfluorooctanoic acid were detected in the method blank associated with the following sample: MPCA-SAFF-111523-OP1 (752-13791-2). The following action was taken: This sample(s) was re-extracted within the required holding time and target analyte(s) Perfluorooctanoic acid were again detected in the re-extracted method blank.

Method CIC_Fluorine: Reporting limits were raised for the following samples due to interference from the sample matrix. MPCA-SAFF-111523-OP1 (752-13791-2) and MPCA-SAFF-111523-Stock (752-13791-5)

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Eurofins Raleigh

Detection Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil	Fac	D	Method	Prep Type
Perfluorodecanoic acid	2.76	H	1.99	0.298	ng/L	1			537 IDA	Pre-Treatment
Perfluorohexanoic acid	3.40	H	1.99	0.995	ng/L	1			537 IDA	Pre-Treatment
Perfluorooctanoic acid	2.97	H	1.99	0.298	ng/L	1			537 IDA	Pre-Treatment
Perfluorohexanoic acid	6.12	J	10.0	5.00	ng/L	1			537 TOP	Post-Treatment
Perfluorooctanoic acid	2.53	J B	10.0	1.50	ng/L	1			537 TOP	Post-Treatment
Adsorbable Organic Fluorine (AOF)	56.9		20.0	10.0	ug/L	1			ELLE SOP	Total/NA
Perfluorobutanoic acid	0.000				ng/L	1			Total PFCA-Dif	Total/NA
Perfluoropentanoic acid	0.000				ng/L	1			Total PFCA-Dif	Total/NA
Perfluorohexanoic acid	2.72				ng/L	1			Total PFCA-Dif	Total/NA
Perfluoroheptanoic acid	0.000				ng/L	1			Total PFCA-Dif	Total/NA
Perfluorooctanoic acid	0.000				ng/L	1			Total PFCA-Dif	Total/NA
Perfluorononanoic acid	0.000				ng/L	1			Total PFCA-Dif	Total/NA
Total PFCA	2.28				ng/L	1			Total PFCA-Dif	Total/NA

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil	Fac	D	Method	Prep Type
Adsorbable Organic Fluorine (AOF)	4720		200	100	ug/L	1			ELLE SOP	Total/NA

This Detection Summary does not include radiochemical test results.

Eurofins Raleigh

Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 537 IDA - EPA 537 Isotope Dilution - Pre-Treatment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
9Cl-PF3ONS	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
11Cl-PF3OUdS	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
4:2 Fluorotelomer sulfonic acid	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
6:2 Fluorotelomer sulfonic acid	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
8:2 Fluorotelomer sulfonic acid	ND	H	1.99	0.597	ng/L		01/05/24 09:12	01/09/24 16:32	1
10:2 FTS	ND	H	1.99	0.796	ng/L		01/05/24 09:12	01/09/24 16:32	1
HFPODA	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
NEtFOSA	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
NEtFOSAA	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
NEtFOSE	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
NMeFOSA	ND	H	1.99	0.696	ng/L		01/05/24 09:12	01/09/24 16:32	1
NMeFOSAA	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
NMeFOSE	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorobutanesulfonic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorobutanoic acid	ND	H	1.99	0.995	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorodecanesulfonic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorodecanoic acid	2.76	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorododecanoic acid	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluoroheptanesulfonic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluoroheptanoic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorohexadecanoic acid	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorohexanesulfonic acid	ND	H	1.99	0.199	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorohexanoic acid	3.40	H	1.99	0.995	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorononanesulfonic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorononanoic acid	ND	H	1.99	0.199	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorooctadecanoic acid	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorooctanesulfonamide	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorooctanesulfonic acid	ND	H	1.99	0.497	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorooctanoic acid	2.97	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluoropentanesulfonic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluoropentanoic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorotetradecanoic acid	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluorotridecanoic acid	ND	H	1.99	0.398	ng/L		01/05/24 09:12	01/09/24 16:32	1
Perfluoroundecanoic acid	ND	H	1.99	0.298	ng/L		01/05/24 09:12	01/09/24 16:32	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C8 FOSA	77		10 - 155	01/05/24 09:12	01/09/24 16:32	1
13C3 HFPO-DA	91		13 - 170	01/05/24 09:12	01/09/24 16:32	1
13C4 PFBA	89		22 - 174	01/05/24 09:12	01/09/24 16:32	1
13C3 PFBS	141		34 - 200	01/05/24 09:12	01/09/24 16:32	1
13C6 PFDA	83		53 - 151	01/05/24 09:12	01/09/24 16:32	1
13C2-PFDoDA	71		22 - 165	01/05/24 09:12	01/09/24 16:32	1
13C4 PFHpA	96		40 - 165	01/05/24 09:12	01/09/24 16:32	1
13C5 PFHxA	86		28 - 166	01/05/24 09:12	01/09/24 16:32	1
13C3 PFHxS	116		48 - 169	01/05/24 09:12	01/09/24 16:32	1
13C9 PFNA	65		52 - 168	01/05/24 09:12	01/09/24 16:32	1
13C8 PFOA	92		52 - 153	01/05/24 09:12	01/09/24 16:32	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 537 IDA - EPA 537 Isotope Dilution - Pre-Treatment (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C8 PFOS	96		59 - 155	01/05/24 09:12	01/09/24 16:32	1
13C5 PFPeA	85		33 - 196	01/05/24 09:12	01/09/24 16:32	1
13C2 PFTeDA	71		10 - 171	01/05/24 09:12	01/09/24 16:32	1
13C7 PFUnA	74		41 - 163	01/05/24 09:12	01/09/24 16:32	1
d5-NEtFOSAA	0.7	*5-	34 - 181	01/05/24 09:12	01/09/24 16:32	1
d9-N-EtFOSE-M	113		10 - 151	01/05/24 09:12	01/09/24 16:32	1
d5-NEtPFOSA	51		10 - 130	01/05/24 09:12	01/09/24 16:32	1
d3-NMeFOSAA	0.7	*5-	38 - 168	01/05/24 09:12	01/09/24 16:32	1
d7-N-MeFOSE-M	115		10 - 149	01/05/24 09:12	01/09/24 16:32	1
d3-NMePFOSA	49		10 - 130	01/05/24 09:12	01/09/24 16:32	1
M2-4:2 FTS	94		35 - 200	01/05/24 09:12	01/09/24 16:32	1
M2-6:2 FTS	101		40 - 200	01/05/24 09:12	01/09/24 16:32	1
M2-8:2 FTS	75		37 - 200	01/05/24 09:12	01/09/24 16:32	1

Method: EPA 537 TOP - Fluorinated Alkyl Substances - Post-Treatment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
9Cl-PF3ONS	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
11Cl-PF3OUdS	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
DONA	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
10:2 Fluorotelomer sulfonic acid	ND		10.0	4.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
4:2 Fluorotelomer sulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
6:2 Fluorotelomer sulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
8:2 Fluorotelomer sulfonic acid	ND		10.0	3.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
HFPODA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
NEtFOSA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
NEtFOSAA	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
NEtFOSE	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
NMeFOSA	ND		10.0	3.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
NMeFOSAA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
NMeFOSE	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorobutanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorobutanoic acid	ND		10.0	5.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorodecanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorodecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorododecanesulfonic acid (PFDoS)	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorododecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluoroheptanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluoroheptanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorohexadecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorohexanesulfonic acid	ND		10.0	1.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorohexanoic acid	6.12	J	10.0	5.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorononanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorononanoic acid	ND		10.0	1.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorooctadecanoic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorooctanesulfonamide	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorooctanesulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorooctanoic acid	2.53	J I B	10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluoropentanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluoropentanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Method: EPA 537 TOP - Fluorinated Alkyl Substances - Post-Treatment (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorotetradecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluorotridecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 19:05	1
Perfluoroundecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 19:05	1

Isotope Dilution	%Recovery	Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C8 FOSA	84		10 - 155				11/30/23 10:08	12/05/23 19:05	1
13C3 HFPO-DA	94		13 - 170				11/30/23 10:08	12/05/23 19:05	1
13C4 PFBA	83		22 - 174				11/30/23 10:08	12/05/23 19:05	1
13C3 PFBS	99		34 - 200				11/30/23 10:08	12/05/23 19:05	1
13C6 PFDA	100		53 - 151				11/30/23 10:08	12/05/23 19:05	1
13C2-PFDoDA	90		22 - 165				11/30/23 10:08	12/05/23 19:05	1
13C4 PFHpA	99		40 - 165				11/30/23 10:08	12/05/23 19:05	1
13C5 PFHxA	99		28 - 166				11/30/23 10:08	12/05/23 19:05	1
13C3 PFHxS	101		48 - 169				11/30/23 10:08	12/05/23 19:05	1
13C9 PFNA	107		52 - 168				11/30/23 10:08	12/05/23 19:05	1
13C8 PFOA	96		52 - 153				11/30/23 10:08	12/05/23 19:05	1
13C8 PFOS	99		59 - 155				11/30/23 10:08	12/05/23 19:05	1
13C5 PFPeA	95		33 - 196				11/30/23 10:08	12/05/23 19:05	1
13C2 PFTeDA	79		10 - 171				11/30/23 10:08	12/05/23 19:05	1
13C7 PFUnA	88		41 - 163				11/30/23 10:08	12/05/23 19:05	1
d5-NEtFOSAA	84		34 - 181				11/30/23 10:08	12/05/23 19:05	1
d9-N-EtFOSE-M	80		10 - 151				11/30/23 10:08	12/05/23 19:05	1
d5-NEtPFOSA	62		10 - 130				11/30/23 10:08	12/05/23 19:05	1
d7-N-MeFOSE-M	80		10 - 149				11/30/23 10:08	12/05/23 19:05	1
d3-NMePFOSA	58		10 - 130				11/30/23 10:08	12/05/23 19:05	1
M2-6:2 FTS	85		40 - 200				11/30/23 10:08	12/05/23 19:05	1
M2-8:2 FTS	102		37 - 200				11/30/23 10:08	12/05/23 19:05	1

Surrogate	%Recovery	Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C2 PFHxA	94		26 - 150				11/30/23 10:08	12/05/23 19:05	1
13C4 PFOA	92		45 - 147				11/30/23 10:08	12/05/23 19:05	1
13C2 PFUnA	92		11 - 187				11/30/23 10:08	12/05/23 19:05	1

Method: ELLE - Lancaster ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	56.9		20.0	10.0	ug/L		12/28/23 09:19	12/29/23 05:16	1

Method: TAL SOP Total PFCA-Dif - Total PFCA (Treatment Difference)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid	0.000				ng/L			01/23/24 10:59	1
Perfluoropentanoic acid	0.000				ng/L			01/23/24 10:59	1
Perfluorohexanoic acid	2.72				ng/L			01/23/24 10:59	1
Perfluoroheptanoic acid	0.000				ng/L			01/23/24 10:59	1
Perfluorooctanoic acid	0.000				ng/L			01/23/24 10:59	1
Perfluorononanoic acid	0.000				ng/L			01/23/24 10:59	1
Total PFCA	2.28				ng/L			01/23/24 10:59	1

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Client Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Method: ELLE - Lancaster ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography									
Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	4720		200	100	ug/L		12/28/23 09:19	12/29/23 06:55	1

Surrogate Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances

Matrix: Water

Prep Type: Post-Treatment

		Percent Surrogate Recovery (Acceptance Limits)		
Lab Sample ID	Client Sample ID	PFHxA (26-150)	PFOA (45-147)	PFUnA (11-187)
752-13791-2	MPCA-SAFF-111523-OP1	94	92	92
LCS 410-448516/3-A	Lab Control Sample	90	96	91
LCSD 410-448516/4-A	Lab Control Sample Dup	92	92	94
MB 410-448516/2-A	Method Blank	92	90	90
Surrogate Legend				
PFHxA = 13C2 PFHxA				
PFOA = 13C4 PFOA				
PFUnA = 13C2 PFUnA				

Isotope Dilution Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution

Matrix: Water

Prep Type: Pre-Treatment

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFOSA (10-155)	HFPODA (13-170)	PFBA (22-174)	C3PFBS (34-200)	C6PFDA (53-151)	PFDODA (22-165)	C4PFHA (40-165)	13C5PHA (28-166)
752-13791-2	MPCA-SAFF-111523-OP1	77	91	89	141	83	71	96	86
LCS 410-460615/2-A	Lab Control Sample	81	81	90	95	91	83	88	88
LCS 410-464649/2-A	Lab Control Sample	85	81	91	92	91	89	90	91
LCSD 410-460615/3-A	Lab Control Sample Dup	105	104	112	123	115	106	111	108
LCSD 410-464649/3-A	Lab Control Sample Dup	88	91	94	97	96	89	98	94
MB 410-460615/1-A	Method Blank	75	106	96	89	95	95	94	95
MB 410-464649/1-A	Method Blank	68	78	87	90	85	81	82	81

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	C3PFHS (48-169)	C9PFNA (52-168)	C8PFOA (52-153)	C8PFOS (59-155)	PFPeA (33-196)	PFTDA (10-171)	13C7PUA (41-163)	d5NEFOS (34-181)
752-13791-2	MPCA-SAFF-111523-OP1	116	65	92	96	85	71	74	0.7 *5-
LCS 410-460615/2-A	Lab Control Sample	90	85	90	89	89	82	85	92
LCS 410-464649/2-A	Lab Control Sample	88	89	89	88	93	89	90	94
LCSD 410-460615/3-A	Lab Control Sample Dup	113	111	109	112	113	102	104	114
LCSD 410-464649/3-A	Lab Control Sample Dup	93	95	97	93	94	89	95	93
MB 410-460615/1-A	Method Blank	84	116	101	94	69	81	94	91
MB 410-464649/1-A	Method Blank	81	93	85	84	86	74	77	118

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	NEFM (10-151)	d5NPFSA (10-130)	d3NMFOS (38-168)	NMFM (10-149)	d3NMFSA (10-130)	M242FTS (35-200)	M262FTS (40-200)	M282FTS (37-200)
752-13791-2	MPCA-SAFF-111523-OP1	113	51	0.7 *5-	115	49	94	101	75
LCS 410-460615/2-A	Lab Control Sample	55	46	84	59	48	88	98	93
LCS 410-464649/2-A	Lab Control Sample	73	63	87	76	64	91	95	96
LCSD 410-460615/3-A	Lab Control Sample Dup	72	61	111	75	62	111	122	115
LCSD 410-464649/3-A	Lab Control Sample Dup	82	72	90	87	70	99	102	93
MB 410-460615/1-A	Method Blank	72	50	94	73	45	99	82	73
MB 410-464649/1-A	Method Blank	71	61	96	67	56	82	111	146

Surrogate Legend

PFOSA = 13C8 FOSA
HFPODA = 13C3 HFPO-DA
PFBA = 13C4 PFBA
C3PFBS = 13C3 PFBS
C6PFDA = 13C6 PFDA
PFDODA = 13C2-PFDODA
C4PFHA = 13C4 PFHpA
13C5PHA = 13C5 PFHxA
C3PFHS = 13C3 PFHxS
C9PFNA = 13C9 PFNA
C8PFOA = 13C8 PFOA
C8PFOS = 13C8 PFOS
PFPeA = 13C5 PFPeA
PFTDA = 13C2 PFTeDA
13C7PUA = 13C7 PFUnA
d5NEFOS = d5-NEtFOSAA
NEFM = d9-N-EtFOSE-M
d5NPFSA = d5-NEtPFOSA
d3NMFOS = d3-NMeFOSAA
NMFM = d7-N-MeFOSE-M

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Isotope Dilution Summary

Client: 374Water Inc
 Project/Site: PFAs (MPCA-SAFF)
 d3NMFSA = d3-NMePFOSA
 M242FTS = M2-4:2 FTS
 M262FTS = M2-6:2 FTS
 M282FTS = M2-8:2 FTS

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances

Matrix: Water

Prep Type: Post-Treatment

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	PFOSA (10-155)	HFPODA (13-170)	PFBA (22-174)	C3PFBS (34-200)	C6PFDA (53-151)	PFDODA (22-165)	C4PFHA (40-165)	13C5PHA (28-166)
752-13791-2	MPCA-SAFF-111523-OP1	84	94	83	99	100	90	99	99
LCS 410-448516/3-A	Lab Control Sample	82	98	60	100	102	96	104	100
LCSD 410-448516/4-A	Lab Control Sample Dup	83	94	9 *5-	104	105	98	107	95
MB 410-448516/2-A	Method Blank	87	94	40	99	100	92	106	100

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	C3PFHS (48-169)	C9PFNA (52-168)	C8PFOA (52-153)	C8PFOS (59-155)	PFPeA (33-196)	PFTDA (10-171)	13C7PUA (41-163)	d5NEFOS (34-181)
752-13791-2	MPCA-SAFF-111523-OP1	101	107	96	99	95	79	88	84
LCS 410-448516/3-A	Lab Control Sample	105	110	102	99	97	82	98	88
LCSD 410-448516/4-A	Lab Control Sample Dup	106	120	101	104	97	88	92	93
MB 410-448516/2-A	Method Blank	108	104	98	97	102	81	92	92

		Percent Isotope Dilution Recovery (Acceptance Limits)							
Lab Sample ID	Client Sample ID	NEFM (10-151)	d5NPFSA (10-130)	NMFM (10-149)	d3NMFSA (10-130)	M262FTS (40-200)	M282FTS (37-200)		
752-13791-2	MPCA-SAFF-111523-OP1	80	62	80	58	85	102		
LCS 410-448516/3-A	Lab Control Sample	87	69	82	62	96	95		
LCSD 410-448516/4-A	Lab Control Sample Dup	96	75	91	67	98	91		
MB 410-448516/2-A	Method Blank	89	75	86	70	96	100		

Surrogate Legend

PFOSA = 13C8 FOSA
 HFPODA = 13C3 HFPO-DA
 PFBA = 13C4 PFBA
 C3PFBS = 13C3 PFBS
 C6PFDA = 13C6 PFDA
 PFDODA = 13C2-PFDODA
 C4PFHA = 13C4 PFHpA
 13C5PHA = 13C5 PFHxA
 C3PFHS = 13C3 PFHxS
 C9PFNA = 13C9 PFNA
 C8PFOA = 13C8 PFOA
 C8PFOS = 13C8 PFOS
 PFPeA = 13C5 PFPeA
 PFTDA = 13C2 PFTeDA
 13C7PUA = 13C7 PFUnA
 d5NEFOS = d5-NEtFOSAA
 NEFM = d9-N-EtFOSE-M
 d5NPFSA = d5-NEtPFOSA
 NMFM = d7-N-MeFOSE-M
 d3NMFSA = d3-NMePFOSA
 M262FTS = M2-6:2 FTS
 M282FTS = M2-8:2 FTS

QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution

Lab Sample ID: MB 410-460615/1-A
Matrix: Water
Analysis Batch: 461937

Client Sample ID: Method Blank
Prep Type: Pre-Treatment
Prep Batch: 460615

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
9Cl-PF3ONS	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
11Cl-PF3OUdS	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
4:2 Fluorotelomer sulfonic acid	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
6:2 Fluorotelomer sulfonic acid	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
8:2 Fluorotelomer sulfonic acid	ND		2.00	0.600	ng/L		01/05/24 09:12	01/10/24 10:15	1
10:2 FTS	ND		2.00	0.800	ng/L		01/05/24 09:12	01/10/24 10:15	1
HFPODA	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
NEtFOSA	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
NEtFOSAA	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
NEtFOSE	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
NMeFOSA	ND		2.00	0.700	ng/L		01/05/24 09:12	01/10/24 10:15	1
NMeFOSAA	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
NMeFOSE	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorobutanesulfonic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorobutanoic acid	ND		2.00	1.00	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorodecanesulfonic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorodecanoic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorododecanesulfonic acid (PFDoS)	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorododecanoic acid	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluoroheptanesulfonic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluoroheptanoic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorohexadecanoic acid	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorohexanesulfonic acid	ND		2.00	0.200	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorohexanoic acid	ND		2.00	1.00	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorononanesulfonic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorononanoic acid	ND		2.00	0.200	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorooctadecanoic acid	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorooctanesulfonamide	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorooctanesulfonic acid	ND		2.00	0.500	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorooctanoic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluoropentanesulfonic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluoropentanoic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorotetradecanoic acid	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluorotridecanoic acid	ND		2.00	0.400	ng/L		01/05/24 09:12	01/10/24 10:15	1
Perfluoroundecanoic acid	ND		2.00	0.300	ng/L		01/05/24 09:12	01/10/24 10:15	1

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C8 FOSA	75		10 - 155	01/05/24 09:12	01/10/24 10:15	1
13C3 HFPO-DA	106		13 - 170	01/05/24 09:12	01/10/24 10:15	1
13C4 PFBA	96		22 - 174	01/05/24 09:12	01/10/24 10:15	1
13C3 PFBS	89		34 - 200	01/05/24 09:12	01/10/24 10:15	1
13C6 PFDA	95		53 - 151	01/05/24 09:12	01/10/24 10:15	1
13C2-PFDoDA	95		22 - 165	01/05/24 09:12	01/10/24 10:15	1
13C4 PFHpA	94		40 - 165	01/05/24 09:12	01/10/24 10:15	1
13C5 PFHxA	95		28 - 166	01/05/24 09:12	01/10/24 10:15	1
13C3 PFHxS	84		48 - 169	01/05/24 09:12	01/10/24 10:15	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: MB 410-460615/1-A

Matrix: Water

Analysis Batch: 461937

Client Sample ID: Method Blank

Prep Type: Pre-Treatment

Prep Batch: 460615

Isotope Dilution	MB MB		Limits	Prepared	Analyzed	Dil Fac
	%Recovery	Qualifier				
13C9 PFNA	116		52 - 168	01/05/24 09:12	01/10/24 10:15	1
13C8 PFOA	101		52 - 153	01/05/24 09:12	01/10/24 10:15	1
13C8 PFOS	94		59 - 155	01/05/24 09:12	01/10/24 10:15	1
13C5 PFPeA	69		33 - 196	01/05/24 09:12	01/10/24 10:15	1
13C2 PFTeDA	81		10 - 171	01/05/24 09:12	01/10/24 10:15	1
13C7 PFUnA	94		41 - 163	01/05/24 09:12	01/10/24 10:15	1
d5-NEtFOSAA	91		34 - 181	01/05/24 09:12	01/10/24 10:15	1
d9-N-EtFOSE-M	72		10 - 151	01/05/24 09:12	01/10/24 10:15	1
d5-NEtPFOSA	50		10 - 130	01/05/24 09:12	01/10/24 10:15	1
d3-NMeFOSAA	94		38 - 168	01/05/24 09:12	01/10/24 10:15	1
d7-N-MeFOSE-M	73		10 - 149	01/05/24 09:12	01/10/24 10:15	1
d3-NMePFOSA	45		10 - 130	01/05/24 09:12	01/10/24 10:15	1
M2-4:2 FTS	99		35 - 200	01/05/24 09:12	01/10/24 10:15	1
M2-6:2 FTS	82		40 - 200	01/05/24 09:12	01/10/24 10:15	1
M2-8:2 FTS	73		37 - 200	01/05/24 09:12	01/10/24 10:15	1

Lab Sample ID: LCS 410-460615/2-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample

Prep Type: Pre-Treatment

Prep Batch: 460615

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
9Cl-PF3ONS	23.8	19.60		ng/L		82	60 - 130
11Cl-PF3OUdS	23.8	18.92		ng/L		79	57 - 130
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	24.2	20.40		ng/L		84	61 - 130
4:2 Fluorotelomer sulfonic acid	23.9	21.53		ng/L		90	61 - 131
6:2 Fluorotelomer sulfonic acid	24.3	20.14		ng/L		83	61 - 132
8:2 Fluorotelomer sulfonic acid	24.5	21.53		ng/L		88	55 - 134
10:2 FTS	24.7	21.34		ng/L		86	47 - 141
HFPODA	25.6	21.73		ng/L		85	53 - 131
NEtFOSA	25.6	23.83		ng/L		93	67 - 135
NEtFOSAA	25.6	21.31		ng/L		83	63 - 130
NEtFOSE	25.6	23.65		ng/L		92	65 - 132
NMeFOSA	25.6	23.25		ng/L		91	53 - 167
NMeFOSAA	25.6	22.93		ng/L		90	62 - 131
NMeFOSE	25.6	21.32		ng/L		83	65 - 130
Perfluorobutanesulfonic acid	22.7	18.95		ng/L		84	64 - 132
Perfluorobutanoic acid	25.6	22.81		ng/L		89	58 - 130
Perfluorodecanesulfonic acid	24.7	19.14		ng/L		78	55 - 130
Perfluorodecanoic acid	25.6	21.78		ng/L		85	62 - 133
Perfluorododecanesulfonic acid (PFDoS)	24.8	19.52		ng/L		79	56 - 130
Perfluorododecanoic acid	25.6	21.91		ng/L		86	61 - 132
Perfluoroheptanesulfonic acid	24.4	20.21		ng/L		83	59 - 130
Perfluoroheptanoic acid	25.6	22.01		ng/L		86	64 - 130
Perfluorohexadecanoic acid	25.6	20.89		ng/L		82	50 - 130
Perfluorohexanesulfonic acid	23.3	19.32		ng/L		83	62 - 130
Perfluorohexanoic acid	25.6	20.91		ng/L		82	59 - 130
Perfluorononanesulfonic acid	24.6	20.71		ng/L		84	56 - 130

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCS 410-460615/2-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample

Prep Type: Pre-Treatment

Prep Batch: 460615

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorononanoic acid	25.6	23.05		ng/L		90	63 - 133
Perfluorooctadecanoic acid	25.6	22.87		ng/L		89	45 - 137
Perfluorooctanesulfonamide	25.6	24.08		ng/L		94	67 - 132
Perfluorooctanesulfonic acid	23.7	20.05		ng/L		85	62 - 130
Perfluorooctanoic acid	25.6	21.44		ng/L		84	58 - 132
Perfluoropentanesulfonic acid	24.0	19.53		ng/L		81	64 - 132
Perfluoropentanoic acid	25.6	22.21		ng/L		87	60 - 130
Perfluorotetradecanoic acid	25.6	21.53		ng/L		84	62 - 131
Perfluorotridecanoic acid	25.6	22.42		ng/L		88	59 - 136
Perfluoroundecanoic acid	25.6	22.11		ng/L		86	62 - 131

Isotope Dilution	LCS		Limits
	%Recovery	Qualifier	
13C8 FOSA	81		10 - 155
13C3 HFPO-DA	81		13 - 170
13C4 PFBA	90		22 - 174
13C3 PFBS	95		34 - 200
13C6 PFDA	91		53 - 151
13C2-PFDoDA	83		22 - 165
13C4 PFHpA	88		40 - 165
13C5 PFHxA	88		28 - 166
13C3 PFHxS	90		48 - 169
13C9 PFNA	85		52 - 168
13C8 PFOA	90		52 - 153
13C8 PFOS	89		59 - 155
13C5 PFPeA	89		33 - 196
13C2 PFTeDA	82		10 - 171
13C7 PFUnA	85		41 - 163
d5-NEtFOSAA	92		34 - 181
d9-N-EtFOSE-M	55		10 - 151
d5-NEtPFOSA	46		10 - 130
d3-NMeFOSAA	84		38 - 168
d7-N-MeFOSE-M	59		10 - 149
d3-NMePFOSA	48		10 - 130
M2-4:2 FTS	88		35 - 200
M2-6:2 FTS	98		40 - 200
M2-8:2 FTS	93		37 - 200

Lab Sample ID: LCSD 410-460615/3-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample Dup

Prep Type: Pre-Treatment

Prep Batch: 460615

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	
								RPD	Limit
9Cl-PF3ONS	23.8	21.31		ng/L		90	60 - 130	8	30
11Cl-PF3OUdS	23.8	19.83		ng/L		83	57 - 130	5	30
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	24.2	20.16		ng/L		83	61 - 130	1	30
4:2 Fluorotelomer sulfonic acid	23.9	22.57		ng/L		94	61 - 131	5	30
6:2 Fluorotelomer sulfonic acid	24.3	20.84		ng/L		86	61 - 132	3	30
8:2 Fluorotelomer sulfonic acid	24.5	22.71		ng/L		93	55 - 134	5	30

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-460615/3-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample Dup

Prep Type: Pre-Treatment

Prep Batch: 460615

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits		RPD	RPD Limit
10:2 FTS	24.7	23.64		ng/L		96	47 - 141		10	30
HFPODA	25.6	21.38		ng/L		84	53 - 131		2	30
NEtFOSA	25.6	24.36		ng/L		95	67 - 135		2	30
NEtFOSAA	25.6	24.28		ng/L		95	63 - 130		13	30
NEtFOSE	25.6	24.88		ng/L		97	65 - 132		5	30
NMeFOSA	25.6	24.16		ng/L		94	53 - 167		4	30
NMeFOSAA	25.6	22.73		ng/L		89	62 - 131		1	30
NMeFOSE	25.6	22.75		ng/L		89	65 - 130		6	30
Perfluorobutanesulfonic acid	22.7	19.30		ng/L		85	64 - 132		2	30
Perfluorobutanoic acid	25.6	23.54		ng/L		92	58 - 130		3	30
Perfluorodecanesulfonic acid	24.7	20.60		ng/L		83	55 - 130		7	30
Perfluorodecanoic acid	25.6	22.17		ng/L		87	62 - 133		2	30
Perfluorododecanesulfonic acid (PFDoS)	24.8	20.89		ng/L		84	56 - 130		7	30
Perfluorododecanoic acid	25.6	22.48		ng/L		88	61 - 132		3	30
Perfluoroheptanesulfonic acid	24.4	20.63		ng/L		85	59 - 130		2	30
Perfluoroheptanoic acid	25.6	22.79		ng/L		89	64 - 130		3	30
Perfluorohexadecanoic acid	25.6	22.42		ng/L		88	50 - 130		7	30
Perfluorohexanesulfonic acid	23.3	19.75		ng/L		85	62 - 130		2	30
Perfluorohexanoic acid	25.6	22.67		ng/L		89	59 - 130		8	30
Perfluorononanesulfonic acid	24.6	21.15		ng/L		86	56 - 130		2	30
Perfluorononanoic acid	25.6	22.79		ng/L		89	63 - 133		1	30
Perfluorooctadecanoic acid	25.6	25.03		ng/L		98	45 - 137		9	30
Perfluorooctanesulfonamide	25.6	25.27		ng/L		99	67 - 132		5	30
Perfluorooctanesulfonic acid	23.7	20.59		ng/L		87	62 - 130		3	30
Perfluorooctanoic acid	25.6	22.99		ng/L		90	58 - 132		7	30
Perfluoropentanesulfonic acid	24.0	19.79		ng/L		82	64 - 132		1	30
Perfluoropentanoic acid	25.6	22.99		ng/L		90	60 - 130		3	30
Perfluorotetradecanoic acid	25.6	22.89		ng/L		89	62 - 131		6	30
Perfluorotridecanoic acid	25.6	23.07		ng/L		90	59 - 136		3	30
Perfluoroundecanoic acid	25.6	23.76		ng/L		93	62 - 131		7	30

Isotope Dilution	LCSD		Limits
	%Recovery	Qualifier	
13C8 FOSA	105		10 - 155
13C3 HFPO-DA	104		13 - 170
13C4 PFBA	112		22 - 174
13C3 PFBS	123		34 - 200
13C6 PFDA	115		53 - 151
13C2-PFDoDA	106		22 - 165
13C4 PFHpA	111		40 - 165
13C5 PFHxA	108		28 - 166
13C3 PFHxS	113		48 - 169
13C9 PFNA	111		52 - 168
13C8 PFOA	109		52 - 153
13C8 PFOS	112		59 - 155
13C5 PFPeA	113		33 - 196
13C2 PFTeDA	102		10 - 171
13C7 PFUnA	104		41 - 163
d5-NEtFOSAA	114		34 - 181

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-460615/3-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample Dup

Prep Type: Pre-Treatment

Prep Batch: 460615

Isotope Dilution	LCSD		Limits
	%Recovery	Qualifier	
d9-N-EtFOSE-M	72		10 - 151
d5-NEtPFOSA	61		10 - 130
d3-NMeFOSAA	111		38 - 168
d7-N-MeFOSE-M	75		10 - 149
d3-NMePFOSA	62		10 - 130
M2-4:2 FTS	111		35 - 200
M2-6:2 FTS	122		40 - 200
M2-8:2 FTS	115		37 - 200

Lab Sample ID: MB 410-464649/1-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Method Blank

Prep Type: Pre-Treatment

Prep Batch: 464649

Analyte	MB		RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
	Result	Qualifier							
9Cl-PF3ONS	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
11Cl-PF3OUdS	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
4:2 Fluorotelomer sulfonic acid	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
6:2 Fluorotelomer sulfonic acid	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
8:2 Fluorotelomer sulfonic acid	ND		2.00	0.600	ng/L		01/18/24 09:54	01/19/24 19:46	1
10:2 FTS	ND		2.00	0.800	ng/L		01/18/24 09:54	01/19/24 19:46	1
HFPODA	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
NEtFOSA	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
NEtFOSAA	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
NEtFOSE	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
NMeFOSA	ND		2.00	0.700	ng/L		01/18/24 09:54	01/19/24 19:46	1
NMeFOSAA	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
NMeFOSE	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorobutanesulfonic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorobutanoic acid	ND		2.00	1.00	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorodecanesulfonic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorodecanoic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorododecanesulfonic acid (PFDoS)	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorododecanoic acid	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluoroheptanesulfonic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluoroheptanoic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorohexadecanoic acid	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorohexanesulfonic acid	ND		2.00	0.200	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorohexanoic acid	ND		2.00	1.00	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorononanesulfonic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorononanoic acid	ND		2.00	0.200	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorooctadecanoic acid	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorooctanesulfonamide	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorooctanesulfonic acid	ND		2.00	0.500	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorooctanoic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluoropentanesulfonic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluoropentanoic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: MB 410-464649/1-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Method Blank

Prep Type: Pre-Treatment

Prep Batch: 464649

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorotetradecanoic acid	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluorotridecanoic acid	ND		2.00	0.400	ng/L		01/18/24 09:54	01/19/24 19:46	1
Perfluoroundecanoic acid	ND		2.00	0.300	ng/L		01/18/24 09:54	01/19/24 19:46	1
Isotope Dilution	MB %Recovery	MB Qualifier	Limits				Prepared	Analyzed	Dil Fac
13C8 FOSA	68		10 - 155				01/18/24 09:54	01/19/24 19:46	1
13C3 HFPO-DA	78		13 - 170				01/18/24 09:54	01/19/24 19:46	1
13C4 PFBA	87		22 - 174				01/18/24 09:54	01/19/24 19:46	1
13C3 PFBS	90		34 - 200				01/18/24 09:54	01/19/24 19:46	1
13C6 PFDA	85		53 - 151				01/18/24 09:54	01/19/24 19:46	1
13C2-PFDoDA	81		22 - 165				01/18/24 09:54	01/19/24 19:46	1
13C4 PFHpA	82		40 - 165				01/18/24 09:54	01/19/24 19:46	1
13C5 PFHxA	81		28 - 166				01/18/24 09:54	01/19/24 19:46	1
13C3 PFHxS	81		48 - 169				01/18/24 09:54	01/19/24 19:46	1
13C9 PFNA	93		52 - 168				01/18/24 09:54	01/19/24 19:46	1
13C8 PFOA	85		52 - 153				01/18/24 09:54	01/19/24 19:46	1
13C8 PFOS	84		59 - 155				01/18/24 09:54	01/19/24 19:46	1
13C5 PFPeA	86		33 - 196				01/18/24 09:54	01/19/24 19:46	1
13C2 PFTeDA	74		10 - 171				01/18/24 09:54	01/19/24 19:46	1
13C7 PFUnA	77		41 - 163				01/18/24 09:54	01/19/24 19:46	1
d5-NEtFOSAA	118		34 - 181				01/18/24 09:54	01/19/24 19:46	1
d9-N-EtFOSE-M	71		10 - 151				01/18/24 09:54	01/19/24 19:46	1
d5-NEtPFOSA	61		10 - 130				01/18/24 09:54	01/19/24 19:46	1
d3-NMeFOSAA	96		38 - 168				01/18/24 09:54	01/19/24 19:46	1
d7-N-MeFOSE-M	67		10 - 149				01/18/24 09:54	01/19/24 19:46	1
d3-NMePFOSA	56		10 - 130				01/18/24 09:54	01/19/24 19:46	1
M2-4:2 FTS	82		35 - 200				01/18/24 09:54	01/19/24 19:46	1
M2-6:2 FTS	111		40 - 200				01/18/24 09:54	01/19/24 19:46	1
M2-8:2 FTS	146		37 - 200				01/18/24 09:54	01/19/24 19:46	1

Lab Sample ID: LCS 410-464649/2-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample

Prep Type: Pre-Treatment

Prep Batch: 464649

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
9Cl-PF3ONS	23.8	21.70		ng/L		91	60 - 130
11Cl-PF3OUdS	23.8	21.63		ng/L		91	57 - 130
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	24.2	20.50		ng/L		85	61 - 130
4:2 Fluorotelomer sulfonic acid	23.9	22.92		ng/L		96	61 - 131
6:2 Fluorotelomer sulfonic acid	24.3	22.13		ng/L		91	61 - 132
8:2 Fluorotelomer sulfonic acid	24.5	23.02		ng/L		94	55 - 134
10:2 FTS	24.7	26.25		ng/L		106	47 - 141
HFPODA	25.6	23.73		ng/L		93	53 - 131
NEtFOSA	25.6	23.88		ng/L		93	67 - 135
NEtFOSAA	25.6	21.46		ng/L		84	63 - 130
NEtFOSE	25.6	25.35		ng/L		99	65 - 132
NMeFOSA	25.6	23.15		ng/L		90	53 - 167
NMeFOSAA	25.6	21.55		ng/L		84	62 - 131

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCS 410-464649/2-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample

Prep Type: Pre-Treatment

Prep Batch: 464649

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
NMeFOSE	25.6	22.29		ng/L		87	65 - 130
Perfluorobutanesulfonic acid	22.7	19.76		ng/L		87	64 - 132
Perfluorobutanoic acid	25.6	23.87		ng/L		93	58 - 130
Perfluorodecanesulfonic acid	24.7	22.08		ng/L		89	55 - 130
Perfluorodecanoic acid	25.6	23.42		ng/L		91	62 - 133
Perfluorododecanesulfonic acid (PFDoS)	24.8	22.78		ng/L		92	56 - 130
Perfluorododecanoic acid	25.6	22.31		ng/L		87	61 - 132
Perfluoroheptanesulfonic acid	24.4	21.79		ng/L		89	59 - 130
Perfluoroheptanoic acid	25.6	22.48		ng/L		88	64 - 130
Perfluorohexadecanoic acid	25.6	23.12		ng/L		90	50 - 130
Perfluorohexanesulfonic acid	23.3	20.13		ng/L		86	62 - 130
Perfluorohexanoic acid	25.6	22.66		ng/L		89	59 - 130
Perfluorononanesulfonic acid	24.6	22.47		ng/L		91	56 - 130
Perfluorononanoic acid	25.6	24.42		ng/L		95	63 - 133
Perfluorooctadecanoic acid	25.6	25.92		ng/L		101	45 - 137
Perfluorooctanesulfonamide	25.6	25.58		ng/L		100	67 - 132
Perfluorooctanesulfonic acid	23.7	21.39		ng/L		90	62 - 130
Perfluorooctanoic acid	25.6	22.79		ng/L		89	58 - 132
Perfluoropentanesulfonic acid	24.0	21.31		ng/L		89	64 - 132
Perfluoropentanoic acid	25.6	22.35		ng/L		87	60 - 130
Perfluorotetradecanoic acid	25.6	22.89		ng/L		89	62 - 131
Perfluorotridecanoic acid	25.6	23.91		ng/L		93	59 - 136
Perfluoroundecanoic acid	25.6	22.85		ng/L		89	62 - 131

Isotope Dilution	LCS LCS		Limits
	%Recovery	Qualifier	
13C8 FOSA	85		10 - 155
13C3 HFPO-DA	81		13 - 170
13C4 PFBA	91		22 - 174
13C3 PFBS	92		34 - 200
13C6 PFDA	91		53 - 151
13C2-PFDoDA	89		22 - 165
13C4 PFHpA	90		40 - 165
13C5 PFHxA	91		28 - 166
13C3 PFHxS	88		48 - 169
13C9 PFNA	89		52 - 168
13C8 PFOA	89		52 - 153
13C8 PFOS	88		59 - 155
13C5 PFPeA	93		33 - 196
13C2 PFTeDA	89		10 - 171
13C7 PFUnA	90		41 - 163
d5-NEtFOSAA	94		34 - 181
d9-N-EtFOSE-M	73		10 - 151
d5-NEtPFOSA	63		10 - 130
d3-NMeFOSAA	87		38 - 168
d7-N-MeFOSE-M	76		10 - 149
d3-NMePFOSA	64		10 - 130
M2-4:2 FTS	91		35 - 200
M2-6:2 FTS	95		40 - 200

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCS 410-464649/2-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample

Prep Type: Pre-Treatment

Prep Batch: 464649

Isotope Dilution	LCS LCS		Limits
	%Recovery	Qualifier	
M2-8:2 FTS	96		37 - 200

Lab Sample ID: LCSD 410-464649/3-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample Dup

Prep Type: Pre-Treatment

Prep Batch: 464649

Analyte	Spike Added	LCSD LCSD		Unit	D	%Rec	%Rec		RPD	Limit
		Result	Qualifier				Limits	RPD		
9CI-PF3ONS	23.8	20.90		ng/L		88	60 - 130	4	30	
11CI-PF3OUdS	23.8	20.90		ng/L		88	57 - 130	3	30	
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	24.2	19.89		ng/L		82	61 - 130	3	30	
4:2 Fluorotelomer sulfonic acid	23.9	22.32		ng/L		93	61 - 131	3	30	
6:2 Fluorotelomer sulfonic acid	24.3	21.66		ng/L		89	61 - 132	2	30	
8:2 Fluorotelomer sulfonic acid	24.5	23.85		ng/L		97	55 - 134	4	30	
10:2 FTS	24.7	24.07		ng/L		98	47 - 141	9	30	
HFPODA	25.6	22.42		ng/L		88	53 - 131	6	30	
NEtFOSA	25.6	24.14		ng/L		94	67 - 135	1	30	
NEtFOSAA	25.6	23.06		ng/L		90	63 - 130	7	30	
NEtFOSE	25.6	24.83		ng/L		97	65 - 132	2	30	
NMeFOSA	25.6	24.73		ng/L		97	53 - 167	7	30	
NMeFOSAA	25.6	22.51		ng/L		88	62 - 131	4	30	
NMeFOSE	25.6	23.23		ng/L		91	65 - 130	4	30	
Perfluorobutanesulfonic acid	22.7	19.39		ng/L		86	64 - 132	2	30	
Perfluorobutanoic acid	25.6	23.96		ng/L		94	58 - 130	0	30	
Perfluorodecanesulfonic acid	24.7	21.18		ng/L		86	55 - 130	4	30	
Perfluorodecanoic acid	25.6	22.77		ng/L		89	62 - 133	3	30	
Perfluorododecanesulfonic acid (PFDoS)	24.8	21.31		ng/L		86	56 - 130	7	30	
Perfluorododecanoic acid	25.6	23.32		ng/L		91	61 - 132	4	30	
Perfluoroheptanesulfonic acid	24.4	21.41		ng/L		88	59 - 130	2	30	
Perfluoroheptanoic acid	25.6	22.88		ng/L		89	64 - 130	2	30	
Perfluorohexadecanoic acid	25.6	23.04		ng/L		90	50 - 130	0	30	
Perfluorohexanesulfonic acid	23.3	20.32		ng/L		87	62 - 130	1	30	
Perfluorohexanoic acid	25.6	22.37		ng/L		87	59 - 130	1	30	
Perfluorononanesulfonic acid	24.6	22.26		ng/L		91	56 - 130	1	30	
Perfluorononanoic acid	25.6	23.47		ng/L		92	63 - 133	4	30	
Perfluorooctadecanoic acid	25.6	26.26		ng/L		103	45 - 137	1	30	
Perfluorooctanesulfonamide	25.6	26.19		ng/L		102	67 - 132	2	30	
Perfluorooctanesulfonic acid	23.7	20.78		ng/L		88	62 - 130	3	30	
Perfluorooctanoic acid	25.6	22.30		ng/L		87	58 - 132	2	30	
Perfluoropentanesulfonic acid	24.0	20.52		ng/L		85	64 - 132	4	30	
Perfluoropentanoic acid	25.6	23.22		ng/L		91	60 - 130	4	30	
Perfluorotetradecanoic acid	25.6	22.75		ng/L		89	62 - 131	1	30	
Perfluorotridecanoic acid	25.6	23.11		ng/L		90	59 - 136	3	30	
Perfluoroundecanoic acid	25.6	22.51		ng/L		88	62 - 131	1	30	

Isotope Dilution	LCSD LCSD		Limits
	%Recovery	Qualifier	
13C8 FOSA	88		10 - 155
13C3 HFPO-DA	91		13 - 170

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 IDA - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-464649/3-A

Matrix: Water

Analysis Batch: 464907

Client Sample ID: Lab Control Sample Dup

Prep Type: Pre-Treatment

Prep Batch: 464649

Isotope Dilution	LCSD		Limits
	%Recovery	Qualifier	
13C4 PFBA	94		22 - 174
13C3 PFBS	97		34 - 200
13C6 PFDA	96		53 - 151
13C2-PFDoDA	89		22 - 165
13C4 PFHpA	98		40 - 165
13C5 PFHxA	94		28 - 166
13C3 PFHxS	93		48 - 169
13C9 PFNA	95		52 - 168
13C8 PFOA	97		52 - 153
13C8 PFOS	93		59 - 155
13C5 PFPeA	94		33 - 196
13C2 PFTeDA	89		10 - 171
13C7 PFUnA	95		41 - 163
d5-NEtFOSAA	93		34 - 181
d9-N-EtFOSE-M	82		10 - 151
d5-NEtPFOSA	72		10 - 130
d3-NMeFOSAA	90		38 - 168
d7-N-MeFOSE-M	87		10 - 149
d3-NMePFOSA	70		10 - 130
M2-4:2 FTS	99		35 - 200
M2-6:2 FTS	102		40 - 200
M2-8:2 FTS	93		37 - 200

Method: 537 TOP - Fluorinated Alkyl Substances

Lab Sample ID: MB 410-448516/2-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Method Blank

Prep Type: Post-Treatment

Prep Batch: 448516

Analyte	MB MB		RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
	Result	Qualifier							
9CI-PF3ONS	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
11CI-PF3OUdS	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
DONA	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
10:2 Fluorotelomer sulfonic acid	ND		10.0	4.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
4:2 Fluorotelomer sulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
6:2 Fluorotelomer sulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
8:2 Fluorotelomer sulfonic acid	ND		10.0	3.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
HFPODA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
NEtFOSA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
NEtFOSAA	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
NEtFOSE	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
NMeFOSA	ND		10.0	3.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
NMeFOSAA	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
NMeFOSE	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorobutanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorobutanoic acid	ND		10.0	5.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorodecanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorodecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances (Continued)

Lab Sample ID: MB 410-448516/2-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Method Blank

Prep Type: Post-Treatment

Prep Batch: 448516

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanesulfonic acid (PFDoS)	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorododecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluoroheptanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluoroheptanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorohexadecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorohexanesulfonic acid	ND		10.0	1.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorohexanoic acid	ND		10.0	5.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorononanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorononanoic acid	ND		10.0	1.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorooctadecanoic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorooctanesulfonamide	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorooctanesulfonic acid	ND		10.0	2.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorooctanoic acid	2.596	J I	10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluoropentanesulfonic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluoropentanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorotetradecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluorotridecanoic acid	ND		10.0	2.00	ng/L		11/30/23 10:08	12/05/23 18:21	1
Perfluoroundecanoic acid	ND		10.0	1.50	ng/L		11/30/23 10:08	12/05/23 18:21	1

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C8 FOSA	87		10 - 155	11/30/23 10:08	12/05/23 18:21	1
13C3 HFPO-DA	94		13 - 170	11/30/23 10:08	12/05/23 18:21	1
13C4 PFBA	40		22 - 174	11/30/23 10:08	12/05/23 18:21	1
13C3 PFBS	99		34 - 200	11/30/23 10:08	12/05/23 18:21	1
13C6 PFDA	100		53 - 151	11/30/23 10:08	12/05/23 18:21	1
13C2-PFDoDA	92		22 - 165	11/30/23 10:08	12/05/23 18:21	1
13C4 PFHpA	106		40 - 165	11/30/23 10:08	12/05/23 18:21	1
13C5 PFHxA	100		28 - 166	11/30/23 10:08	12/05/23 18:21	1
13C3 PFHxS	108		48 - 169	11/30/23 10:08	12/05/23 18:21	1
13C9 PFNA	104		52 - 168	11/30/23 10:08	12/05/23 18:21	1
13C8 PFOA	98		52 - 153	11/30/23 10:08	12/05/23 18:21	1
13C8 PFOS	97		59 - 155	11/30/23 10:08	12/05/23 18:21	1
13C5 PFPeA	102		33 - 196	11/30/23 10:08	12/05/23 18:21	1
13C2 PFTeDA	81		10 - 171	11/30/23 10:08	12/05/23 18:21	1
13C7 PFUnA	92		41 - 163	11/30/23 10:08	12/05/23 18:21	1
d5-NEtFOSAA	92		34 - 181	11/30/23 10:08	12/05/23 18:21	1
d9-N-EtFOSE-M	89		10 - 151	11/30/23 10:08	12/05/23 18:21	1
d5-NEtPFOSA	75		10 - 130	11/30/23 10:08	12/05/23 18:21	1
d7-N-MeFOSE-M	86		10 - 149	11/30/23 10:08	12/05/23 18:21	1
d3-NMePFOSA	70		10 - 130	11/30/23 10:08	12/05/23 18:21	1
M2-6:2 FTS	96		40 - 200	11/30/23 10:08	12/05/23 18:21	1
M2-8:2 FTS	100		37 - 200	11/30/23 10:08	12/05/23 18:21	1

Surrogate	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C2 PFHxA	92		26 - 150	11/30/23 10:08	12/05/23 18:21	1
13C4 PFOA	90		45 - 147	11/30/23 10:08	12/05/23 18:21	1
13C2 PFUnA	90		11 - 187	11/30/23 10:08	12/05/23 18:21	1

Eurofins Raleigh

QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances (Continued)

Lab Sample ID: LCS 410-448516/3-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Lab Control Sample

Prep Type: Post-Treatment

Prep Batch: 448516

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
9CI-PF3ONS	119	118.2		ng/L		99	60 - 130
11CI-PF3OUdS	119	126.4		ng/L		106	57 - 130
DONA	121	119.4		ng/L		99	61 - 130
10:2 Fluorotelomer sulfonic acid	123	107.8		ng/L		87	47 - 141
4:2 Fluorotelomer sulfonic acid	120	126.7		ng/L		106	61 - 131
6:2 Fluorotelomer sulfonic acid	121	129.6		ng/L		107	61 - 132
8:2 Fluorotelomer sulfonic acid	123	116.7		ng/L		95	55 - 134
HFPODA	128	120.5		ng/L		94	53 - 131
NEtFOSA	128	116.1		ng/L		91	67 - 135
NEtFOSAA	128	135.2		ng/L		106	63 - 130
NEtFOSE	128	130.0		ng/L		102	65 - 132
NMeFOSA	128	125.4		ng/L		98	53 - 167
NMeFOSAA	128	144.1	I	ng/L		113	62 - 131
NMeFOSE	128	127.6		ng/L		100	65 - 130
Perfluorobutanesulfonic acid	113	110.7		ng/L		98	64 - 132
Perfluorobutanoic acid	128	137.4		ng/L		107	58 - 130
Perfluorodecanesulfonic acid	123	120.2	I	ng/L		97	55 - 130
Perfluorodecanoic acid	128	118.1	I	ng/L		92	62 - 133
Perfluorododecanesulfonic acid (PFDoS)	124	120.4		ng/L		97	56 - 130
Perfluorododecanoic acid	128	120.6	I	ng/L		94	61 - 132
Perfluoroheptanesulfonic acid	122	109.0		ng/L		89	59 - 130
Perfluoroheptanoic acid	128	126.0	I	ng/L		98	64 - 130
Perfluorohexadecanoic acid	128	135.0	I	ng/L		105	50 - 130
Perfluorohexanesulfonic acid	117	109.0		ng/L		93	62 - 130
Perfluorohexanoic acid	128	121.8	I	ng/L		95	59 - 130
Perfluorononanesulfonic acid	123	127.3		ng/L		104	56 - 130
Perfluorononanoic acid	128	122.1	I	ng/L		95	63 - 133
Perfluorooctadecanoic acid	128	155.9	I	ng/L		122	45 - 137
Perfluorooctanesulfonamide	128	135.3		ng/L		106	67 - 132
Perfluorooctanesulfonic acid	118	109.4		ng/L		92	62 - 130
Perfluorooctanoic acid	128	130.1	I	ng/L		102	58 - 132
Perfluoropentanesulfonic acid	120	114.3		ng/L		95	64 - 132
Perfluoropentanoic acid	128	124.1		ng/L		97	60 - 130
Perfluorotetradecanoic acid	128	130.5	I	ng/L		102	62 - 131
Perfluorotridecanoic acid	128	125.0	I	ng/L		98	59 - 136
Perfluoroundecanoic acid	128	120.1	I	ng/L		94	62 - 131

Isotope Dilution	LCS LCS		Limits
	%Recovery	Qualifier	
13C8 FOSA	82		10 - 155
13C3 HFPO-DA	98		13 - 170
13C4 PFBA	60		22 - 174
13C3 PFBS	100		34 - 200
13C6 PFDA	102		53 - 151
13C2-PFDoDA	96		22 - 165
13C4 PFHpA	104		40 - 165
13C5 PFHxA	100		28 - 166
13C3 PFHxS	105		48 - 169
13C9 PFNA	110		52 - 168

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances (Continued)

Lab Sample ID: LCS 410-448516/3-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Lab Control Sample

Prep Type: Post-Treatment

Prep Batch: 448516

Isotope Dilution	LCS		Limits
	%Recovery	Qualifier	
13C8 PFOA	102		52 - 153
13C8 PFOS	99		59 - 155
13C5 PFPeA	97		33 - 196
13C2 PFTeDA	82		10 - 171
13C7 PFUnA	98		41 - 163
d5-NEtFOSAA	88		34 - 181
d9-N-EtFOSE-M	87		10 - 151
d5-NEtPFOSA	69		10 - 130
d7-N-MeFOSE-M	82		10 - 149
d3-NMePFOSA	62		10 - 130
M2-6:2 FTS	96		40 - 200
M2-8:2 FTS	95		37 - 200

Surrogate	LCS		Limits
	%Recovery	Qualifier	
13C2 PFHxA	90		26 - 150
13C4 PFOA	96		45 - 147
13C2 PFUnA	91		11 - 187

Lab Sample ID: LCSD 410-448516/4-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Lab Control Sample Dup

Prep Type: Post-Treatment

Prep Batch: 448516

Analyte	Spike Added	LCSD		Unit	D	%Rec	%Rec		RPD	Limit
		Result	Qualifier				Limits	RPD		
9Cl-PF3ONS	119	130.4		ng/L		110	60 - 130	10	30	
11Cl-PF3OUdS	119	124.8		ng/L		105	57 - 130	1	30	
DONA	121	118.3		ng/L		98	61 - 130	1	30	
10:2 Fluorotelomer sulfonic acid	123	121.3		ng/L		98	47 - 141	12	30	
4:2 Fluorotelomer sulfonic acid	120	127.4		ng/L		107	61 - 131	1	30	
6:2 Fluorotelomer sulfonic acid	121	138.3		ng/L		114	61 - 132	7	30	
8:2 Fluorotelomer sulfonic acid	123	127.5		ng/L		104	55 - 134	9	30	
HFPODA	128	118.0		ng/L		92	53 - 131	2	30	
NEtFOSA	128	118.8		ng/L		93	67 - 135	2	30	
NEtFOSAA	128	137.6		ng/L		107	63 - 130	2	30	
NEtFOSE	128	132.0		ng/L		103	65 - 132	2	30	
NMeFOSA	128	124.1		ng/L		97	53 - 167	1	30	
NMeFOSAA	128	137.2	I	ng/L		107	62 - 131	5	30	
NMeFOSE	128	123.6		ng/L		97	65 - 130	3	30	
Perfluorobutanesulfonic acid	113	106.3		ng/L		94	64 - 132	4	30	
Perfluorobutanoic acid	128	145.0		ng/L		113	58 - 130	5	30	
Perfluorodecanesulfonic acid	123	122.5	I	ng/L		99	55 - 130	2	30	
Perfluorodecanoic acid	128	118.9	I	ng/L		93	62 - 133	1	30	
Perfluorododecanesulfonic acid (PFDoS)	124	115.6		ng/L		93	56 - 130	4	30	
Perfluorododecanoic acid	128	126.1	I	ng/L		99	61 - 132	4	30	
Perfluoroheptanesulfonic acid	122	106.2		ng/L		87	59 - 130	3	30	
Perfluoroheptanoic acid	128	129.3	I	ng/L		101	64 - 130	3	30	
Perfluorohexadecanoic acid	128	128.2	I	ng/L		100	50 - 130	5	30	
Perfluorohexanesulfonic acid	117	109.9		ng/L		94	62 - 130	1	30	
Perfluorohexanoic acid	128	134.5	I	ng/L		105	59 - 130	10	30	

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: 537 TOP - Fluorinated Alkyl Substances (Continued)

Lab Sample ID: LCSD 410-448516/4-A

Matrix: Water

Analysis Batch: 450333

Client Sample ID: Lab Control Sample Dup

Prep Type: Post-Treatment

Prep Batch: 448516

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorononanesulfonic acid	123	136.0		ng/L		111	56 - 130	7	30
Perfluorononanoic acid	128	122.9	I	ng/L		96	63 - 133	1	30
Perfluorooctadecanoic acid	128	147.7	I	ng/L		115	45 - 137	5	30
Perfluorooctanesulfonamide	128	139.9		ng/L		109	67 - 132	3	30
Perfluorooctanesulfonic acid	118	109.8		ng/L		93	62 - 130	0	30
Perfluorooctanoic acid	128	129.3	I	ng/L		101	58 - 132	1	30
Perfluoropentanesulfonic acid	120	110.6		ng/L		92	64 - 132	3	30
Perfluoropentanoic acid	128	121.4		ng/L		95	60 - 130	2	30
Perfluorotetradecanoic acid	128	124.9	I	ng/L		98	62 - 131	4	30
Perfluorotridecanoic acid	128	133.9	I	ng/L		105	59 - 136	7	30
Perfluoroundecanoic acid	128	130.3	I	ng/L		102	62 - 131	8	30

Isotope Dilution	LCSD %Recovery	LCSD Qualifier	Limits
13C8 FOSA	83		10 - 155
13C3 HFPO-DA	94		13 - 170
13C4 PFBA	9	*5-	22 - 174
13C3 PFBS	104		34 - 200
13C6 PFDA	105		53 - 151
13C2-PFDoDA	98		22 - 165
13C4 PFHpA	107		40 - 165
13C5 PFHxA	95		28 - 166
13C3 PFHxS	106		48 - 169
13C9 PFNA	120		52 - 168
13C8 PFOA	101		52 - 153
13C8 PFOS	104		59 - 155
13C5 PFPeA	97		33 - 196
13C2 PFTeDA	88		10 - 171
13C7 PFUnA	92		41 - 163
d5-NEtFOSAA	93		34 - 181
d9-N-EtFOSE-M	96		10 - 151
d5-NEtPFOSA	75		10 - 130
d7-N-MeFOSE-M	91		10 - 149
d3-NMePFOSA	67		10 - 130
M2-6:2 FTS	98		40 - 200
M2-8:2 FTS	91		37 - 200

Surrogate	LCSD %Recovery	LCSD Qualifier	Limits
13C2 PFHxA	92		26 - 150
13C4 PFOA	92		45 - 147
13C2 PFUnA	94		11 - 187

Method: ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Lab Sample ID: MB 410-458277/1-A

Matrix: Water

Analysis Batch: 458299

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 458277

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	ND		2.00	1.00	ug/L		12/28/23 09:19	12/28/23 10:18	1

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QC Sample Results

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method: ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Lab Sample ID: LCS 410-458277/2-A

Matrix: Water

Analysis Batch: 458299

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 458277

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Adsorbable Organic Fluorine (AOF)	20.3	21.65		ug/L		107	50 - 150

Lab Sample ID: LCSD 410-458277/3-A

Matrix: Water

Analysis Batch: 458299

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 458277

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Adsorbable Organic Fluorine (AOF)	20.3	21.70		ug/L		107	50 - 150	0	20

QC Association Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

LCMS

Prep Batch: 448516

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Post-Treatment	Water	TOP Post Prep	
MB 410-448516/1-A	Method Blank	Post-Treatment	Water	TOP Post Prep	
MB 410-448516/2-A	Method Blank	Post-Treatment	Water	TOP Post Prep	
LCS 410-448516/3-A	Lab Control Sample	Post-Treatment	Water	TOP Post Prep	
LCSD 410-448516/4-A	Lab Control Sample Dup	Post-Treatment	Water	TOP Post Prep	

Analysis Batch: 450333

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Post-Treatment	Water	537 TOP	448516
MB 410-448516/1-A	Method Blank	Post-Treatment	Water	537 TOP	448516
MB 410-448516/2-A	Method Blank	Post-Treatment	Water	537 TOP	448516
LCS 410-448516/3-A	Lab Control Sample	Post-Treatment	Water	537 TOP	448516
LCSD 410-448516/4-A	Lab Control Sample Dup	Post-Treatment	Water	537 TOP	448516

Prep Batch: 458277

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Total/NA	Water	NONE	
752-13791-5	MPCA-SAFF-111523-Stock	Total/NA	Water	NONE	
MB 410-458277/1-A	Method Blank	Total/NA	Water	NONE	
LCS 410-458277/2-A	Lab Control Sample	Total/NA	Water	NONE	
LCSD 410-458277/3-A	Lab Control Sample Dup	Total/NA	Water	NONE	

Analysis Batch: 458299

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Total/NA	Water	ELLE SOP	458277
752-13791-5	MPCA-SAFF-111523-Stock	Total/NA	Water	ELLE SOP	458277
MB 410-458277/1-A	Method Blank	Total/NA	Water	ELLE SOP	458277
LCS 410-458277/2-A	Lab Control Sample	Total/NA	Water	ELLE SOP	458277
LCSD 410-458277/3-A	Lab Control Sample Dup	Total/NA	Water	ELLE SOP	458277

Prep Batch: 460615

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	TOP Pre - Prep	
752-13791-2 - RA	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	TOP Pre - Prep	
MB 410-460615/1-A	Method Blank	Pre-Treatment	Water	TOP Pre - Prep	
LCS 410-460615/2-A	Lab Control Sample	Pre-Treatment	Water	TOP Pre - Prep	
LCSD 410-460615/3-A	Lab Control Sample Dup	Pre-Treatment	Water	TOP Pre - Prep	

Analysis Batch: 461552

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	537 IDA	460615

Analysis Batch: 461937

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 410-460615/1-A	Method Blank	Pre-Treatment	Water	537 IDA	460615

Prep Batch: 464649

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2 - RE	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	TOP Pre - Prep	
MB 410-464649/1-A	Method Blank	Pre-Treatment	Water	TOP Pre - Prep	
LCS 410-464649/2-A	Lab Control Sample	Pre-Treatment	Water	TOP Pre - Prep	

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QC Association Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

LCMS (Continued)

Prep Batch: 464649 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCSD 410-464649/3-A	Lab Control Sample Dup	Pre-Treatment	Water	TOP Pre - Prep	

Analysis Batch: 464907

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2 - RA	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	537 IDA	460615
752-13791-2 - RE	MPCA-SAFF-111523-OP1	Pre-Treatment	Water	537 IDA	464649
MB 410-464649/1-A	Method Blank	Pre-Treatment	Water	537 IDA	464649
LCS 410-460615/2-A	Lab Control Sample	Pre-Treatment	Water	537 IDA	460615
LCS 410-464649/2-A	Lab Control Sample	Pre-Treatment	Water	537 IDA	464649
LCSD 410-460615/3-A	Lab Control Sample Dup	Pre-Treatment	Water	537 IDA	460615
LCSD 410-464649/3-A	Lab Control Sample Dup	Pre-Treatment	Water	537 IDA	464649

Analysis Batch: 465811

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
752-13791-2	MPCA-SAFF-111523-OP1	Total/NA	Water	Total PFCA-Dif	

Lab Chronicle

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Client Sample ID: MPCA-SAFF-111523-OP1

Lab Sample ID: 752-13791-2

Date Collected: 11/15/23 11:22

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Pre-Treatment	Prep	TOP Pre - Prep			460615	S7AC	ELLE	01/05/24 09:12
Pre-Treatment	Analysis	537 IDA		1	461552	DQV6	ELLE	01/09/24 16:32
Pre-Treatment	Prep	TOP Pre - Prep	RA		460615	S7AC	ELLE	01/05/24 09:12
Pre-Treatment	Analysis	537 IDA	RA	1	464907	R7RE	ELLE	01/19/24 17:16
Pre-Treatment	Prep	TOP Pre - Prep	RE		464649	S7AC	ELLE	01/18/24 09:54
Pre-Treatment	Analysis	537 IDA	RE	1	464907	R7RE	ELLE	01/19/24 20:26
Post-Treatment	Prep	TOP Post Prep			448516	S7AC	ELLE	11/30/23 10:08
Post-Treatment	Analysis	537 TOP		1	450333	V4RH	ELLE	12/05/23 19:05
Total/NA	Prep	NONE			458277	QLP7	ELLE	12/28/23 09:19
Total/NA	Analysis	ELLE SOP		1	458299	F9DU	ELLE	12/29/23 05:16
Total/NA	Analysis	Total PFCA-Dif		1	465811	V3JD	ELLE	01/23/24 10:59

Client Sample ID: MPCA-SAFF-111523-Stock

Lab Sample ID: 752-13791-5

Date Collected: 11/15/23 12:00

Matrix: Water

Date Received: 11/16/23 15:20

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	NONE			458277	QLP7	ELLE	12/28/23 09:19
Total/NA	Analysis	ELLE SOP		1	458299	F9DU	ELLE	12/29/23 06:55

Laboratory References:
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Accreditation/Certification Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
North Carolina (WW/SW)	State	521	12-31-24

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
537 IDA	TOP Pre - Prep	Water	10:2 FTS
537 IDA	TOP Pre - Prep	Water	11Cl-PF3OUdS
537 IDA	TOP Pre - Prep	Water	4,8-Dioxa-3H-perfluorononanoic acid (ADONA)
537 IDA	TOP Pre - Prep	Water	4:2 Fluorotelomer sulfonic acid
537 IDA	TOP Pre - Prep	Water	6:2 Fluorotelomer sulfonic acid
537 IDA	TOP Pre - Prep	Water	8:2 Fluorotelomer sulfonic acid
537 IDA	TOP Pre - Prep	Water	9Cl-PF3ONS
537 IDA	TOP Pre - Prep	Water	HFPODA
537 IDA	TOP Pre - Prep	Water	NEtFOSA
537 IDA	TOP Pre - Prep	Water	NEtFOSAA
537 IDA	TOP Pre - Prep	Water	NEtFOSE
537 IDA	TOP Pre - Prep	Water	NMeFOSA
537 IDA	TOP Pre - Prep	Water	NMeFOSAA
537 IDA	TOP Pre - Prep	Water	NMeFOSE
537 IDA	TOP Pre - Prep	Water	Perfluorobutanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluorobutanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorodecanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluorodecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorododecanesulfonic acid (PFDoS)
537 IDA	TOP Pre - Prep	Water	Perfluorododecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluoroheptanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluoroheptanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorohexadecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorohexanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluorohexanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorononanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluorononanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorooctadecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorooctanesulfonamide
537 IDA	TOP Pre - Prep	Water	Perfluorooctanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluorooctanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluoropentanesulfonic acid
537 IDA	TOP Pre - Prep	Water	Perfluoropentanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorotetradecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluorotridecanoic acid
537 IDA	TOP Pre - Prep	Water	Perfluoroundecanoic acid
537 TOP	TOP Post Prep	Water	10:2 Fluorotelomer sulfonic acid
537 TOP	TOP Post Prep	Water	11Cl-PF3OUdS
537 TOP	TOP Post Prep	Water	4:2 Fluorotelomer sulfonic acid
537 TOP	TOP Post Prep	Water	6:2 Fluorotelomer sulfonic acid
537 TOP	TOP Post Prep	Water	8:2 Fluorotelomer sulfonic acid
537 TOP	TOP Post Prep	Water	9Cl-PF3ONS
537 TOP	TOP Post Prep	Water	DONA
537 TOP	TOP Post Prep	Water	HFPODA
537 TOP	TOP Post Prep	Water	NEtFOSA

Accreditation/Certification Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC (Continued)

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.			
Analysis Method	Prep Method	Matrix	Analyte
537 TOP	TOP Post Prep	Water	NETFOSAA
537 TOP	TOP Post Prep	Water	NETFOSE
537 TOP	TOP Post Prep	Water	NMeFOSA
537 TOP	TOP Post Prep	Water	NMeFOSAA
537 TOP	TOP Post Prep	Water	NMeFOSE
537 TOP	TOP Post Prep	Water	Perfluorobutanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluorobutanoic acid
537 TOP	TOP Post Prep	Water	Perfluorodecanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluorodecanoic acid
537 TOP	TOP Post Prep	Water	Perfluorododecanesulfonic acid (PFDoS)
537 TOP	TOP Post Prep	Water	Perfluorododecanoic acid
537 TOP	TOP Post Prep	Water	Perfluoroheptanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluoroheptanoic acid
537 TOP	TOP Post Prep	Water	Perfluorohexadecanoic acid
537 TOP	TOP Post Prep	Water	Perfluorohexanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluorohexanoic acid
537 TOP	TOP Post Prep	Water	Perfluorononanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluorononanoic acid
537 TOP	TOP Post Prep	Water	Perfluorooctadecanoic acid
537 TOP	TOP Post Prep	Water	Perfluorooctanesulfonamide
537 TOP	TOP Post Prep	Water	Perfluorooctanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluorooctanoic acid
537 TOP	TOP Post Prep	Water	Perfluoropentanesulfonic acid
537 TOP	TOP Post Prep	Water	Perfluoropentanoic acid
537 TOP	TOP Post Prep	Water	Perfluorotetradecanoic acid
537 TOP	TOP Post Prep	Water	Perfluorotridecanoic acid
537 TOP	TOP Post Prep	Water	Perfluoroundecanoic acid
ELLE SOP	NONE	Water	Adsorbable Organic Fluorine (AOF)
Total PFCA-Dif		Water	Perfluorobutanoic acid
Total PFCA-Dif		Water	Perfluoroheptanoic acid
Total PFCA-Dif		Water	Perfluorohexanoic acid
Total PFCA-Dif		Water	Perfluorononanoic acid
Total PFCA-Dif		Water	Perfluorooctanoic acid
Total PFCA-Dif		Water	Perfluoropentanoic acid
Total PFCA-Dif		Water	Total PFCA

Method Summary

Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Method	Method Description	Protocol	Laboratory
537 IDA	EPA 537 Isotope Dilution	EPA	ELLE
537 TOP	Fluorinated Alkyl Substances	EPA	ELLE
ELLE SOP	Total or Organic Fluorine by Combustion Ion Chromatography	ELLE - Lancaster	ELLE
Total PFCA-Dif	Total PFCA (Treatment Difference)	TAL SOP	ELLE
NONE	Preparation, Fluorine	ELLE - Lancaster	ELLE
TOP Post Prep	Solid-Phase Extraction (SPE)	SW846	ELLE
TOP Pre - Prep	Solid-Phase Extraction (SPE)	SW846	ELLE

Protocol References:

ELLE - Lancaster = Eurofins Lancaster, Facility Standard Operating Procedure.

EPA = US Environmental Protection Agency

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

TAL SOP = TestAmerica Laboratories, Standard Operating Procedure

Laboratory References:

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Sample Summary

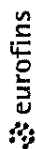
Client: 374Water Inc
Project/Site: PFAs (MPCA-SAFF)

Job ID: 752-13791-2

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
752-13791-2	MPCA-SAFF-111523-OP1	Water	11/15/23 11:22	11/16/23 15:20
752-13791-5	MPCA-SAFF-111523-Stock	Water	11/15/23 12:00	11/16/23 15:20

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16

Chain of Custody Record



Environment Testing

Client Information		Sampler		Lab Pmt:		Carrier Tracking No(s):		COC No:			
Client Contact: Russ Schmitz		Phone: 919 452 4980		Lab Pmt: Andros, John		Carrier Tracking No(s):		COC No: 680-151309-54750.1			
Company: 374Water Inc		PWSID:		E-Mail: John.Andros@eurofins.com		State of Origin: NC		Page: Page 1 of 2			
Address: 3710 Shannon Rd Suite 51877		Due Date Requested:		Analysis Requested		Job #:					
City: Durham		TAT Requested (days): Standard									
State, Zip: NC, 27717		Compliance Project: ☐ Yes ☒ No									
Phone: 919-452-4980		Advance Payment Required									
Email: rs@374water.com		PO #:									
Project Name: PFAS		WFO #:									
Site: Raleigh Lab		Project #: 68030200									
		SSOW#:									
Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=grab)	Matrix (W=Water, S=Solid, O=Other)	Field Filled Sample (Yes or No)	Perform MS/MSD (Yes or No)	1633 PFAS List of 40	CIC Fluorine Total Fluorine	PFAS, IDA, Total PFAS, DHT	Total Number of Containers	Special Instructions/Note:
MPCA - SAFF-111623 - PRE	11/15/2023	10:53	G	W	☒	☒	☒	☒	☒	2	13791
MPCA - SAFF-111623 - OPI	11/15/2023	11:22	G	W	☒	☒	☒	☒	☒	7	
MPCA - SAFF-111623 - OP2	11/15/2023	13:40	G	W	☒	☒	☒	☒	☒	2	
MPCA - SAFF-111623 - Post	11/15/2023	14:15	G	W	☒	☒	☒	☒	☒	2	
MPCA - SAFF-111623 - Stock	11/15/2023	12:00	G	W	☒	☒	☒	☒	☒	4	
MPCA - SAFF-111623 - PRE	11/16/2023	10:23	G	W	☒	☒	☒	☒	☒	2	
MPCA - SAFF-111623 - OPI	11/16/2023	11:13	G	W	☒	☒	☒	☒	☒	2	
MPCA - SAFF-111623 - OP2	11/16/2023	11:34	G	W	☒	☒	☒	☒	☒	2	
MPCA - SAFF-111623 - Post	11/16/2023	12:15	G	W	☒	☒	☒	☒	☒	2	
Possible Hazard Identification ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐ Radiological ☒ PFAS											
Deliverable Requested: I, II, III, IV Other (specify)											
Empty Kit Relinquished by: _____ Date: _____											
Relinquished by: _____ Date/Time: _____ Company: _____											
Relinquished by: _____ Date/Time: _____ Company: _____											
Relinquished by: _____ Date/Time: _____ Company: _____											
Custody Seal Intact: ☐ Yes ☒ No											
Custody Seal No. _____											

Preservation Codes:
A HCL
B NaOH
C Zn Acetate
D Nitric Acid
E NaHSO4
F MeOH
G Antichlor
H Ascorbic Acid
I Ice
J DI Water
K EDTA
L EDA
Other
M Hexane
N None
O AsNaO2
P Na2OAS
Q Na2SO3
R Na2SO4
S H2SO4
T TSP Dodecahydrate
U μ
V μ
W μ
Y μ
Z μ

752-13791 COC

Special Instructions/Note:
13791

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ Return To Client ☒ Disposal By Lab ☐ Archive For _____ Months

Special Instructions/QC Requirements:

Received by: _____ Date/Time: _____ Company: _____

Received by: _____ Date/Time: _____ Company: _____

Received by: _____ Date/Time: _____ Company: _____

Cooler Temperature(s) °C and Other Remarks: _____

Ver: 06/08/2021

Login Sample Receipt Checklist

Client: 374Water Inc

Job Number: 752-13791-2

Login Number: 13791

List Source: Eurofins Raleigh

List Number: 1

Creator: Hyatt, Samantha

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	N/A	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Login Sample Receipt Checklist

Client: 374Water Inc

Job Number: 752-13791-2

Login Number: 13791

List Number: 2

Creator: Arroyo, Haley

List Source: Eurofins Lancaster Laboratories Environment Testing, LLC

List Creation: 11/17/23 01:07 PM

Question	Answer	Comment
The cooler's custody seal is intact.	True	Seals on cooler but date and time not filled out.
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature acceptable,where thermal pres is required(</=6C, not frozen).	True	
Cooler Temperature is recorded.	True	
WV:Container Temp acceptable,where thermal pres is required (</=6C, not frozen).	N/A	
WV: Container Temperature is recorded.	N/A	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
There are no discrepancies between the containers received and the COC.	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
There is sufficient vol. for all requested analyses.	True	
Is the Field Sampler's name present on COC?	False	Received project as a subcontract.
Sample custody seals are intact.	N/A	
VOA sample vials do not have headspace >6mm in diameter (none, if from WV)?	N/A	

Attachment G2: Axine Final Report



Transforming Wastewater

Document D000811-00

Minnesota Pollution Control Agency

Test Report for Axine PFAS Destructive Technology Test
on PFAS Concentrate



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Executive Summary

Axine completed benchtop testing on the PFAS concentrate sample received from the MPCA Project 1007 foam fractionation pilot site at Tablyn Park. PFAS analytical results on samples taken during and after Axine's electrochemical oxidation treatment showed 6-log (99.9999%) destruction of total concentration of PFAS compounds under the draft EPA Method 1633. Notably, PFOA and PFOS concentrations after treatment were both **3.8 ng/L**, below the 4.0 ng/L maximum contaminant level under EPA's proposed PFAS National Primary Drinking Water Regulation, while all other measured PFAS were **under the 2 ng/L reporting limit**. Note that all PFAS analytical result summaries shown in this report only include those that are detected at above the minimum reporting limit.

Total oxidizable precursor (TOP) assay and total organic fluorine (TOF) analyses showed significant removal of oxidizable precursors and total organofluorine following PFAS destruction. Fluoride ion analysis showed a 63% recovery of PFAS-bound fluorine. However, supplemental tests showed evidence indicating the remaining fluoride ion may have precipitated with metal ions and/or adsorbed onto metal hydroxides. Investigation into complete fluoride balance will require further testing with larger volumes of concentrate at the pilot-scale.

The energy required to achieve 6-log removal was 2,937 kWh/m³, with the electrical energy per order of magnitude removal (EE/O) increasing from an average of 100 kWh/m³ for the first 2 orders of magnitude of removal and then increasing to 500 – 800 kWh/m³ for subsequent orders of magnitude up to 6-log destruction. Note that these energy consumption figures are higher than those expected in pilot- and commercial-scale operations due to the relatively static conditions and less efficient mixing of the laboratory test apparatus. Commercial reactor modules used in pilot testing and commercial operation are built with power distribution and flow control elements that optimize treatment efficiency.

Following successful benchtop demonstration of PFAS treatment in this Test Program, Axine proposes to perform pilot-scale tests at the Tablyn Park pilot site following the foam fractionation concentration process. Such testing will allow Axine to further optimize energy efficiency results and develop more complete fluoride balance calculations. Pilot-scale testing would also enable Axine to explore post-treatment options that may further reduce electrochemical system footprint and energy consumption.

1.0 Overview

Axine Water Technologies ("Axine") has developed a new standard for on-site treatment of wastewater contaminated with per- and polyfluoroalkyl substances (PFAS), polymers and other organic pollutants. Our treatment systems are based on proprietary electrochemical oxidation technology which has the unique capability to treat and destroy PFAS and other organics. Our Treatment-as-a-Service (TaaS) model provides economical treatment solutions at low risk for customers.

The Minnesota Pollution Control Agency (MPCA) is conducting a Pilot Test of a foam fractionation system on PFAS-impacted water in the East Metro as a part of the Feasibility Study required under the 2018 3M Settlement with the state of Minnesota. The Pilot Study is currently being conducted to test the effectiveness of PFAS removal in groundwater and surface water at Tablyn Park in Lake Elmo. The result of the PFAS removal is a concentrated form of PFAS-containing water (concentrate), generally ranging from the 100's to 1,000's parts per billion ($\mu\text{g/L}$) PFOA/PFOS constituents.

This document describes the results of the benchtop testing ("Test Program") on the concentrate provided by the MPCA, to verify Axine's technology for effectively destroying PFAS compounds.

2.0 Objectives

The main objective of the Test Program is to verify and demonstrate the capability of Axine's electrochemical oxidation technology to achieve a minimum 99.9% destruction of all analyzable PFAS compounds present in the concentrate from the upstream foam fractionation process. The Test Program includes generating treatment curves showing incremental PFAS destruction at multiple points during the treatment process. The Test Program will also illustrate the fate of PFAS destroyed by evaluating formation of oxidizable precursors of PFAS compounds, liberation of PFAS-bound fluorine, and destruction of total organic fluorine (TOF) during treatment. Finally, the test program provides an estimate of the energy required to achieve various treatment targets.

3.0 Methodologies

3.1 Analytical Test Methods and QA/QC Procedures

Sample Storage and Transfer

All samples taken before, during, and after treatment were collected in PFAS-free HDPE bottles which were refrigerated at 4°C. Sampling included the collection of DI water blank sample to check for possible PFAS leaching. Immediately before shipment, the samples were split into different sample bottles as provided by the third-party analytical laboratory corresponding to different analytical methods to be employed. All samples were shipped to the third-party analytical laboratory in the coolers with refrigerant-free ice, using the same-day shipment service.

Analytical Test Methods

The following table describes the analyses performed during the Test Program and corresponding analytical methods. Analysis excluding COD, pH, and TOF were performed by ALS Environmental, a Canadian Association for Laboratory Accreditation (CALA) and US Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) accredited lab. TOF samples were analyzed by Bureau Veritas, accredited by the Standards Council of Canada (SCC).

Table 1 – Summary of analytical methods

Analysis	Method Description
Chemical Oxygen Demand (COD)	Axine In-house Test with HACH Method 8000: Dichromate digestion based on Standard Method 5220D
PFAS	ALS Method E745 (Extended List) and E745-L (Low Level): LC/MS/MS method for 51 PFAS compounds including those under draft EPA 1633
Total Oxidizable Precursor (TOP)	ALS Method EP745.Ox (Routine Level) and EP745.Ox-L (Low Level): Analysis after oxidation by LC/MS/MS for 28 compounds (Houtz and Sedlak, 2012)
Fluoride/Chloride	ALS Method E235: Analysis by IC based on EPA 300.1 (mod)
Total Suspended Solids (TSS) / Total Dissolved Solids (TDS)	ALS Method E160 and E162: Analysis by Gravimetry based APHA 2540 D and C (mod)
Total Metals	ALS Method E420: Analysis by Collision/Reaction Cell ICPMS based on EPA 200.2/6020B (mod)
Total Organofluorine (TOF)	Bureau Veritas Method CAM SOP-00812: Combustion by Ion Chromatography (CIC)

PFAS and Oxidizable Precursor Analytical Methods

PFAS analysis was performed by ALS Environmental, which holds ISO 17025 accreditation for all the PFAS analytes included in the PFAS analytical package. A total of 51 analytes, including all analytes from Draft US EPA Method 1633, were tested using an analytical method compatible with draft EPA 1633. ALS environmental guarantees that their PFAS analytical method meets all fundamental elements of EPA draft Method 1633 via the following practices (ALS, Environmail 34).

- LC/MS/MS with multiple reaction monitoring
- Whole sample bottle extractions for waters
- Isotope dilution where labelled PFAS isotopes are available
- Solid phase extraction for lowest required detection limits
- Extensive cleanups to remove interference
- Quantification of both linear and branched PFAS isomers

TOP assay was also performed by ALS Environmental. The TOP assay method includes two PFAS analyses, before and after chemical oxidation. The chemical oxidation process uses heat and an oxidizing agent under alkaline conditions to convert PFAS precursors into

detectable PFAS analytes prior to LC/MS/MS quantification. Total oxidizable precursors are quantified by comparing two data sets measured pre- and post-oxidation. The analytical method is based on the study published by Houtz and Sedlak (2012), which is widely adopted by academia and industry for the monitoring of PFAS precursors.

TOF analysis was performed to evaluate the removal of non-target PFAS compounds and/or their precursors. TOF was performed by Bureau Veritas using a combustion ion chromatography (CIC) method. The method involves a combustion process that heats the sample to 1,000°C in the presence of humidified oxygen gas followed by ion chromatography to quantify target analytes in the combustion output gas stream that are trapped in an absorption medium.

Analytical Data Precision and Accuracy Assurance

All third-party analytical laboratory procedures were controlled by their respective internal QA/QC control practices which generally include method blank, matrix spike, duplicate, and spiked blank tests. For instance, ALS Environmental performs duplicate tests on random samples to evaluate method precision and requires the relative percent difference between samples to be less than twice the applicable reporting limit in order to pass QA/QC evaluation. Result accuracy is also confirmed prior to release by spiking internal standards into the samples before the analysis. In the case of PFAS analysis, labelled PFOS (13C8-PFOS) is spiked as an internal standard, and a 50-150% recovery rate is required for the results to pass QA/QC.

3.2 Benchtop Test Setup

Treatment tests were performed on samples of foam fractionation concentrate using Axine's benchtop test setup shown in Figure 1. The benchtop test setup consists of a 10L glass container where the concentrate was treated with Axine's proprietary electrochemical cell. The benchtop setup is a scaled-down version of a commercial-scale reactor module, which contains 30 cells. The benchtop setup was selected for this Test Program due to the limited volume of concentrate available, as pilot test units containing commercial-scale reactor modules require a minimum 150-gal test volume.



Figure 1 Axine Benchtop Scale Setup

4.0 Wastewater Characteristics

Axine received five one-gallon HDPE bottles containing foam fractionation concentrate, which were blended to create a single five-gallon composite sample. Table 2 below summarizes the concentrations of PFAS and total oxidizable precursors (TOP) of the composite samples. Note that PFAS analytical result summaries shown in this report only include those that are detected at above the minimum reporting limit.

Table 2 – As received concentrate characteristics

Analytes	Unit	MPCA provided results	Axine - 3 rd Party Laboratory result	
<i>PFAS analysis</i>		<i>PFAS</i>	<i>PFAS</i>	<i>TOP Assay</i>
PFBA	ng/L	463	<10,000*	15,800
PFBS	ng/L	194	<2,000*	<2,000*
PFPeA	ng/L	135	<2,000*	7,800
PFPeS	ng/L	n/a	6,800	11,200
PFHxA	ng/L	2,650	2,200	8,600
PFHxS	ng/L	149,000	137,000	136,000
PFHpA	ng/L	84,800	71,400	68,000
PFHpS	ng/L	n/a	36,000	79,000

PFOA	ng/L	2,440,000	1,380,000	2,050,000
PFOS	ng/L	4,670,000	4,160,000	5,260,000
PFecHS	ng/L	n/a	202,000	n/a
PFNA	ng/L	12,000	13,600	13,400
PFDA	ng/L	14,700	16,800	12,400
PFUnA	ng/L	28	<2,000*	<2,000*
PFDaA	ng/L	<33.3	<2,000*	<2,000*
<i>Other water quality parameters</i>				
TOC	mg/L	102	20.2	
COD	mg/L	n/a	550	
TSS	mg/L	n/a	106	
TDS	mg/L	n/a	859	
Chloride	mg/L	210	204	
Fluoride	mg/L	0.11	0.119	
Sulfate	mg/L	5,500	3.89	
TOF	µg/L	n/a	3,700	
Hardness (as CaCO ₃)	mg/L	n/a	263	
pH		n/a	7.5	
Conductivity	µS/cm	n/a	1,094	

* Indicates concentration below analytical reporting limit. Note that the reporting limit was raised for the influent sample due to high expected PFAS concentration.

As shown in Table 2, the concentrations of PFAS, chloride and fluoride results are comparable to the analytical results reported by MPCA, provided to Axine prior to sample receipt. Conversely TOC and sulfate ion concentrations were lower than the MPCA provided results. The COD, conductivity, and pH results measured by Axine, were 550 mg/L, 1,094 µS/cm, and 7.5, respectively.

5.0 Test Activities and Results

5.1 Electrochemical Oxidation Treatment Test Activities and Results

The concentrate was treated by Axine's benchtop setup with no additional physical treatment. Sodium hydroxide was added to the concentrate prior to the start of treatment to maintain an alkaline pH to prevent hydrofluoric acid (HF) accumulation from liberation of PFAS-bound fluorine.

As electrolysis started, the pH of the solution decreased to 7 during the early stage of the treatment (0%-25% treatment progress). Sodium Hydroxide was added periodically to maintain a pH between 8 – 9 to prevent HF accumulation. As destruction of organics in the concentrate continued during the latter parts of the treatment process, pH began increasing. Hence, sulfuric acid was periodically added to maintain a pH between 8 - 9 to prevent hardness precipitation. No further post-treatment was performed after the electrochemical

oxidation process. Similar treatment can be expected in pilot testing and commercial reactors at slightly lower acid concentrations due to the more efficient mixing in these systems.

Samples for analysis were taken before activating the electrochemical cell, during different stages of the treatment, and after treatment. Samples collected in HDPE bottles were refrigerated (<4°C) until they are sent out for analysis, within allowable holding time for the test methods employed.

PFAS treatment results and changes in other water quality parameters throughout the electrochemical treatment process are summarized in Table 3 below.

Table 3 – Treatment Results on Concentrate

Analytes	Unit	Starting	17% Treated	33% Treated	50% Treated	67% Treated	100% Treated	Removal %
PFAS Analysis								
Sum of Reported PFAS	ng/L	6,025,800	24,480	3,144	2,400	811	7.6	99.9999%
PFBA	ng/L	<10,000	<1,000	<100	<100	<50	<20	BDL
PFBS	ng/L	<2,000	<200	<20	<20	7.3	<2	BDL
PFPeA	ng/L	<2,000	1,240	78	44	25.4	<2	BDL
PFPeS	ng/L	6,800	<200	<20	<20	<2	<2	>99.971%
PFHxA	ng/L	2,200	980	54	54	34.0	<2	>99.909%
PFHxS	ng/L	137,000	<200	<20	20	4.2	<2	>99.999%
PFHpA	ng/L	71,400	480	20	20	11.6	<2	>99.997%
PFHpS	ng/L	36,000	<200	30	<20	5.6	<2	>99.994%
PFOA	ng/L	1,380,000	1,280	326	102	62.5	3.8	99.9997%
PFOS	ng/L	4,160,000	20,500	2,590	2,160	644	3.8	99.9999%
PFecHS	ng/L	202,000	<200	46	<20	5.0	<2	>99.999%
PFNA	ng/L	13,600	<200	<20	<20	2.5	<2	>99.985%
PFDA	ng/L	16,800	<200	<20	<20	4.6	<2	>99.988%
PFUnA	ng/L	<2,000	<200	<20	<20	<2	<2	BDL
PFDoA	ng/L	<2,000	<200	<20	<20	3.8	<2	BDL
Other Water Quality Parameters								
Chloride	mg/L	204	n/a	<10.0	n/a	<25.0	<25.0	-
Fluoride	mg/L	0.119	n/a	2.73	n/a	2.41	2.47	-
Sulfate (as SO4)	mg/L	3.89	n/a	1,750	n/a	1,980	2,370	-
TOC	mg/L	20.2	1.45	<0.50	<0.50	<0.50	0.50	>98%
TOF	µg/L	3700	n/a	n/a	11	10	13	>99%
COD	mg/L	550	<20	<20	<20	<20	<20	>98%

Analytical results demonstrated that Axine’s electrochemical oxidation technology achieved 6-log destruction of total reported PFAS in the concentrate. PFOA and PFOS concentrations were both 3.8 ng/L after treatment, where other reported PFAS were below reporting limits of as low as 2 ng/L.

Among the six PFAS contaminants included in EPA’s proposed National Primary Drinking Water Regulation, destruction to below proposed limits was demonstrated on five - PFBS, PFHpS, PFOA, PFOS, and PFNA; the remaining compound, GenX, was not detected in any samples before, during, and after treatment.

Sample COD and TOC concentrations, which indicate the level of organic contaminants in wastewater, decreased proportionally with PFAS destruction to over 98% removal.

5.2 TOP Assay Analysis

TOP assay was performed on concentrate samples taken before treatment, late in the treatment, and after treatment to ensure destruction of PFAS oxidizable precursors in addition to the PFAS compounds.

Table 4 – PFAS and TOP Assay Analysis Results on SAFF Concentrate

Analytes	Unit	Starting		67% Treated		100% Treated		Removal %	
		PFAS	TOP Assay	PFAS	TOP Assay	PFAS	TOP Assay	PFAS	TOP Assay
PFBA	ng/L	<10,000	15,800	<50	<80	<20	<40	BDL	BDL
PFBS	ng/L	<2,000	<2,000	7.3	<9	<2	<3	BDL	BDL
PFPeA	ng/L	<2,000	7,800	25.4	<36	<2	<3	BDL	BDL
PFPeS	ng/L	6,800	11,200	<2	<6	<2	<3	>99.971%	BDL
PFHxA	ng/L	2,200	8,600	34.0	<36	<2	3.2	>99.909%	99.96%
PFHxS	ng/L	137,000	136,000	4.2	<6	<2	<3	>99.999%	BDL
PFHpA	ng/L	71,400	68,000	11.6	<18	<2	<3	>99.997%	BDL
PFHpS	ng/L	36,000	79,000	5.6	<6	<2	<3	>99.994%	BDL
PFOA	ng/L	1,380,000	2,050,000	62.5	66.5	3.8	6.3	99.9997%	99.9997%
PFOS	ng/L	4,160,000	5,260,000	644	452	3.8	4.0	99.9999%	99.9999%
PFecHS	ng/L	202,000	n/a	5.0	n/a	<2	n/a	>99.999%	-
PFNA	ng/L	13,600	13,400	2.5	<6	<2	<3	>99.985%	BDL
PFDA	ng/L	16,800	12,400	4.6	<6	<2	<3	>99.988%	BDL
PFUnA	ng/L	<2,000	<2,000	<2	<6	<2	<3	BDL	BDL
PFDoA	ng/L	<2,000	<2,000	3.8	<6	<2	<3	BDL	BDL

The results, as shown in Table 4, demonstrate that Axine’s electrochemical treatment system is capable of destroying PFAS without leaving behind significant levels of oxidizable precursors that can potentially revert to PFAS downstream of the treatment. Most of the detected precursor concentrations decreased below the detection limit, and precursors of

PFHxA, PFOA and PFOS were consistently removed by more than 99.96% in the case of PFHxA and PFOA and by 99.999% in the case of PFOS.

5.3 TOF & Fluoride Ion Analysis

TOF concentration is an indirect indicator of the presence of fluorinated organic compounds in a sample. Fluoride ion concentration can also be used as an indication of defluorination of the fluorinated organic compounds resulting from the PFAS destruction process.

The graph in Figure 2 shows the changes in TOF and Fluoride ion concentrations during the treatment, along with the changes in total detectable PFAS concentration.

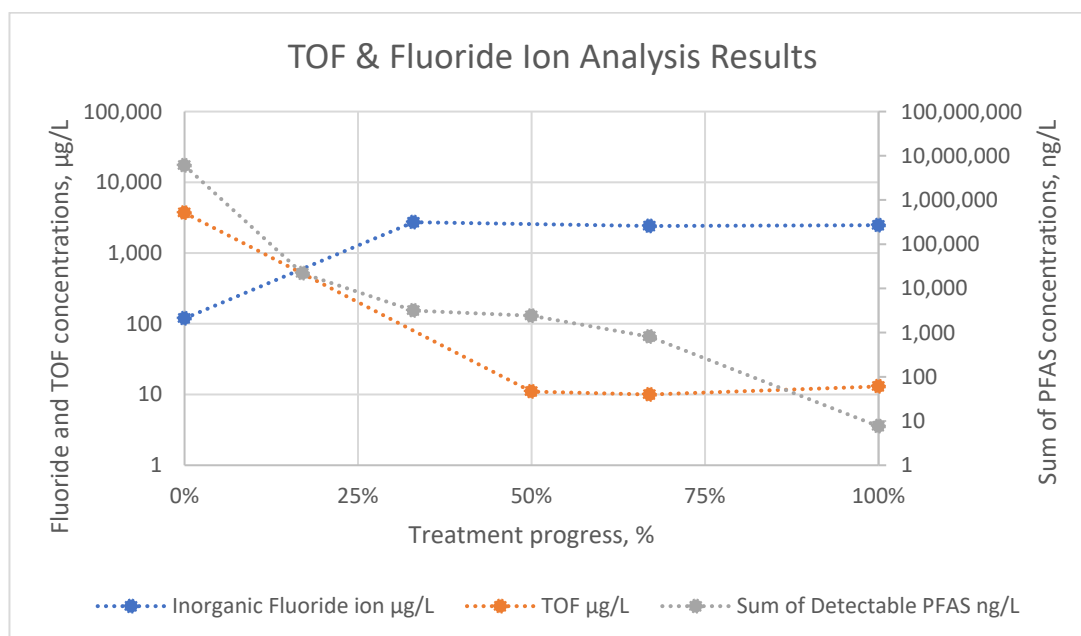


Figure 2 TOF and Fluoride Ion Analysis Results

As the PFAS in the concentrate is destroyed during the treatment process, TOF concentration decreased simultaneously, with an overall TOF removal of 99.8% at the end of treatment, from 3,700 µg/L to 10 µg/L. Meanwhile, the fluoride ion concentration increased from 120 µg/L at the start of testing to 2,470 µg/L after treatment.

The total theoretical concentration of PFAS-bound fluorine is approximately 3,900 µg/L. The fluoride ion recovered in the final samples was 2,470 µg/L, which translates to 63% fluoride recovery. Note that these calculated results are somewhat less than the PFAS results showing removal of total detectable PFAS to less than 8 ng/L, with near complete removal of oxidizable PFAS precursors and TOF.

Upon investigation into the lower than expected fluoride recovery, Axine postulates that the remaining fluoride has undergone coprecipitation with metal ions or adsorption onto metal hydroxides such as magnesium hydroxide $Mg(OH)_2$. This hypothesis is substantiated by the

well-known water treatment process in which fluoride can be removed from the water through calcium fluoride (CaF_2) and aluminum hydroxide ($\text{Al}(\text{OH})_3$) precipitation under alkaline conditions. At higher pH conditions, fluoride ions can also be removed through adsorption onto magnesium hydroxide $\text{Mg}(\text{OH})_2$ (Tsuchiya, K., 2020). Fluoride ion could have precipitated with metal ions or be adsorbed onto metal hydroxides given that high hardness was observed in concentrate (263 mg/L as CaCO_3) and the treatment process was carried out in a weak alkaline condition (pH 8 - 9). These results are further corroborated by 81% and 82% reductions in hardness in samples collected at 67% and 100% of treatment, respectively, which indicate that hardness or metal ion precipitation occurred during the treatment.

To investigate the plausibility of fluoride ion removal through precipitation or adsorption, samples of the concentrate taken at the start of treatment and 67% of the treatment process were utilized. The pH of the two samples were decreased to 4 using a sulfuric acid solution. As a result, as shown in Table 5, fluoride ion concentration increased from 2,410 $\mu\text{g/L}$ to 7,920 $\mu\text{g/L}$ in the 67% treated sample, while the untreated sample showed no fluoride release. The elevated fluoride concentration in the 67% sample indicates that fluoride loss through precipitation and/or adsorption is both plausible and likely. The 7,920 $\mu\text{g/L}$ of fluoride measured indicate a 200% fluoride recovery, which is most likely a result of the benchtop test setup which operates in batch mode, having treated several batches of the concentrate prior to the batch from which the fluoride analytical samples were taken.

Table 5 - Metal Ions and Fluoride Ion Concentrations at Starting and 67% Treated Sample

Analytes	Unit	Starting		67% Treated	
pH	-	4	7.5	4	8.4
Fluoride	mg/L	<0.100	0.119	7.92	2.41

Due to the small volume of concentrate available, Axine was not able to definitively conclude that all PFAS-bound fluoride has been recovered. However, available evidence showed that liberated PFAS-bound fluoride is either detected as fluoride ions or lost through precipitation with metals and/or adsorbed on metal hydroxides. Further investigation will require testing larger volumes of concentrate which is best achieved via a field pilot test program. Continued testing at a pilot-scale using commercial electrochemical reactor modules would also enable by-product gas measurement to determine whether HF gas is generated during treatment and a neutralization step can be considered.

5.4 Energy Consumption

The total energy consumption required to achieve the 6-log removal of total detectable PFAS under the draft EPA 1633 method was 2,973 kWh/m³. Figure 3 shows the energy consumption as a function of PFAS log removal. The energy consumption trends showed that the electrical energy per order of magnitude ("EE/O") for destruction of total detectable PFAS is not linear and increases with the order of magnitude of treatment. The energy required to reach 1-log (90%) destruction of total detectable PFAS is 90 kWh/m³, that

required for 2-log removal (99%) destruction is 198 kWh/m³, with an average EE/O of 100 kWh/m³. Further PFAS destruction required significantly higher energy, with the EE/O to reach 3 to 6 log removal ranging from 500 – 800 kWh/m³ per order of magnitude. Given the non-selected nature of reactions in the electrochemical oxidation process, this trend is likely the result of oxidation of other organic compounds that occurs with extended treatment.

nts: look at toc vs pfas mass

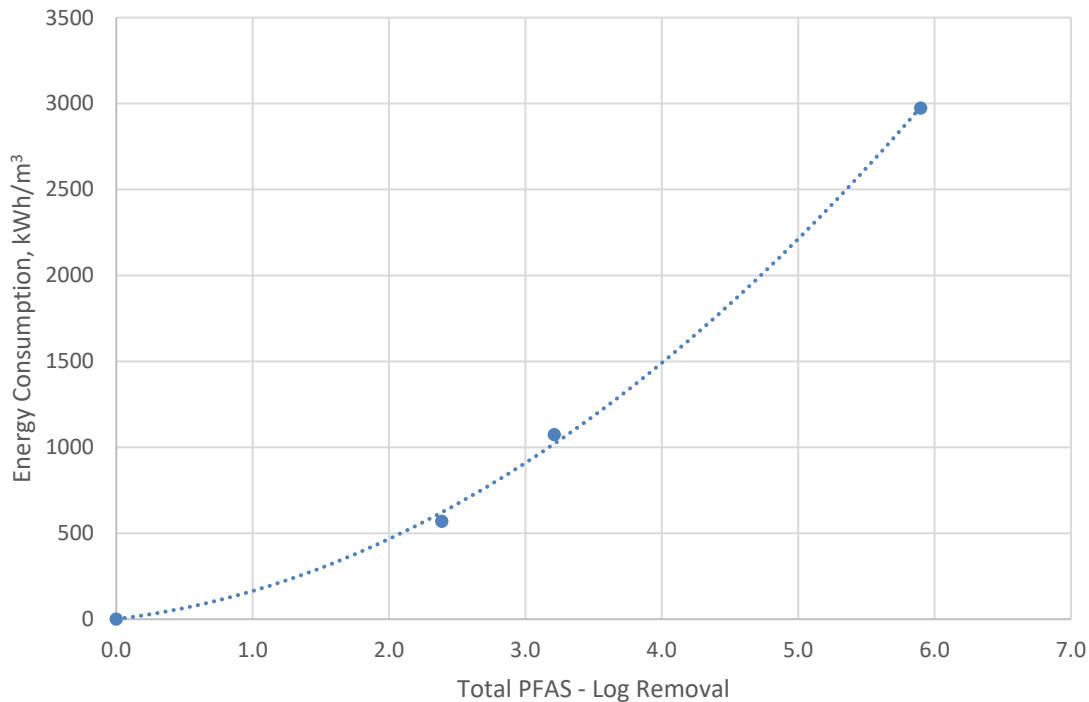


Figure 3 Electrical Energy Consumption for Total PFAS Log Removal

A notable factor in the evaluation of this report is the relative efficiency of benchtop versus pilot and full-scale reactor design. Axine's benchtop test setup is less efficient than commercial reactor modules which contains flow control elements to optimize treatment efficiency. The benchtop setup was used for this Test Program due to the small volume of concentration sample available. Axine's pilot-scale test system is typically used when the available treatment volume is above 150 USG. As such, Axine typically sees both reduction in energy consumption and a higher contaminant removal efficiency in pilot or commercial scale testing with more concentrated wastewater streams. Furthermore, as the aim of the current Test Program is to evaluate PFAS destruction, energy optimization was not performed as a part of testing. For commercial scale representative energy consumption estimates Axine proposes follow-up testing at the pilot scale where flow control and current density optimization can be further evaluated. Figure 4 below shows images of Axine's pilot-scale test system, housed within a shipping container measuring 10 ft x 10 ft x 9 ft.



Figure 4. Axine's Pilot-scale Test System

6.0 Summary and Conclusions

The Test Program on the concentrate verifies that the Axine system achieved a 6-log (99.9999%) destruction of total detectable PFAS under the draft EPA 1633 analytical method. In addition, TOP assay and TOF analysis showed significant removal of oxidizable precursor and total organofluorine. Fluoride ion analysis showed a 63% recovery of PFAS-bound fluorine with supplemental evidence indicating the remaining fluoride ion may have precipitated with metal ions and/or adsorbed onto metal hydroxides.

The energy required to achieve 6-log PFAS removal was 2,937 kWh/m³, with the EE/O increasing from an average of 100 kWh/m³ for the first 2 orders of magnitude of removal, to 500 – 800 kWh/m³ for subsequent orders of magnitude up to 6-log destruction. However, it is important to note that Axine's benchtop test setup is less efficient than commercial reactor modules that are built with cell configuration and flow control elements that optimize treatment efficiency. As such, bench scale energy consumption figures are higher than those expected in pilot testing and commercial operation.

The results of this Test Program showed successful PFAS destruction to target levels. Testing was further able to identify key areas for optimization to be implemented during future pilot-scale testing. In addition to completing the fluoride balance and testing commercial electrochemical reactor modules to reduce energy consumption, pilot-scale testing will also enable further treatment optimization through evaluation of additional treatment processes in a treatment train. Such testing could not be completed at the benchtop scale due to the small concentrate volume available for testing. For example, instead of using electrochemical oxidation to achieve a 6-log destruction of PFAS, a

membrane separation process such as reverse osmosis (RO) or nanofiltration (NF) may be introduced downstream of the electrochemical treatment, where the permeate can be safely discharged while the reject can be partially or fully recycled to the electrochemical oxidation process. By doing so, the log removal of PFAS by electrochemical oxidation can be decreased while still ensuring a clean discharge, leading to reductions in energy consumption and electrochemical cell requirements, which translates to lower CapEx and OpEx for the destruction solution.

7.0 References

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Attachment G3: General Atomics Final Report

Draft

PFAS Destruction Research Report

Surface Active Foam Fractionation Material



General Atomics, San Diego, California

January 2024



Prepared Under U.S. Army Engineer Research and Development Center Contract W912HZ-23-C-0037
for:



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EXECUTIVE SUMMARY

The Minnesota Pollution Control Agency (MPCA) provided Bay West with five gallons of Surface-Active Foam Fractionation (SAFF) concentrate material, obtained from a water treatment study, for the purpose of demonstrating a per- and polyfluoroalkyl substance (PFAS) destruction technology. As part of the US Army Engineer Research and Development Center (ERDC) Contract No. W912HZ-23-C-0037, Bay West teamed with General Atomics (GA) of San Diego, California to test and demonstrate supercritical water oxidation technology's effectiveness to destroy PFAS in the SAFF material. The PFAS destruction testing is a part of ERDC's in-depth, applied research projects. ERDC is an integral component of the Office of the Assistant Secretary of Defense for Research and Engineering, helping to solve challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, Department of Defense, civilian agencies, and the public good.

GA's Industrial Supercritical Water Oxidation (iSCWO) demonstration unit, a full-scale system located in San Diego, California, was used for the SAFF Test study. Because the iSCWO system is a fully functional field scale unit designed for treating larger volumes of material, dilutions of the five gallons of SAFF material were prepared in order to run the system long enough and at non-ideal conditions for adequate sample collection and analysis.

Two test phases were completed using the SAFF material. Phase 1 consisted of a mixture of 2.5 gallons of SAFF and approximately 179.1 gallons of San Diego tap water. This SAFF mixture was fed through the iSCWO system at the system's minimum flow rate of approximately 1 gallon per minute. Once system operating flows, pressures, and temperatures were consistent, the various system influent and effluent streams were sampled for PFAS and various other analytes three times at roughly 30-minute intervals. Phase 2 consisted of injecting the remaining 2.5 gallons of SAFF at 200 milliliters per minute directly into the process feed line of the first SAFF mixture to form a more concentrated SAFF mixture stream into the reactor. Due to the limited quantity of SAFF material, only one sampling round was conducted during the Phase 2 testing period.

In addition to PFAS, various other samples were collected for air and water analysis during each testing phase. Analytes included volatile organic compounds (VOCs), fixed gases, chemical oxygen demand (COD), total organic carbon (TOC), polycyclic aromatic hydrocarbons (PAHs), oil & grease, flashpoint, adsorbable organic fluorine, total fluorine, alkalinity, select cations, select anions, corrosion metals, and gaseous, particulate and total fluoride in air. Field parameters monitored by the iSCWO system instrumentation or handheld meters included pH, temperature, conductivity, salinity, oxidation-reduction potential (ORP), combustion gases including oxygen, carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x) and sulfur oxides (SO_x), and various system pressures, temperatures and flow rates.

VOCs, SO_x, and NO_x were detected in effluent air during the SAFF tests but at very low concentrations and, for SO_x and NO_x, for very limited durations during system start-up and shutdown. CO was observed at up to 5,117 parts per million for a brief period during start-up. CO₂ was observed at up to 6% per volume in the effluent air during the test runs.

There were no exceedances of Minnesota Department of Health (MDH) Health Risk Limits (HRLs) or Environmental Protection Agency (EPA) Primary Maximum Contaminant Levels (MCLs) in effluent water from the SAFF tests. Sulfate slightly exceeded the EPA secondary MCL in one effluent sample.

PFAS destruction was determined by evaluating the total mass flow of individual target PFAS entering and exiting the iSCWO reactor. Target PFAS destruction efficiency, and presumably total PFAS destruction efficiency, averaged approximately 99.46% during Phase 1 testing and 99.84% during Phase 2 testing.

The PFAS destruction efficiencies determined from the SAFF tests are much lower than those previously observed with GA's iSCWO unit using dilutions of aqueous film forming foam (AFFF) in 2021 (McDonough et. Al., 2022), where PFAS destruction was observed to be greater than 99.999%. Possible explanations for the lower observed destruction efficiencies during the SAFF tests include:

- The iSCWO system uses a significant amount of municipal water as a reactor quench source. This water source, provided by the City of San Diego, was determined to have low but consistent concentrations of PFAS. An increase in quench water flow was initiated after the first Phase 1 test round. PFOS was not detected in the effluent air of the first phase 1 test round but was detected in the effluent air samples in all subsequent Phase 1 test rounds and during the Phase 2 testing.
- The bulk of PFAS mass detected in the effluent of the iSCWO reactor was from low estimated values of PFOS that were less than the reporting limit but greater than or equal to the method detection limit in effluent air samples. PFOS was detected in two of the ambient air samples, in a field blank resin sample, and in pre-SAFF test reactor effluent air samples. In addition, for the effluent samples in which PFOS was detected – the detections were observed in both the front and back resin samplers in the series sample trains. The one sample that showed a PFOS result above the detection limit came from the back end sorbent tube (rather than the front end), suggesting that perhaps the sample result is an anomaly. It is possible that the method selected for collecting PFAS air samples during the SAFF tests combined with the low-level detections of PFAS in the ambient air space of the sample location area may expose the air samplers to ambient air prior to and just after sampling. The effluent air sampling method utilized for the SAFF test was TO-13M, a grab sample method for dry vapor, and not method OTM-45 which is more of a composite sample method typically used for stack gas testing in heavy industry and the method used during the 2021 AFFF PFAS destruction tests with GA's iSCWO unit. Collecting air samples via method TO-13M from a stack branch line that feeds the instrument air line may not be representative of the stack air flow – may be biased high which would result in destruction efficiencies that are biased low.
- The iSCWO system was operated at the lowest flow rate possible for the unit. At this low flow rate, system pressure was below standard operating conditions resulting in reduced reactor retention times. Though not quantified here, reduced retention times could allow unoxidized hydrocarbons through the reactor. For this situation, the corrective measure would be to increase system backpressure allowing for longer reactor retention times, which can be done routinely.
- PFAS concentrations in the diluted SAFF mixtures used for these tests were much lower than those utilized in the 2021 AFFF tests, while the PFAS concentrations in the liquid effluent were very similar (at non-detect or very close to non-detect). When calculating destruction efficiency in this case, higher feed concentrations will always demonstrate better destruction efficiency. Future testing will include PFAS-related feeds with higher concentrations and should demonstrate higher destruction efficiencies.

The primary resources and energy required for iSCWO include water, fuel, and electricity. Resource usage was documented to the greatest extent possible using the existing system sensors and meters and through physical observations of tank levels. The total volume of municipal tap water used by the system during the 4.27-hour testing period was approximately 1,460.7 gallons (1.95 hundred cubic feet [HCF]). Other resources used during the testing period included approximately 91.7 gallons of diesel fuel, up to five gallons of propane, and ten liters of a 5% by weight NaOH solution. The estimated total amount of power used during the 4.27-hour

SAFF Test period, which includes startup and shutdown, was approximately 1,800 kilowatt-hours (kWh).

Based on current utility pricing for the City of Minneapolis or State of Minnesota, the average hourly material and utility costs incurred during the SAFF processing test was \$162.19/hr plus a cost of \$9.33 (for propane), for a total estimated cost of \$701.35 over the entire 4.27-hour testing period. Due to the limited volume of SAFF concentrate available for testing and the time needed to complete the planned testing, dilution of the SAFF concentrate was required during each of the testing phases to meet the minimum system flow rate of 1 gpm. The costs associated with treatment of this waste stream are therefore higher on a per-mass destroyed basis due to the additional energy required to bring the total feed volume to supercritical conditions. For full-scale treatment conditions with a greater available volume of undiluted feed material and optimized conditions, treatment costs per unit mass of PFAS destroyed are expected to decrease significantly and therefore become more economical.

In summary, the testing was a success that demonstrated the destruction of SAFF concentrate using GA's supercritical water oxidation process.

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Appendices

Appendix 1 – Aqueous Sample Analytical Result Tables

- Appendix 1 – Table 1. SAFF Concentrate Sample Analytical Result Summary
- Appendix 1 – Table 2A. Quench Water Analytical Results - All Data
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Appendix 2 – Air Sample Analytical Result Tables

- Appendix 2 – Table 1A. VOC and Fixed Gas Air Sample Analytical Results - All Data
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- Appendix 2 – Table 2. Fluoride Air Sample Analytical Results
- Appendix 2 – Table 3A. PFAS Air Sample Analytical Results - All Data
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- SAFF Test – Testo Combustion Gas Analyzer Air Emission Readings Chart

Appendix 3 – Destruction Efficiency Evaluation

- Appendix 3 – Table 1. PFAS Destruction Efficiency Summary
- iSCWO SAFF and AFFF PFAS Destruction Efficiency Chart

Acronyms and Abbreviations

°C, deg C	degrees Celsius	mV	millivolts
°F, deg F	degrees Fahrenheit	NaOH	sodium hydroxide
%	percent	ng	nanograms
µg/L	micrograms per liter	ng/L	nanograms per liter
µg/m ³	micrograms per cubic meter	ng/min	nanograms per minute
µg/min	micrograms per minute	NIOSH	National Institute for Occupational Safety and Health
AFFF	Aqueous Film Forming Foam	NO	nitrogen oxide
AOF	adsorbable organic fluorine	NO _x	nitrogen oxides
ASTM	American Society for Testing and Materials	O ₂	oxygen
atm	atmosphere	ORP	Oxidation-Reduction Potential
CO	carbon monoxide	P	pressure
CO ₂	carbon dioxide	PAH	polycyclic aromatic hydrocarbon
COD	Chemical Oxygen Demand	PFAS	per- and polyfluoroalkyl substance
EPA	Environmental Protection Agency	PFBA	Perfluorobutanoic acid
GA	General Atomics	PFBS	Perfluorobutanesulfonic acid
gpm	gallons per minute	PFHxA	Perfluorohexanoic acid
HCF	hundred cubic feet	PFHxS	Perfluorohexanesulfonic acid
HF	hydrogen fluoride	PFOA	Perfluorooctanoic acid
HRL	Health Risk Limit	PFOS	Perfluorooctanesulfonic acid
iSCWO	Industrial Supercritical Water Oxidation	ppm	parts per million
kW	kilowatts	SAFF	Surface Active Foam Fractionation
kWh, kWhr	kilowatt-hour	SCWO	supercritical water oxidation
LL	low level	SO ₂	sulfur dioxide
LPM	liters per minute	SO _x	sulfur oxides
m ³ /min	cubic meters per minute	s.u.	standard units
MCL	Maximum Contaminant Level	T	Temperature
MDH	Minnesota Department of Health	TF	Total Fluorine
mg/L	milligrams per liter	TOC	Total Organic Carbon
ml/min	milliliters per minute	TSS	Total Suspended Solids
MPCA	Minnesota Pollution Control Agency	VOC	volatile organic compound
mS/cm	milliSiemens per centimeter		

1.0 MPCA AWARD

Through a grant program, the Minnesota Pollution Control Agency (MPCA) provided Bay West with five gallons of Surface-Active Foam Fractionation (SAFF) concentrate material, obtained from a water treatment study that the MPCA is currently conducting, for the purpose of demonstrating a per- and polyfluoroalkyl substance (PFAS) destruction technology. SAFF is a proprietary name for a foam fractionation process which utilizes the natural physiochemistry of PFAS to adhere to fine air bubbles injected into an impacted source water stream processed through a series of narrow water columns. As the bubbles rise, they collect PFAS compounds which accumulate at the top of the columns as a foam, which is then vacuumed off into a concentrate stream.

The five gallons of SAFF material was shipped via FedEx to the General Atomics (GA) testing facility in San Diego, CA, on 17 August 2023, in five one-gallon containers. The material was stored by GA for the test, which was completed on October 25, 2023.

A SAFF sample analytical summary was provided to Bay West from the MPCA. A sample of SAFF material was also collected by Bay West and submitted to Eurofins for analysis of PFAS via Environmental Protection Agency (EPA) method 1633. Results of the MPCA SAFF analysis and detected PFAS compounds from the Eurofins analysis are included in **Table 1** below. A full SAFF concentrate analytical data summary table is presented in **Appendix 1**.

Table 1. SAFF Concentrate PFAS and Select Analyte Concentrations

Detected PFAS Analyte	MPCA-Reported SAFF Sample Concentration (ng/L)	Bay West/GA SAFF Sample Concentration (ng/L)
Perfluorobutanoic acid (PFBA)	463	< 40,000
Perfluorobutanesulfonic acid (PFBS)	194	< 10,000
Perfluorodecanoic acid (PFDA)	14,700	12,000
Perfluorododecanoic acid (PFDoA)	<33.3	< 10,000
Perfluoroheptanoic acid (PFHpA)	84,800	100,000
Perfluoroheptanesulfonic acid (PFHpS)	NA	52,000
Perfluorohexanoic acid (PFHxA)	2,650	< 10,000
Perfluorohexanesulfonic acid (PFHxS)	149,000	170,000
Perfluorononanoic acid (PFNA)	12,000	19,000
Perfluorooctanoic acid (PFOA)	2,440,000	2,100,000
Perfluorooctanesulfonic acid (PFOS)	4,670,000	4,600,000
Perfluoropentanoic acid (PFPA)	135	< 20,000
Perfluoropentanesulfonic acid (PFPeS)	NA	11,000
Perfluoroundecanoic acid (PFUnA)	28.1	< 10,000
Additional Analytes	(mg/L)	(mg/L)
Total Organic Carbon	102	NA
Chloride	210	NA
Fluoride	0.11	NA
Sulfate	5,500	NA

Notes:

ng/L = nanograms per Liter (parts per trillion)

mg/L = milligrams per Liter (parts per million)

"<" = less than the listed laboratory reporting limit

NA = Not Analyzed for that analyte

2.0 BACKGROUND AND OBJECTIVES

2.1 Background

In March 2023, the Environmental Protection Agency (EPA) proposed the first federal limits on PFAS in drinking water. While PFAS environmental impact has been studied and means for removing it from contaminated water have been identified, these chemicals continue to be challenging for treatment and disposal. Supercritical Water Oxidation (SCWO) is an evolving yet well-documented technology that conveys an aqueous waste stream to an enclosed alloy steel reactor that is then heated and pressurized above the supercritical state of water (above 374 degrees Celsius [°C] and 218.2 atmospheres [atm]) and combined with an oxidant to achieve rapid and complete oxidation of all organics to carbon dioxide (CO₂), clean water, and inorganic salts.

Many pilot- and full-scale plants are being developed and tested for the destruction of industrial hazardous wastes and sludges. SCWO technology presents a significant environmental advantage for treating recalcitrant pollutants due to high attainable destruction efficiencies combined with little to no emissions that rarely require a pollution abatement system. However, SCWO treatment of diverse types of PFAS-impacted media is relatively new, and additional testing is needed to verify the minimization of PFAS by-product generation during treatment, and to further establish the associated SCWO treatment costs at a full and sustainable production scale.

2.2 Objectives

Through the grant program, MPCA is facilitating research into the ability and cost-effectiveness of various technologies for destroying PFAS using the concentrated PFAS waste (SAFF Concentrate) provided as a common test medium. Numerous entities were provided with SAFF material to evaluate various technologies. The goal of Bay West's research is to test SCWO as a PFAS destruction technology by processing the SAFF material through a working SCWO demonstration unit and collecting pre-, mid- and post-destruction operations and analytical data to evaluate the following:

- PFAS destruction efficiency;
- Quality and quantity of various system emissions and discharges;
- Resources and time needed to operate the technology; and
- Estimated costs for treating SAFF at test or full scale.

3.0 SYSTEM USED AND OPERATING CONDITIONS

The SCWO PFAS waste treatment study took place at GA's test facility in San Diego, CA, using an existing full-scale and proprietary unit dubbed Industrial Supercritical Water Oxidation (iSCWO). GA's iSCWO system is a mature technology that has been used and proven in industry and in the field for over 10 years for the destruction of numerous hydrocarbon wastes including recalcitrant contaminants. Several recent demonstration studies have applied GA's system for the destruction of PFAS in diluted mixtures of Aqueous Film Forming Foam (AFFF). The waste stream used for this PFAS destruction demonstration was the five gallons of SAFF provided by the MPCA.

GA's iSCWO system is a full-scale unit that nominally operates at 3 gallons per minute (gpm) but can reduce flow to a minimum flow rate of 1 gpm (3.785 liters per minute [lpm]). Due to the limited volume of SAFF available and the time needed to complete the planned testing, dilution of the SAFF was required during each of the testing phases. During the first testing phase, 2.5 gallons of SAFF was diluted with 177.5 gallons of municipal-supplied, softened, potable tap water and approximately 1.6 gallons of SAFF container rinse water for a total mixture volume of 181.6 gallons (687.4 liters). Approximately 10 milliliters of Sigma-Aldrich Antifoam C Emulsion were added to the SAFF-water mixture to eliminate potential foaming of the SAFF while the mixture is recirculated in the tank during the tests. The SAFF mixture was fed through the system at approximately 3.8 liters per minute (lpm). During the second testing phase, the remaining 2.5 gallons of SAFF material was fed directly into the influent stream of the first mixture via a chemical feed pump at a rate of 0.2 lpm (combined flow of approximately 4 liters per minute). The ratio of water to SAFF for the two test phases were approximately 72:1 and 14.8:1, respectively.

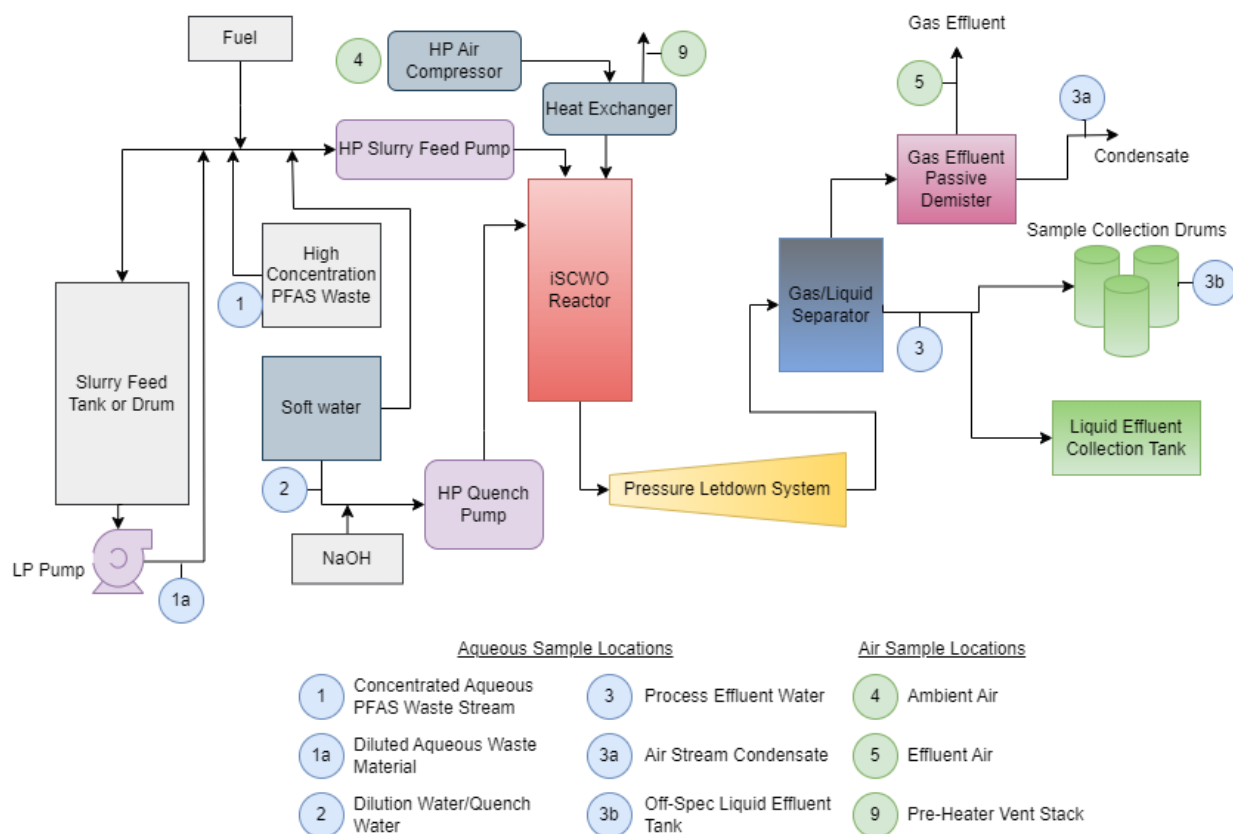
The iSCWO system's general operation sequence follows:

1. Initiate system startup by introducing heated pressurized air, quench water, and clean process water. The pressurized air is initially heated via a propane heater and heat exchanger unit. Quench water and initial clean process water, for GA's iSCWO demo unit, are provided by the municipal-supplied potable water source (City of San Diego municipal water supply) after treatment with soft water tanks.
2. Once the internal reactor temperature reaches 280°C, a fuel source (for GA's iSCWO system, diesel fuel is used) is then introduced into the clean water process feed. The 280°C reactor temperature is above the autoignition temperature of diesel fuel, which ignites and brings the reactor temperature up to operating condition. The reactor temperature quickly (in less than 30 seconds) climbs to the operating temperature of greater than 650°C. The propane heater shuts down shortly after diesel fuel is introduced and is no longer needed for operations. Conditions within the SCWO reactor during the SAFF tests were recorded as follows:
 - Pressure range of 176 to 205 bar with an average of 196 bar (193 atm). Even though these pressures are below the supercritical state for water, previous study and testing of GA's iSCWO has determined that these pressures still produce high destruction efficiency of organic materials and that temperature is the primary factor that drives the destruction reactions.
 - Upper reactor temperature range of 637.2°C to 707.1°C with an average temperature of 673.4°C
3. Once the reactor pressure and temperature rise and level to operating conditions (i.e., steady state), the clean process water is slowly replaced by the targeted waste stream into the reactor.

4. Quench water is introduced within the reactor walls in parallel with process feeds and mixes with the oxidized products at the reactor bottom. A sodium hydroxide (NaOH) solution is added to the quench water as needed to neutralize any acids produced by the destruction of the waste. For the SAFF tests, a 5% NaOH solution was used. The pH of the effluent water stream was continuously monitored to ensure no acids escape through the gas exhaust stack. Target pH is nominally 7.0.
5. Once the waste is processed, clean process water is added back into the reactor and the system operates with clean feed for an additional 15 minutes to flush the system.
6. After 15 minutes of system flushing, the diesel fuel feed is stopped, followed sequentially by the process water feed, the high-pressure air compressor, and finally the quench water feed.

A block diagram of the iSCWO system is provided in **Figure 1** below, with process sample locations for the SAFF tests identified.

Figure 1. Block Diagram of iSCWO System



4.0 SAMPLING PROCEDURES AND RATIONALE

Sampling was conducted at several points throughout the iSCWO system, as shown in **Figure 1**. These points included the influent mixture (1a), quench water stream (2), effluent water (3/3b), effluent air condensate water (3a), ambient air (4), and effluent air (5). Only one sample of effluent air condensate water (3a) was collected as a composite sample from both phases of SAFF testing due to the minimal amount of condensate produced by the air sample chiller system and sample port, which was utilized for effluent air sample collection during the SAFF tests. In addition, one grab sample of the iSCWO system start-up phase effluent water (3b) was collected to evaluate the condition of “off-spec” effluent water – water processed through the reactor prior to achieving the supercritical state - during iSCWO start-up.

Three sampling phases were conducted and are described as follows:

1. A pre-test analysis (Phase 0) was conducted using municipal-supplied potable tap water as iSCWO process and quench water. Clean process water is required during start-up while the reactor heats up to operating conditions. In addition, clean water processing ensures that any residual materials from any previous tests are cleaned out of the system prior to conducting the SAFF tests. The first few minutes of system start-up effluent water was directed to and collected in a 55-gallon drum. After the iSCWO system reached a *steady state condition*, defined as the point where iSCWO system influent air, fuel, quench and process water flow rates and reactor temperature and pressure reach equilibrium operating levels and process data becomes steady (repeatable) (approximately 15 to 30 minutes from start-up), the system was allowed to operate at steady state for an additional 20 minutes before pre-SAFF test sampling was conducted. Effluent water was re-directed from the 55-gallon drum to an effluent collection tank once the system reached steady state. The following pre-Test (Phase 0) samples were collected approximately 55 minutes after system start-up for laboratory analysis:

Table 2. Pre-Test Analysis Parameters

Test#	Time	Sample Location	Process Material Description	LABORATORY SAMPLES																FIELD PARAMETERS							
				PFAS	VOCs	Fixed Gases	COD	TOC	AOF	TF	Alkalinity	Cations	Anions	Corr. Metals	PAH	O&G	HF	Flashpoint	Temperature	pH	Conductivity	ORP	Salinity	SO _x /NO _x	P, T, Flow, Other		
Phase 0	Pre-Test Analysis																										
Sample Round 1	Base 2	Quench Water	2D	1		1	1	1	1	1	1	1	1					1	1	1	1	1		i			
	Base 3	Effluent Water	1	1				1	1									1	1	1	1	1		i			
	Base 3b	Effluent Water (Comp off-spec)													1	1		1									
	Base 4	Ambient Air	1																								
	Base 5	Effluent Air	1	1	1												1						i	i			
	Base 5	Sample Area Indoor Air	1																								

Notes: 1,2 = number of samples. Those designated with a two include a duplicate sample (D). C = composite sample collected over duration of the test. i = monitored by field instruments or system instrumentation.

PFAS = per- and polyfluoroalkyl substances; VOCs = volatile organic compounds; COD = chemical oxygen demand;

TOC = total organic carbon; AOF = adsorbable organic fluoride, TF = total fluorine;

EOF/TIF = extractable organic fluoride/total inorganic fluoride; Corr. Metals = corrosion metals (metals associated with the reactor materials); PAH = polycyclic aromatic hydrocarbons; O&G = oil and grease; HF = Hydrogen fluoride;

ORP = oxidation/reduction potential; SO_x/NO_x = sulfur oxides/nitrogen oxides; P = pressures; T = temperatures

2. After the pre-test sampling phase was complete, the 72:1 water-SAFF mixture was slowly introduced into the reactor until an approximate flow rate of 1 gpm was achieved. Phase 1 Test #1 sampling was initiated approximately 20 minutes after the SAFF mixture began being fed to the reactor. Shortly after the Phase 1 Test #1 sampling round was completed, a decision was made to increase the reactor temperature, which required an increase in quench water flow. As a result of the quench flow increase, the reactor pressure increased by approximately 10 to 15 bar.. Two additional rounds of sampling for Phase 1 were conducted at approximately 30-minute intervals following the Phase 1 Test #1 sampling round. The following samples were collected for laboratory analysis:

Table 3. SAFF Testing Phase #1 Analysis Parameters

Test#	Time (min since test start)	Sample Location	Process Material Description	LABORATORY SAMPLES														FIELD PARAMETERS							
				PFAS	VOCs	Fixed Gases	COD	TOC	AOF	TF	Alkalinity	Cations	Anions	Corr. Metals	PAH	O&G	HF	Flashpoint	Temperature	pH	Conductivity	ORP	Salinity	SO _x /NO _x	P, T, Flow, Other
Phase 1	MPCA SAFF Concentrate Batch 1 – 2.5 gallons concentrate mixed with 177.5 gallons of water																								
Sample Round 1	20	1a	Dilute Waste Material 1	1	1				1	1														i	
	20	2	Quench Water	1	1				1	1														i	
	20	3	Effluent Water	1	1				1	1														i	
	20	4	Ambient Air	1	1C	1C																		i	
	20	5	Effluent Air	1	1	1										1							i	i	
Sample Round 2	45	1a	Dilute Waste Material 1	2D	1		1	1	1	1	1	1	1	1				1	1	1	1	1		i	
	45	2	Quench Water	2D	1		1	1	1	1	1	1	1	1				1	1	1	1	1		i	
	45	3	Effluent Water	2D	1		1	1	1	1	1	1	1	1				1	1	1	1	1		i	
	45	4	Ambient Air	1																				i	
	45	5	Effluent Air	1	1	1										1							i	i	
Sample Round 3	80	1a	Dilute Waste Material 1	1	1				1	1														i	
	80	2	Quench Water	1	1				1	1														i	
	80	3	Effluent Water	1	1				1	1														i	
	80	4	Ambient Air	1																				i	
	80	5	Effluent Air	1	1	1										1							i	i	

Notes: 1,2 = number of samples. Those designated with a two include a duplicate sample (D). C = composite sample collected over duration of the test. I = monitored by system instrumentation.

PFAS = per- and polyfluoroalkyl substances; VOCs = volatile organic compounds; COD = chemical oxygen demand;

TOC = total organic carbon; AOF = adsorbable organic fluorine; TF = total fluorine

EOF/TIF = extractable organic fluoride/total inorganic fluoride; Corr. Metals = corrosion metals (metals associated with the reactor materials; PAH = polycyclic aromatic hydrocarbons; O&G = oil and grease; HF = Hydrogen fluoride;

ORP = oxidation/reduction potential; SO_x/NO_x = sulfur oxides/nitrogen oxides; P = pressures; T = temperatures

3. Phase 2 testing began after the remaining 2.5 gallons of SAFF concentrate was fed via chemical feed pump at a rate of 200 ml/min directly into the process stream running the remaining Phase 1 material, which continued to be pumped at a rate of approximately 1 gpm. After approximately 22 minutes of processing, Phase 2 samples were collected. Due to the limited volume available for processing, only one round of sampling was completed for the Phase 2 test material. The following samples were collected for laboratory analysis:

Table 4. SAFF Testing Phase #2 Analysis Parameters

Test#	Time (min since test start)	Sample Location	Process Material Description	LABORATORY SAMPLES																FIELD PARAMETERS						
				PFAS	VOCs	Fixed Gases	COD	TOC	AOF	TF	Alkalinity	Cations	Anions	Corr. Metals	PAH	O&G	HF	Flashpoint	Temperature	pH	Conductivity	ORP	Salinity	SO _x /NO _x	P, T, Flow	
Phase 2	MPCA SAFF Concentrate Batch 2 - Additional 2.5 gal SAFF concentrate fed into process stream																									
Sample Round 1	22	1a	Dilute Waste Material 2	2D	1		1	1	1	1	1	1	1	1					1	1	1	1	1		i	
	22	2	Quench Water	2D	1		1	1	1	1	1	1	1	1					1	1	1	1	1		i	
	22	3	Effluent Water	2D	1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1			i	
	22	4	Ambient Air	1	1C	1C											1								i	
	22	5	Effluent Air	1	1	1											1							i		

Notes: 1,2 = number of samples. Those designated with a two include a duplicate sample (D). C = composite sample collected over duration of the test. i = monitored by system instrumentation.

PFAS = per- and polyfluoroalkyl substances; VOCs = volatile organic compounds; COD = chemical oxygen demand;

TOC = total organic carbon; AOF = adsorbable organic fluorine; TF = total fluorine;

EOF/TIF = extractable organic fluoride/total inorganic fluoride; Corr. Metals = corrosion metals (metals associated with the reactor materials; PAH = polycyclic aromatic hydrocarbons; O&G = oil and grease; HF = Hydrogen fluoride;

ORP = oxidation/reduction potential; SO_x/NO_x = sulfur oxides/nitrogen oxides; P = pressures; T = temperatures

5.0 RESULTS

5.1 System Operational Data

Prior to the SAFF tests, initial volumes of diesel fuel, NaOH solution, and 72:1 SAFF mixture were noted, and an initial municipal-supplied potable water flow meter reading and propane tank level reading were recorded.

From start-up to shut down, the iSCWO system's supervisory control and data acquisition (SCADA) system recorded system instrumentation readings (including system pressures, temperatures, flowrates, pump speeds, etc.) and automatic system equipment status (e.g. on/off, open/closed, setpoint values, etc.) at one second intervals. This data was retained to evaluate system performance, operational parameters, flow rates and total flow of the various system water, waste and fuel streams, and equipment periods of operation.

At the end of the SAFF tests and following system shutdown, a final inventory of diesel fuel, SAFF mixture, NaOH solution, propane, effluent water tank levels and water meter readings was tallied to field truth SCADA readings and to evaluate resource usage.

System operational flow data during steady state conditions for each SAFF Test phase and testing round is presented in **Table 5** below. System operational data recorded over the 4.27-hour SAFF testing period is presented in **Figure 2** below.

Table 5. SAFF Test Operational Flow Data

Process Stream	Phase 0- Pre-Test (LPM)	Phase 1- Test 1 (LPM)	Phase 1- Test 2 (LPM)	Phase 1-Test 3 (LPM)	Phase 2-Test 1 (LPM)
Estimated Influent Air ¹	19,822	19,822	19,822	19,822	19,822
Process Feed ²	5.26	5.26	5.26	5.26	5.38
Process Water ³	4.36	0	0	0	0
Diesel Fuel ^{2,4}	1.44	1.52	1.46	1.50	1.53
72:1 SAFF Mix ⁵	0	3.74	3.8	3.75	3.85
SAFF Concentrate ⁶	0	0	0	0	0.2
Quench Water ²	13.40	13.47	22.36	22.36	22.36
Effluent Water ³	1.68	1.86	9.47	8.91	8.99
Estimated Effluent Air ^{1, 7}	19,822	19,822	19,822	19,822	19,822
Est. Effluent Condensate (Water as Steam) ⁸	16.97	16.86	18.15	18.71	18.96

Notes: LPM = liters per minute

1, Italics = estimated air flow rate at standard conditions. There was no means to measure air flow on the demonstration iSCWO unit. Air flow waste estimated based on GA's operational knowledge of the system and from a previous study using GA's demonstration iSCWO system where temporary means for determining air flow were established (McDonough et. Al, 2022).

2 = flow calculated and recorded by SCADA system using the pump speed information from the pumps variable frequency drive (VFD) unit.

3 = flow recorded by SCADA system via a system flow meter and transmitter

4 = the SCADA calculated flow for the diesel fuel underestimated actual consumption. The flow rate was corrected with a multiplier determined based on actual consumption.

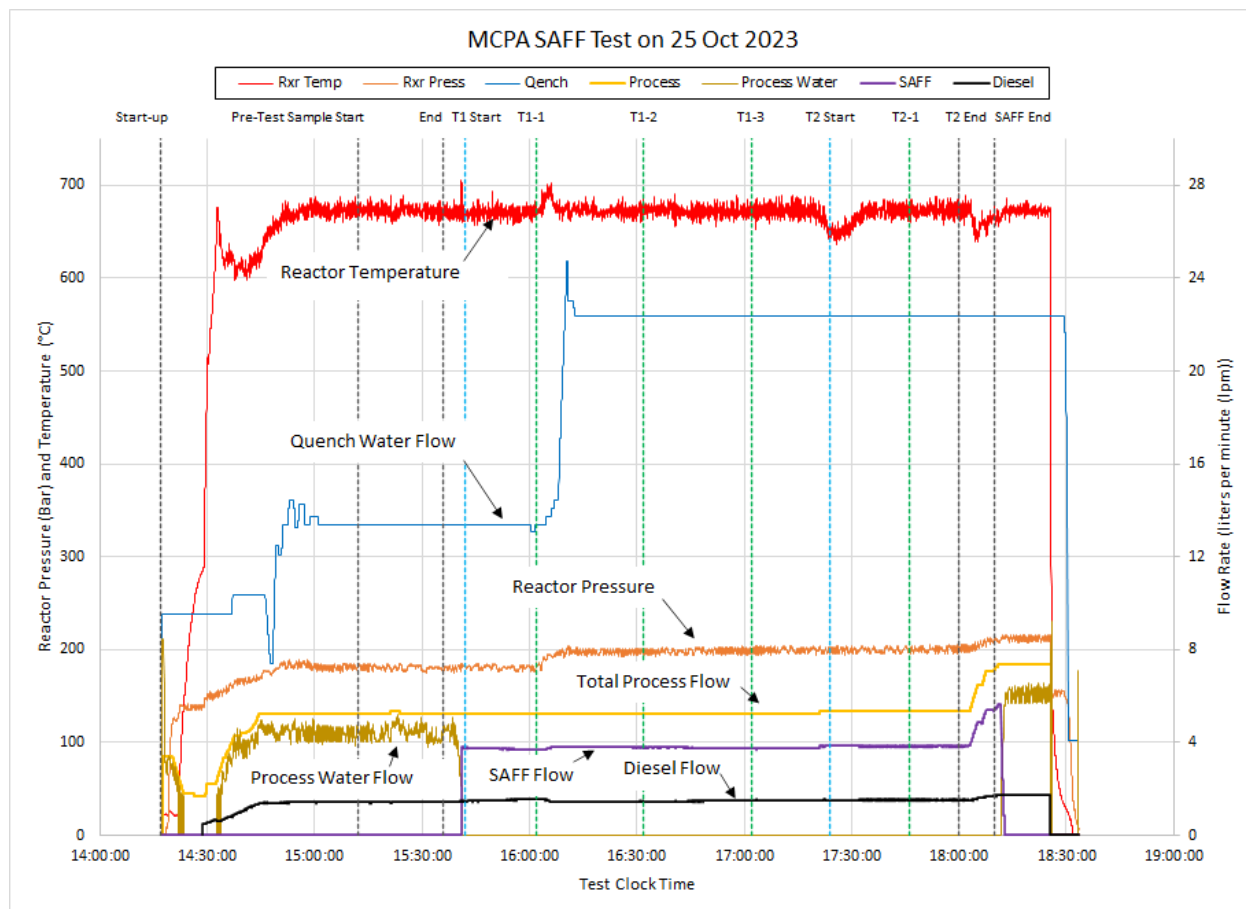
5 = flow determined by subtracting the diesel fuel flow rate from the Process Feed pump flow rate

6 = Undiluted SAFF Concentrate was fed directly into the SAFF Mix influent line to the reactor via a chemical feed pump. The pump flow rate was manually controlled. Flow rate was determined using an inline calibration column.

7 = Assumes that the flow of air in is equivalent to the flow of air out (less steam). A previous study indicated that this assumption is generally valid

8 = The estimated condensate water flow exiting the system as steam is calculated by assuming that the flow of liquid into the reactor (including diesel fuel, which forms water as an oxidation product at near 1:1 by volume) minus the flow of water out must be steam.

Figure 2. SAFF Test System Operational Data



5.2 Air Sampling Results

Ambient air samples were collected adjacent to the intake of the iSCWO system high pressure air compressor during testing phases 1 and 2. The ambient air samples consisted of: two-hour (phase 1) and one-hour (phase 2) time-composited summa canister samples for VOCs and fixed gases analyses via methods TO-15 low level (LL) and American Society for Testing and Materials (ASTM) D1946, respectively, as well as grab samples for PFAS analyses via method TO-13. The PFAS samples were collected by pulling approximately 6 liters of air at 2 lpm through two XAD-resin tube samplers arranged in series (front and back). Additionally, an indoor air sample was collected near the effluent air sample station and consisted of two XAD-resin tube samplers in series for PFAS analysis via method TO-13 (6 liters of air at 2 lpm were pulled through the samplers), and one cartridge sampler for gaseous, particulate and total fluoride analyses via National Institute for Occupational Safety and Health (NIOSH) method 7902 (1 liter of air was pulled through the cartridge at 1 lpm).

Effluent air samples were collected through a sample port on the iSCWO system's instrument air line. The instrument air line is equipped with an air pump to draw air from the discharge stack and a chiller to remove moisture and provide dry, ambient temperature effluent air to the system's oxygen and carbon monoxide sensors. Effluent air samples consisted of summa canister grab samples for VOCs and fixed gases analyses, grab 2x XAD-resin tube samplers for PFAS analysis, and grab cartridge samplers for gaseous fluoride, particulate fluoride, and total fluoride analyses.

A blank XAD resin tube was left open on each end of the sampler resin tube and set near the effluent air sampling station for the duration of the SAFF Tests. No air was pumped through the resin, the sampler was just set near the sampling station with each end exposed to the ambient air.

Additionally, %O₂, %CO₂, CO, SO₂ and NO_x, NO, and NO₂ were monitored in the effluent air using a pre-calibrated Testo Combustion Gas Analyzer connected to a sample port on the iSCWO system's instrument air line. Built-in iSCWO system instrumentation monitored air pressure and temperature into the reactor and percent oxygen and carbon monoxide in the effluent air. A summary of results for each of the testing locations is provided below. The full air analytical data tables with validation qualifiers are included in **Appendix 2**. A chart displaying the Testo Combustion Gas Analyzer data is presented in **Appendix 2**.

5.2.1 Summa Can Blank Sample (labeled Pre-Heater Effluent)

A summa canister sample labeled "Pre-Heater Effluent" was never collected. However, the canister was mistakenly submitted and analyzed for VOCs and fixed gases. The sample labeled "Pre-Heater Effluent" should be considered a summa can blank sample.

Methylene chloride and toluene were the only VOC constituents detected in the summa can blank sample at concentrations of 3.8 micrograms per cubic meter (µg/m³) and 0.59 µg/m³, respectively. No fixed gases (carbon dioxide, methane, nitrogen, oxygen) were detected above the laboratory limit of detection in the summa can blank, since no air was drawn in to the canister.

5.2.2 Ambient Air

Ambient air samples for VOCs and fixed gases were collected during phase 1 (a 2-hour composite collected from test 1 through test 3) and phase 2 (a 1-hour composite collected during test 1). A number of VOC constituents were detected at low or estimated concentrations in both samples, including but not limited to acetone, various petroleum hydrocarbon constituents and the fluorine-containing VOCs 1,1,2-trichloro-1,2,2-trifluoroethane, chlorodifluoromethane, dichlorodifluoromethane, and trichlorofluoromethane. Methylene chloride and toluene were also detected in the ambient air samples, however these compounds were also detected in the laboratory method blanks and therefore flagged as such. VOC concentrations were generally consistent between the two testing phases. The combined VOC concentration (less surrogates) in ambient air for the two testing phases was 26.36 µg/m³ and 27.6 µg/m³, respectively.

Carbon dioxide was not detected at or above the method detection limit in either ambient air sample. Methane was detected at a concentration of 0.0022% by volume in the phase 1 ambient air sample and was non-detect in the phase 2 sample. Nitrogen ranged from 64% (phase 2) to 71% (phase 1). Oxygen ranged from 18% (phase 2) to 20% (phase 1). The percentages of nitrogen and oxygen in the ambient air samples are notably lower than typical atmospheric air but are within the normal tolerances of the analytical method.

One ambient indoor air sample was collected for analysis of gaseous fluoride, particulate fluoride, and total fluoride. No parameters were detected above the laboratory limits of detection for this sample.

Ambient air samples were collected during all testing phases for PFAS analysis. Five ambient air samples were collected near the intake of the air compressor, and one indoor ambient air sample was collected near the iSCWO system effluent air sample location area. Each sample was collected with two XAD resin samplers connected in series using a pre-calibrated battery-operated air pump to pull approximately 6 liters of air across the samplers. To calculate the concentration in mass per unit volume, each resin sampler laboratory analytical result was divided by the 6 liters of air that was pulled through each sampler. Results for back and front XAD resin samplers were

added to provide the total PFOS concentration for that sample in ng/L. PFOS was detected in the Phase 1, Test #1 ambient air sample, at an estimated concentration of 0.021 ng/L. No other PFAS compounds were detected above laboratory method detection limits for any ambient air samples.

One indoor air sample was collected near the effluent air sampling station for analysis of PFAS. PFOS was detected at a calculated estimated concentration of 0.035 ng/L, although the value is less than the laboratory reporting limit but greater than or equal to the method detection limit. No other PFAS were detected at or above laboratory method detection limits.

An XAD resin sample blank left in the air emission sampling station area for the duration of the SAFF tests with the two end caps of the sampler removed was submitted for PFAS analysis. No air was pulled through the resin sampler. PFOS was detected in the blank at an estimated concentration of 0.16 ng/sample.

5.2.3 Effluent Air

Effluent air samples were collected during all phases and rounds of sampling, including the pre-test. The sample port for effluent air sample collection was located on the iSCWO system's air instrumentation line downstream of a chiller unit. The effluent air samples collected are dry air samples. Condensate water removed from the effluent air sample stream was collected as a composite sample for analysis of PFAS. Results are discussed below.

Numerous VOCs were detected at low concentrations in each of the effluent air samples, and more VOC compounds were detected in the effluent air samples than in the ambient air samples. However, the combined VOC concentration (less surrogates) in the effluent samples only ranged from 79.9 $\mu\text{g}/\text{m}^3$ (phase 2 test 1) to 293.82 $\mu\text{g}/\text{m}^3$ (phase 1 test 1), respectively. Acetone contributed the greatest percentage to the combined VOC concentration value, with concentrations ranging from 31 $\mu\text{g}/\text{m}^3$ (phase 1 test 2) to 160 $\mu\text{g}/\text{m}^3$ (phase 1 test 1). The fluoride containing VOCs detected in ambient air samples were either not detected or were detected at generally lower concentrations in the effluent samples. At an operational air flow rate of approximately 19.82 cubic meters per minute (m^3/min), total VOC air emissions from the iSCWO system during the SAFF Test were negligible (less than 0.00034 pounds per hour [lb/hr]).

Fixed gases were detected in the effluent air samples at the following ranges:

- Carbon dioxide: 4.4% to 6.0%
- Methane: non-detect to 0.039%
- Nitrogen: 54% to 65%
- Oxygen: 8.4% to 9.5%

A Testo Combustion Gas Analyzer was used to measure and record specific gases in the effluent air stream every second, including percent oxygen ($\%\text{O}_2$), percent carbon dioxide ($\%\text{CO}_2$), carbon monoxide (CO) concentrations in parts per million (ppm), sulfur dioxide (SO_2) concentrations in ppm, nitrogen oxide (NO) in ppm and nitrogen dioxide (NO_2) in ppm. A chart displaying the various analyzer data is presented in **Appendix 2**.

SO_2 was generally not detected during the testing period, with the exception of two observed concentration spikes: the first approximately 16 minutes after start-up (maximum concentration = 66 ppm) as the system was coming up to temperature; and the second after the system shutdown sequence began (maximum concentration = 7 ppm) and the system temperature began to drop. Both spikes lasted less than 1.5 minutes.

Low levels of NO_2 were detected at two intervals each less than 25 seconds long near the middle of the SAFF Tests (0.1 to 0.3 ppm) and near system shutdown (0.1 to 0.6 ppm).

CO was detected during system startup after the diesel fuel was first introduced and until the reactor reached steady operating temperature – a period of approximately 32 minutes. CO peaked at a concentration of 5,117 ppm and averaged approximately 686 ppm during this time. Two additional brief peaks of CO were observed near the middle of the SAFF Tests (140 ppm) and near system shutdown (1,255 ppm). Concentrations of CO hovered around 4 ppm through most of the steady state portions of the test.

CO₂ concentrations increased and O₂ concentrations decreased after diesel fuel was introduced into the reactor. Concentrations of O₂ hovered around 10% by volume through most of the test, while CO₂ was generally observed around 6% by volume in the effluent air.

The decrease in O₂, increase in CO₂ and general lack of VOCs, SO₂, NO, NO₂ and CO in the iSCWO effluent air indicates the reactor is highly effective at completely oxidizing the diesel fuel and other organic compounds in the waste feed during operating conditions.

Gaseous fluoride, particulate fluoride, and total fluoride were not detected above laboratory limits of detection in any of the effluent air samples.

PFOS was detected in four of the five effluent air samples collected and generally at estimated concentrations below the laboratory reporting limit. No other PFAS compounds were detected in any of the effluent air samples collected. PFOS was detected in both the front XAD resin sampler and the back XAD resin sampler in the sampler trains and the detections were reported in nanograms per sample. To calculate the concentration in mass per unit volume, each result was divided by the 6 liters of air that was pulled through each sample. Results for back and front XAD resin samplers were added to provide the total PFOS concentration for that sample in ng/L. A summary of PFOS detections in effluent air samples is provided in **Table 6** below.

Table 6. Effluent Air PFOS Detection Summary

Sample ID	PFOS Conc. (ng/sample)	Volume per Sample (Liters)	PFOS Conc. (ng/L)
SAFF-PRE-0-EFFLUENT AIR PUF FRONT	0.16 J	6.0	0.027
SAFF-PRE-0-EFFLUENT AIR PUF BACK	0.35 J	6.0	0.058
SAFF-PRE-0-EFFLUENT AIR PUF TOTAL			0.085
SAFF-TI-2-EFFLUENT AIR PUF FRONT	0.72 J	6.07	0.119
SAFF-TI-2-EFFLUENT AIR PUF BACK	1.4	6.07	0.231
SAFF-TI-2-EFFLUENT AIR PUF TOTAL			0.349
SAFF-T1-3-EFFLUENT AIR PUF FRONT	0.51 J	6.06	0.084
SAFF-T1-3-EFFLUENT AIR PUF BACK	0.29 J	6.06	0.048
SAFF-T1-3-EFFLUENT AIR PUF TOTAL			0.132
SAFF-T2-1-EFFLUENT AIR PUF FRONT	0.41 J	6.2	0.066
SAFF-T2-1-EFFLUENT AIR PUF BACK	0.47 J	6.2	0.076
SAFF-T2-1-EFFLUENT AIR PUF TOTAL			0.142

Notes: PFOS = Perfluorooctanesulfonic acid; Conc. = Concentration; ng = nanograms; ng/L = nanograms per liter
J = Estimated value = sample detected above the laboratory method detection limit but below the laboratory reporting limit

As noted in **Table 6** above, concentrations of PFOS in the effluent air of the more concentrated SAFF Test (Phase 2, Test 1) was less than or similar to the PFOS concentrations observed in Phase 1 Test 2 and Phase 1 Test 3 effluent air samples.

One composite effluent air condensate (aqueous) sample was collected during the SAFF Tests. The condensate was sampled for PFAS via EPA method 1633. PFOS was detected above the

laboratory method detection limit but below the laboratory reporting limit at a concentration of 1.3 ng/L. No other PFAS compounds were detected in the condensate sample.

5.3 Aqueous Sampling Results

Aqueous samples were collected at various points throughout the iSCWO system during the two testing phases as described above. The full analytical data tables with validation qualifiers are included in **Appendix 1**. A general summary of the results for each of the analytical parameters is presented below. It is noted that up to 90% of the influent liquid to the iSCWO reactor was converted to steam during the SAFF Phase 1 Test 1. Steam generation for the remaining SAFF tests was on the order of 66 to 68% (as water by volume) of the incoming liquid.

5.3.1 PFAS

A total of 22 aqueous PFAS samples (including duplicates) were collected over the three testing phases. A PFAS field blank sample was collected during the SAFF tests consisted of laboratory-supplied PFAS-free water which was poured into PFAS sample containers just prior to the SAFF tests. The filled PFAS field blank sample containers were placed near the effluent water sampling station and left open (uncapped) for the duration of the SAFF tests. At the end of the SAFF tests, the sample containers were capped and submitted for PFAS analysis. No PFAS analytes were detected in the PFAS field blank.

Aqueous PFAS samples included seven separate samples of the municipal-supplied potable tap water used during the SAFF Tests as quench water, initial start-up and final shutdown process feed water, and water to make up the initial SAFF test mixture. A number of PFAS compounds, including PFOA and PFOS, were detected in each of the seven quench water samples collected. Across the seven quench water samples collected, PFOA had an average concentration of 2.2 ng/L and PFOS had an average concentration of 2.54 ng/L.

All PFAS compounds detected in influent samples showed reduced concentrations in the associated post-treatment effluent water samples with two exceptions: PFMPA was detected in the effluent during Phase 1, Test 1 at a low estimated value, but was not detected in the influent; 6:2 FTS was detected in the effluent during Phase 2, Test 1, but was not detected in the influent.

For all effluent samples, concentrations of PFBS, PFBA, PFHxS, PFHxA, PFOA, and PFOS were below the established Minnesota Department of Health (MDH) Health Risk Limits (HRLs). An abbreviated summary of all PFAS compounds with established MDH HRLs is provided in **Table 7**. Note that concentrations of most of the PFAS with established MDH HRLs observed in the liquid effluent dropped over time suggesting that oxidation improved even as PFAS concentration in the feed increased when transitioning to Phase 2 Test 1.

Table 7. Select PFAS Aqueous Sample Results Summary

PFAS Analyte	MDH HRL (ng/L)	Phase 1 Test 1		Phase 1 Test 2 ^a		Phase 1 Test 3		Phase 2 Test 1 ^b	
		Inf (ng/L)	Eff (ng/L)	Inf (ng/L)	Eff (ng/L)	Inf (ng/L)	Eff (ng/L)	Inf (ng/L)	Eff (ng/L)
PFBS	100	360	6.9	330	2.8	590	2.5	1,236	2.4
PFBA	7,000	97	56	96	<35	100	5	<400	30
PFHxS	47	4,000	11	4,200	2.8	4,300	1.8	12,524	2.2
PFHxA	200	500	6.9	450	3.2	650	1.9	1,162	1.9
PFOA	35	33,000	29	34,000	12	36,000	7.2	132,146	7.3
PFOS	300	120,000	44	130,000	7.4	150,000	7.6	341,070	4.9

Notes:

a = Duplicate samples were collected for the influent and effluent samples associated with Phase 1 Test 2 and Phase 2 Test 1. The higher concentration between the parent and duplicate sample is shown in the table.

b = Influent results are a calculated combination of the SAFF mixture described and pure SAFF as described in **Section 3.0**

Eff = Effluent sample; HRL = Health Risk Limit; Inf = Influent sample; MDH = Minnesota Department of Health.

ng/L = nanograms per liter; Red = exceeds the MDH HRL; "<" = less than (result is not detected above detection limit)

The SAFF concentrate used for the test was diluted using water supplied by the City of San Diego (quench water) prior to being fed through the system, as described in **Section 3.0**.

Data qualifiers are not shown in **Table 7**. Please refer to **Appendix 1** for all appropriate data qualifiers.

5.3.2 VOCs

A total of 14 aqueous VOC samples were collected over the two testing phases. Acetone, 2-butanone, 2-hexanone, bromodichloromethane, bromoform, chloroform, toluene, and dibromochloromethane were detected in various samples – generally at very low estimated concentrations below the laboratory reporting limit. No VOCs detected exceeded the EPA Primary or Secondary MCL or the MDH HRL with the sole exception of bromodichloromethane, which exceeded the MDH HRL of 3.9 µg/L in the samples collected from the city-supplied quench water. Concentrations ranged from 5.8 µg/L to 6.4 µg/L across five analyses, with an average concentration of 6.12 µg/L. Concentrations of detected analytes such as acetone and toluene remained fairly consistent throughout the different sampling phases and stages of the iSCWO system.

5.3.3 General Chemistry

General chemistry sampling parameters included laboratory analysis of total suspended solids (TSS), oil & grease, flashpoint, chemical oxygen demand (COD), total alkalinity, total organic carbon (TOC), adsorbable organic fluorine (AOF), and total fluorine, and field analysis of pH, temperature, conductivity, oxidation-reduction potential (ORP) and salinity. General chemistry, anions, cations and metals detections in the quench water and for the two tests where all parameters were analyzed in both the influent and effluent are summarized in **Table 8** below.

Table 8. General Chemistry, Anions, Cations and Metals Detection Summary

Parameter	Units	EPA MCL	MDH HRL	Quench Water Avg.*	Phase 1 – Test 2 Inf	Phase 1 – Test 2 Eff	Phase 2 – Test 1 Inf	Phase 2 – Test 1 Eff
pH	s.u.			8.49	8.15	7.73	8.51	7.92
Temperature	Deg C			22.97	22.38	42.25	22.96	41.69
Conductivity	mS/cm			0.602	0.701	2.705	0.737	3.585
ORP	mV			88.33	135.5	149.5	100.9	110.9
Salinity	g/L			0.50	0.48	1.325	0.497	1.757
TSS	mg/L			57.14	50*	55*	55*	80*
COD	mg/L			ND	ND	ND	ND	29
Total Alkalinity	mg/L			91.67	92	520	93	860
TOC	mg/L			2.27	4.3	3.7	4.7	3.9
Ads. Organic Fluorine	µg/L			100.9	1,500	ND	320	1
Total Fluorine	µg/L			668	790	1,600	790	1,700
Fluoride	mg/L	4, 2		0.50	0.5	1.2	0.51	1.4
Chloride	mg/L	250		92.7	88	180	85	170
Nitrate As N	mg/L	10	10	0.87	0.81	1.3	0.8	1.7
Sulfate	mg/L	250		123.33	120	260	110	220
Silicon	µg/L			4,033	4,300	8,500	4,200	8,700
Calcium	µg/L			ND	1,700	590	1,600	1,000
Chromium	µg/L	100	100	0.22	0.69	22	0.65	9.6
Iron	µg/L	300		34.3	260	100	260	130
Magnesium	µg/L			ND	600	240	610	290
Nickel	µg/L		100	ND	1.5	57	2	26
Sodium	µg/L			146,667	150,000	460,000	150,000	670,000
Titanium	µg/L			ND	ND	8.9	ND	4.9

Notes:

See **Appendix 1** for all laboratory qualifiers for the data above.

EPA = Environmental Protection Agency; HRL = Health Risk Limit; MCL = Maximum Contaminant Level; MDH = Minnesota Department of Health

EPA MCL value in italics = secondary MCL

Avg. = Average; Inf = Influent; Eff = Effluent; “*” = value or values represent an average

Ads. = Adsorbable; COD = chemical oxygen demand; TOC = total organic carbon; TSS = total suspended solids; ORP = oxidation reduction potential

deg C = degrees Celsius; deg F = degrees Fahrenheit; g/L = grams per liter; mg/L = milligrams per liter; mS/cm = millisiemens per centimeter;

mV = millivolts; s.u. = standard units; µg/L = micrograms per liter; ND = not detected at or above method detection limit

Blue Font = a decrease by a factor of near 50% or more from influent to effluent; Red Font = an increase by a factor of near 1.5x or more from influent to effluent.

TSS samples were collected with 21 of the 22 PFAS samples collected during the SAFF Tests. Concentrations of TSS remained fairly consistent throughout all testing phases and sampling locations, generally ranging from 40 mg/L to 70 mg/L. The duplicate sample collected from the system effluent associated with the phase 2 sampling returned a TSS result of 110 mg/L. The values for TSS in **Table 8** represent average concentrations between the primary sample result and the duplicate sample result.

Oil & grease and flashpoint were analyzed in two samples, the pre-test effluent and phase 2 test effluent. Flashpoint was non-detect at the limit of detection for both samples. Oil & grease was detected at a concentration of 450 mg/L in the pre-test effluent and at an estimated concentration of 1.7 mg/L in the phase 2 effluent. The higher oil & grease concentration in the pre-test “off-spec”

effluent sample is likely attributable to incompletely oxidized diesel fuel that may pass through the reactor during the initial few minutes of system start-up.

COD was generally non-detect above the limit of detection of 60 mg/L; however, an estimated COD concentration of 29 mg/L was noted in the phase 2 effluent sample. It is noted that this sample did not meet the required preservation pH of 3 when it arrived at the laboratory, and the sample result has been flagged as a result.

Numerous general chemistry parameters exhibited slight to notable increases from influent to effluent, including the field parameters of temperature, conductivity ORP, and salinity, and the laboratory analyzed parameters of alkalinity and total fluorine.

Alkalinity ranged from 92 mg/L to 860 mg/L, with the higher concentrations observed in the effluent samples for the first and second testing phases. The alkalinity of the effluent samples in tests T1-2 in Phase 1 and test T2-1 in Phase 2 study showed a significantly higher alkalinity than that in the influent samples. These alkalinity results are to be expected as sodium hydroxide, which is injected into the reactor bottom to neutralize the hydrofluoric acid formed from destruction of PFAS and excess will develop sodium carbonate, tends to raise the alkalinity. Furthermore, the effluent stream also contains significantly more anions and cations concentrations than the influent, which can also raise the alkalinity in the effluent. Typically, the NaOH additions can be adjusted such that the liquid effluent pH stabilizes at 7.0, however, given the shortened test period, those adjustments were not made for this test.

TOC ranged from 3.7 mg/L to 4.7 mg/L, with concentrations in the effluent slightly lower than influent concentrations.

AOF analyses are assumed to quantify the bulk of organic fluorine compounds, including synthetic organic fluorine compounds such as PFAS in water samples. Thus, AOF may be used as a screening or indicator parameter for PFAS in water when PFAS concentrations are in the µg/L concentration range. AOF concentrations averaged approximately 101 µg/L in the quench water which is strongly influenced by a single sample that showed 500 µg/L while the remaining 4 samples were non-detect for AOF or had estimated concentrations between 1.1 to 2.3 µg/L. AOF concentrations in the SAFF mixture influent for Phase 1, test 1 through 3 samples and the Phase 2, test 1 sample were 180 µg/L, 1,500 µg/L, 180 µg/L, and 320 µg/L, respectively. For comparison, the estimated fluorine concentration associated with the detected PFAS compounds in each sample were approximately 107 µg/L, 114 µg/L, 129 µg/L, and 104 µg/L, respectively. It is noted that reporting limits for AOF were raised for some samples due to interference from the sample matrix. Sample results in **Appendix 1** are flagged as appropriate. AOF concentrations in the water effluent samples for Phase 1, tests 1 through 3 and Phase 2 were 2.1 µg/L, below detection limits, below detection limits and 1 µg/L, respectively. The reductions in AOF through the reactor for the four SAFF test periods ranged from 98.8% to 100%. This data suggests the reactor successfully destroys organic fluorine compounds.

A PFAS-associated fluorine mass reduction evaluation was performed for the tests in the first and second phases and is described in **Section 7.0**. Total fluorine and fluoride concentrations increased in the liquid effluent samples compared to the liquid influent samples collected during the SAFF tests. The increase in fluoride can be attributed to the destruction of PFAS and other organic fluorine compounds through the reactor creating inorganic fluorine salts.

In addition, percent closure of total fluorine, between the liquid influent and liquid effluent streams was calculated. Percent fluorine capture was calculated by dividing the total fluorine mass throughput in the effluent streams by the total fluorine mass throughput in the influent streams and multiplying the result by 100. The percent closure of total fluorine in test T1-1 was about 60%, in test T1-2 was about 84%, in test T1-3 was about 74%, and in test T2-1 was about 85%. The

percent closure numbers observed in this study are typical for a large industrial scale reactor as the SCWO unit. Future tests will include additional analyses to help close the difference in fluorine mass balance.

5.3.4 Anions

Anions analyzed within the liquid streams included chloride, fluoride, nitrate, nitrite, and sulfate. Nitrite was not detected in any of the analyzed samples. Concentration ranges for the other anions are as follows:

- Chloride: 85 mg/L to 180 mg/L
- Fluoride: 0.5 mg/L to 1.4 mg/L
- Nitrate: 0.8 mg/L to 1.7 mg/L
- Sulfate: 110 mg/L to 260 mg/L

Table 8 summarizes the concentrations of anions in samples collected in the quench water and influent and effluent samples from Phase 1 and Phase 2 SAFF testing. For both the first and second testing phases, the concentrations of the anions in the effluent samples generally increased by 2x or more compared to the respective anion concentrations in the influent mixture samples. A large percentage (66 to 90%) of the liquid volume entering the iSCWO reactor exits the system as steam. Therefore, inorganic salts entering the reactor may be concentrated in the liquid water effluent. In addition, any sulfur, chlorine or fluorine associated with organic compounds in the effluent will be converted to inorganic salts in the effluent.

5.3.5 Metals, Cations

Metals and cations detected during analysis included silicon, calcium, chromium, iron, magnesium, nickel, sodium and titanium. In general, concentrations of silicon, chromium, nickel, sodium and titanium were greater in the effluent samples than in the influent samples, while concentrations of calcium, iron, and magnesium were lower in the effluent than the influent samples.

The cations/metals that increased in concentration in the effluent are likely due to the low corrosion effects on system metal. The corrosion losses are very small but do indicate that over time (typically a few years) the liner and other materials may need to be replaced. The addition of NaOH as an acid neutralizer in the iSCWO process contributes to the increase in sodium in the effluent. Silicon also increased in the liquid effluent as a result of adding the antifoaming agent to the feed matrix.

The cations/metals that decreased in concentration are a result of the dilution effect from adding quench water that was previously softened. A soft water system will replace the calcium and magnesium ions with sodium ions and is used to prevent hard scale formation within the iSCWO system.

5.3.6 PAHs

The following PAHs were detected in the pre-test effluent composite sample: 2-methylnaphthalene, anthracene, benzo[g,h,i]perylene, naphthalene, and pyrene. None of the concentrations in the pre-test effluent composite sample exceeded MDH HRLs.

No PAHs were detected above laboratory limits of detection in the effluent sample collected in association with testing Phase 2.

6.0 PFAS DESTRUCTION EFFICIENCY DETERMINATION

PFAS destruction was determined by evaluating the total mass flow of target PFAS in the various process streams going into and coming out of the iSCWO reactor. Process streams entering the reactor include SAFF mix waste streams, quench water and sodium hydroxide solution, diesel fuel, and compressed air. Process streams exiting the reactor include water discharge, air, and steam. A significant volume of steam is generated by the iSCWO process. Up to 90% of the influent liquid was converted to steam during the SAFF Phase 1 Test 1. Steam generation for the remaining SAFF tests was on the order of 66 to 68% (as water by volume) of the incoming liquid.

PFAS concentrations were not evaluated in the diesel fuel or in the NaOH solution. The volume of NaOH solution used was minimal (10 liters). PFAS mass flow from the other process streams were calculated by multiplying the average flow of those streams during steady state conditions through the testing round by the concentration of PFAS in samples of the process stream collected during that testing round. A value of zero was used when the PFAS concentrations was below the method detection limit. PFAS destruction efficiency was determined by the following equation:

$$\frac{(\sum PFAS_{mass\ flow\ in} - \sum PFAS_{mass\ flow\ out})}{\sum PFAS_{mass\ flow\ in}}$$

Individual and total PFAS destruction efficiency evaluations are provided in **Appendix 3**. Total PFAS mass destruction efficiencies are summarized for each of the SAFF tests in **Table 9** below.

Table 9. SAFF Tests - Total PFAS Destruction Efficiency Summary

Process Stream	Ph1 – T1 Total PFAS Mass Flow (ng/min)	Ph1 – T2 Total PFAS Mass Flow (ng/min)	Ph1 – T3 Total PFAS Mass Flow (ng/min)	Ph2 – T1 Total PFAS Mass Flow (ng/min)
72:1 SAFF Mix Feed	612,662	641,734	742,607	619,201
SAFF Concentrate Feed				1,413,494
Quench Water Feed	209	347	347	347
Total IN	612,872	642,081	742,954	2,033,042
Effluent Water	369	408	283	452
Effluent Air	0	6,918*	2,616*	2,815*
Est. Steam/Condensate	22	24	24	25
Total OUT	391	7,349	2,924	3,292
Destruction Efficiency	99.94%	98.86%	99.61%	99.84%

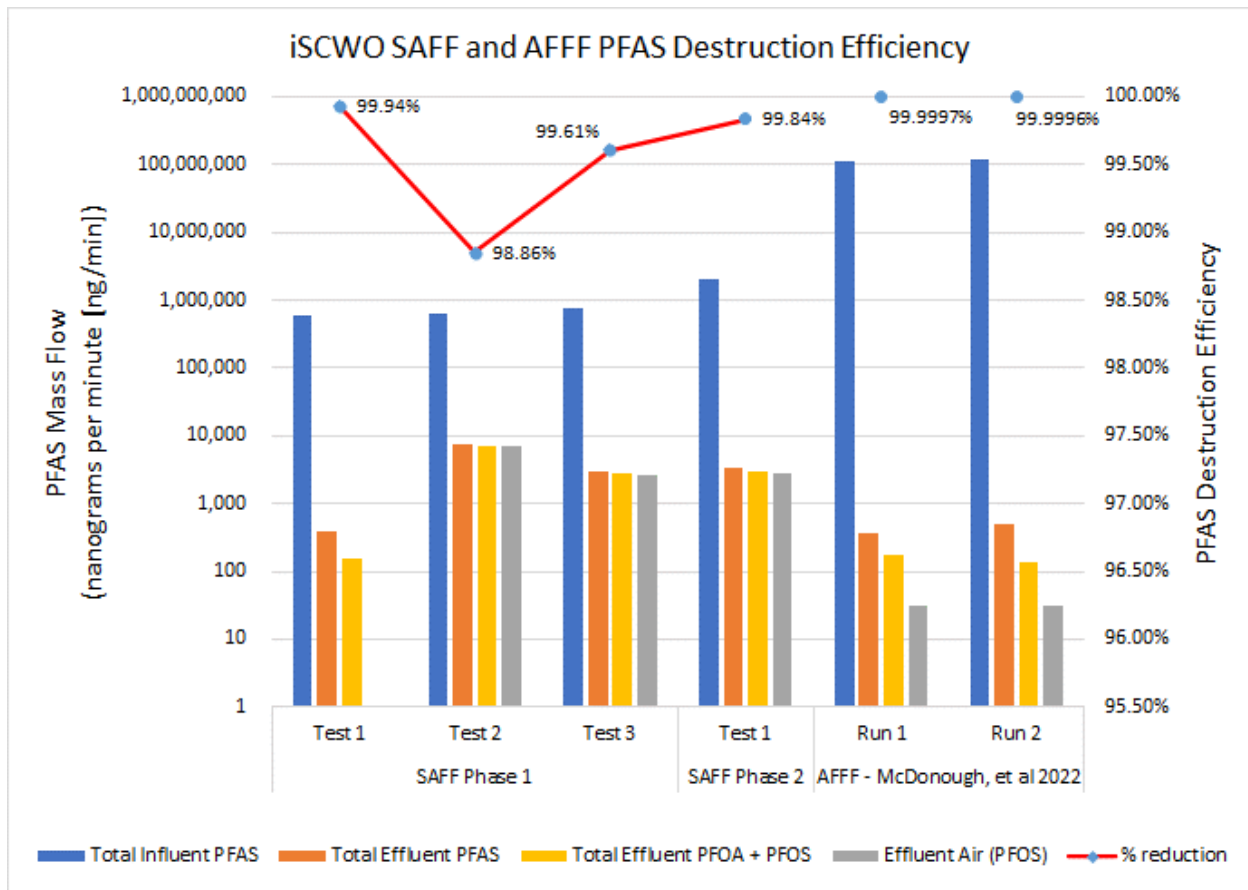
Notes: ng/min = nanograms per minute; PFAS = per- and polyfluoroalkyl substances; SAFF = surface active foam fractionation

“*” = See discussion regarding effluent air sample analytical results in **Section 6.0**

Total PFAS destruction efficiency averaged approximately 99.45% during Phase 1 testing and 99.84% during Phase 2 testing.

A previous study of PFAS destruction using GA’s iSCWO system was conducted in 2021 using mixtures of AFFF at significantly higher PFAS mass flow rates (McDonough et. Al, 2022). Results showed PFAS destruction efficiencies over 99.999% with discharge concentrations of PFAS significantly lower than those observed for the SAFF test. A summary of the SAFF Test PFAS destruction results is graphically illustrated in **Figure 3** below. The results from the 2021 AFFF study are included for comparison.

Figure 3. PFAS Destruction Efficiency for Multiple SAFF Tests



The lower PFAS destruction efficiency observed for the SAFF tests compared to those reported in the 2021 AFFF study may be the result of one or several factors as described below.

- The iSCWO system uses a fair amount of municipal water as a reactor quench source. This water source was determined to have low but consistent concentrations of PFAS. An increase in quench water flow was initiated after the first Phase 1 test round. No PFOS was detected in the effluent air of the first Phase 1 test round but was detected in all subsequent test rounds and in the Phase 2 testing. The Phase 1 Test 1 PFAS destruction efficiency was higher than any other tests. The quench flow rate to process feed rate ratio was approximately 2.56 for Phase 1 Test 1 but was increased up to 4.25 for the remaining SAFF tests. The quench to feed ratio during the 2021 AFFF study, which produce extremely high PFAS destruction efficiencies, ranged from 2.37 to 2.52.
- The bulk of PFAS mass detected in the effluent of the iSCWO reactor was from low estimated values of PFOS below the laboratory reporting limits but above the method detection limits in effluent air samples. PFOS was detected in two of the ambient air samples, in a field blank resin sample, and in pre-SAFF test reactor effluent air samples. In addition, for the effluent samples in which PFOS was detected – the detections were observed in both the front and back resin samplers in the series sample trains. The one sample that showed a PFOS result above the detection limit came from the back end sorbent tube (rather than the front end), suggesting that perhaps the sample result is an anomaly. It is possible that the method selected for collecting PFAS air samples during the SAFF tests combined with the low-level detections of PFAS in the ambient air space of the sample location area may expose the air samplers to ambient air prior to and just after sampling. The effluent air

sampling method utilized for the SAFF test was TO-13M – a grab sample method for dry vapor - and not method OTM-45 which is more of a composite sample method typically used for stack gas testing in heavy industry. Collecting air samples via method TO-13M from a stack branch line that feeds the instrument air line may not be representative of the stack air flow – may be biased high which would result in destruction efficiencies that are biased low. Due to the high air flow rate of the iSCWO process, any small detections in effluent air affect the PFAS mass flow out of the reactor disproportionately. If no detections of PFOS were observed in effluent air during the SAFF Tests, PFAS destruction efficiencies would have ranged from 99.91% (Phase 1) to 99.98% (Phase 2), which are still lower than the 2021 AFFF study. This observation suggests that the iSCWO technology PFAS destruction efficiency actually improves with increased PFAS mass loading.

- The iSCWO system was operated at the lowest flow rate possible for the unit. In addition, the PFAS concentrations in the diluted SAFF mixtures used for the tests were much lower than those utilized in the 2021 AFFF tests. It's possible that the low flow rate and/or the dilutions used during the SAFF tests represent resulting in non-ideal operating conditions for the full-scale demonstration unit.

It was noted that after quench water flow was increased during the SAFF test, increases in PFAS mass flow resulted in increased PFAS destruction efficiency. The increased quench flow helped to increase pressure within the reactor allowing for longer retention times.

Two PFAS compounds, 6:2 FTS and PFBS, exhibited lower destruction efficiencies than most others, with destruction efficiencies up to 89.4% for 6:2 FTS and up to 89.8% for PFBS for the Phase 1 Tests. During the Phase 2 Test, these two PFAS analytes had higher mass flow rates exiting the reactor than entering it. However, it is likely that concentrations of these analytes were actually present at higher concentrations than indicated in the influent samples during the Phase 2, Test 1 testing round, but were below the elevated laboratory detection limits for the SAFF concentrate sample analyses.

A fluorine balance was performed for the tests in the first and second phases. During the Phase 1, T1-1 test, the total mass of fluorine present in the PFAS molecules detected in the influent decreased from 400 micrograms per minute ($\mu\text{g}/\text{min}$) to 0.25 $\mu\text{g}/\text{min}$ in the effluent. That is, a 99.9% decrease of fluorine in the PFAS molecule. This is to be expected as PFAS is destroyed in the reactor and the reactor effluent contains much lower PFAS than in the influent. Similar results were observed in the remaining two tests (T1-2 and T1-3) in Phase 1 and the test (T2-1) in Phase 2. In test T1-2, the influent mass rate of fluorine, present in the PFAS molecule, decreased from 419 $\mu\text{g}/\text{min}$ to 4.85 $\mu\text{g}/\text{min}$ in the effluent, a 98.8 % reduction. In test T1-3, the influent mass rate of fluorine, present in the PFAS molecule, decreased from 485 $\mu\text{g}/\text{min}$ to 1.89 $\mu\text{g}/\text{min}$ in the effluent, a 99.6 % reduction. In T2-1, the influent mass rate of fluorine, present in the PFAS molecule, decreased from 1,334 $\mu\text{g}/\text{min}$ to 2.12 $\mu\text{g}/\text{min}$ in the effluent, a 99.8 % reduction.

Since fluorine is a recalcitrant atom, unaffected by the SCWO, tracking fluoride through the SCWO system and calculating the percent mass reduction in the fluorine present in the PFAS molecule, should give a good approximation of the PFAS reduction in the reactor. High percent destruction of PFAS was obtained in the tests, which agrees well with the high percent reduction observed for fluorine, attached to the PFAS molecule, in the effluent.

7.0 MATERIAL AND ENERGY CONSIDERATIONS

Material and energy usage and associated costs for processing the five gallons of SAFF material are summarized in **Table 10** below. The total volume of municipal tap water used during the 4.27-hour testing period was approximately 1,460.7 gallons (1.95 hundred cubic feet [HCF]). This water includes initial and final process water, quench water, SAFF dilution and rinse water, and NaOH solution water as tracked by the SCADA system and/or by tank level observations.

A diesel flow meter is not provided on the iSCWO system. Diesel usage was physically observed by measuring the level of diesel fuel in the 55-gallons drums before system start-up and after system shutdown. Diesel fuel usage was also tracked by the SCADA system using a calculation based on the variable frequency drive (VFD) speed of the diesel fuel feed pump motor. The SCADA estimated diesel fuel usage was lower than what was actually consumed as verified by physical observation, so SCADA-calculated diesel fuel flow rate and total flow values were corrected using a multiplier based on the total observed diesel fuel use. Based on these calculations, approximately 91.7 gallons of diesel fuel was used during the SAFF Tests.

Propane is used for a brief period in a pre-heater burner at start-up to heat the compressed air entering the reactor. During the SAFF test start-up, propane was utilized for a little over 19 minutes. Readings from a level gauge on the 500-gallon propane tank were recorded before and after the SAFF Tests. It is estimated that up to 5 gallons of propane was used during the system start-up.

Ten liters of a 5% by weight NaOH solution were consumed during the SAFF Test. Approximately 0.53 kilograms of NaOH are present in 10 liters of a 5% by weight NaOH solution.

The iSCWO system was not equipped with power meters. Energy consumption was estimated based on the voltage, phase and full load amps of the various electrical equipment on the iSCWO unit, plus the known run times as logged by the SCADA system. By far, the largest piece of electrical equipment on the iSCWO unit is the high-pressure air compressor at 480 volts, 3-phase, 611 full load amps. Power usage was calculated assuming a 90% power factor and 90% motor efficiencies. The estimated total amount of power used during the 4.27-hour SAFF Test period was approximately 1,800 kilowatt-hours (kWh).

Table 10. SAFF Test - Material and Energy Usage and Cost Summary

	Water	Diesel	Propane	NaOH	Energy
Rate ^a	0.46 HCF/hr	21.48 gal/hr	~ 5 gal	0.12 kg/hr ^d	423kW
Price ^b	\$4.10/HCF	\$3.827/gal	\$1.865/gal	\$50.40/kg	\$0.17/kWh
Hourly cost	\$1.88/hr	\$82.22/hr	\$9.33 ^e	\$6.22/hr	\$71.88/hr
Total hourly cost	\$162.19/hr				
Total cost ^c	\$692.03 + \$9.33 = \$701.35				

Notes: Gal = gallon; HCF = Hundred cubic feet; hr = hour; kg = kilogram; kW = kilowatts; kWh = kilowatt-hour;

NaOH = Sodium Hydroxide

Total run time: 4.27 hours.

a = Rates were determined by dividing the final amount of material/energy used at the end of the SAFF tests by the total run time (4.27 hours) to provide a general average usage rate for the SAFF Tests. Rates are subject to change based on operator selected processing speeds and/or based on the materials being processed.

b = Water price from City of Minneapolis, as of January 2, 2024; Diesel price from AAA MN current diesel prices as of January 5, 2024; Propane Price from US Energy Information Administration as of January 1, 2024; NaOH price from Chemical-book.com accessed on December 28, 2023; Electric price for Minneapolis from Bureau of Labor Statistics as of November 2023. These prices are subject to change through time and by region.

c = total cost assumes all hourly costs times the total run time for the SAFF Test (4.27 hours), plus the cost for propane at start-up. Due to the limited quantity of SAFF, dilutions were prepared to provide adequate run times and testing periods for the SAFF evaluation. GA's iSCWO unit is capable of processing up to 3 gpm of waste material, therefore the five gallons of SAFF could technically have been processed in less than 2 minutes after the system warm-up period. Assuming a 30-minute warm-up and a 30-minute cool down period, the SAFF could have been processed in approximately 1 hour at a cost of \$162.19 + \$9.33 = \$171.52 assuming Minneapolis/Minnesota material and energy costs as of the dates listed above..

d = usage determined assuming 10 liters of a 5% NaOH solution by weight was used over the total run time. The mass rate listed is for the NaOH only (i.e. not the solution).

e = Propane only used at start-up. Assumes a usage rate of 1,000 standard cubic feet per hour and a burn time of 0.32 hours at start-up. Cost represents a one-time cost – not an hourly rate.

It should be noted that the above costs were based on pricing sources for Minnesota and/or the City of Minneapolis as of the dates listed in the footnotes and are subject to change through time and by region. In addition, the above costs were based on the specific operating conditions for the SAFF Tests. Operating conditions, such as feed flow rate, diesel consumption as a result of the thermal energy value of the waste stream, and acid neutralization needs will vary based on the nature and properties of the waste material being processed.

8.0 SUMMARY & CONCLUSIONS

A total of five gallons of concentrated SAFF material provided by the MPCA was processed through the GA iSCWO system in San Diego, CA over approximately four hours on October 25, 2023. The SAFF was processed in two treatment phases, and air and water samples were collected at various points throughout the system during both testing phases. Numerous analytes were detected in both influent and effluent samples; however, concentrations of all PFAS compounds decreased substantially between the influent and effluent samples for all testing runs. In order to properly quantify PFAS destruction efficiency, total mass flow rates for individual target PFAS were calculated for all influent and effluent streams (aqueous and air). Removal efficiencies for each of the PFAS compounds were calculated via mass-flow balance as described in **Section 7.0** and shown in **Appendix 3**.

PFAS Destruction efficiency during the SAFF Tests ranged from 98.82% to 99.94% for the Phase 1 Tests using the diluted SAFF mixture, and was 99.83% for the Phase 2 Test using the diluted SAFF mixture combined with a separate feed of undiluted SAFF. PFAS destruction efficiencies for a 2021 study of AFFF using the same iSCWO unit were greater than 99.999% (McDonough, et al, 2022). The 2021 study used significantly higher PFAS mass flow into the iSCWO unit, and the effluent concentrations were significantly lower than those observed during the SAFF tests. The primary operational/testing differences between the SAFF study and the 2021 AFFF study include the following:

- PFAS concentrations in the 2021 AFFF feed mixtures were much higher than both the SAFF test Phases' influent PFAS concentrations while PFAS concentrations in the liquid effluent were very similar.
- Waste material feed rate was more than double in the 2021 AFFF test compared to the SAFF test. This fact combined with the bullet above resulted in a much higher PFAS feed rate in the 2021 study compared to the SAFF tests.
- The quench water to process feed ratio was approximately 2.5 for SAFF Phase 1 Test 1, which produced the highest PFAS destruction efficiency, and for the 2021 AFFF tests. The quench water to process feed ratio was approximately 4.2 for the other SAFF tests.
- The PFAS air emission sampling method utilized for the SAFF Tests was the grab sample method TO-13M and was conducted on the iSCWO effluent air instrumentation air line. The PFAS sampling method employed during the 2021 AFFF Test study was the composite stack testing method OTM-45 and was conducted on the air emission stack of the iSCWO system. The OTM-45 method is a much more accurate (and expensive) means to determine concentrations within a gas stack.

Low estimated concentrations of PFOS were detected in two ambient air samples, a field blank, and in four of five effluent air samples during the SAFF tests. Due to the high air flow rate, compared to liquid flow rates, any detection in effluent air has a disproportionate effect on destruction efficiency. PFOS concentrations detected in air samples during the SAFF tests were much higher than those detected in the air samples collected during the 2021 AFFF study.

If no detections of PFOS were observed in effluent air during the SAFF Tests, PFAS destruction efficiencies would have ranged from 99.91% (Phase 1) to 99.98% (Phase 2), which are still lower than the 2021 AFFF study. This observation suggests that the iSCWO technology PFAS destruction efficiency actually improves with increased PFAS mass loading.

VOCs, SO_x, and NO_x were detected in effluent air during the SAFF tests but at very low concentrations and, for SO_x and NO_x, for very limited durations during system start-up and shutdown. CO was observed at up to 5,117 parts per million for a brief period during start-up. CO₂ was observed at up to 6% per volume in the effluent air during the test runs.

There were no exceedances of Minnesota Department of Health (MDH) Health Risk Limits (HRLs) or Environmental Protection Agency (EPA) Primary Maximum Contaminant Levels (MCLs) in effluent water from the SAFF tests. Sulfate slightly exceeded the EPA secondary MCL in one effluent sample.

The primary resources and energy required for iSCWO include water, fuel, and electricity. Resource usage was documented to the greatest extent possible using the existing system sensors and meters and through physical observations of tank levels. It is noted that the iSCWO system will likely be modified in the future to include additional meters and sensors to better define resource usage and provide a more comprehensive estimate for costs to treat PFAS-impacted feed material.

Due to the limited volume of SAFF concentrate available for testing and the time needed to complete the planned testing, dilution of the SAFF concentrate was required during each of the testing phases to meet the minimum system flow rate of 1 gpm. The costs associated with treatment of this waste stream are therefore higher on a per-mass treated basis due to the additional energy required to bring the total feed volume to supercritical conditions. For full-scale treatment conditions with a greater available volume of undiluted feed material, treatment costs per unit mass of PFAS destroyed are expected to decrease significantly and therefore become more economical. Due to this uncertainty, utility and resource costs for this study were calculated on a per-hour basis, then multiplied across the total test time (four hours and sixteen minutes) to determine a total treatment cost of \$701.35 for the five gallons of SAFF material, diluted to a total treatment volume of 184.1 gallons. Assuming a 30-minute warm-up and a 30-minute cool down period, the SAFF could have been processed in approximately 1 hour at a cost of $\$162.19 + \$9.33 = \$171.52$ assuming November 2023 to January 5, 2024 Minneapolis material and energy costs. The bulk of the costs are related to electricity use and fuel consumption.

Additional testing is planned for the GA iSCWO system and will examine treatment of various PFAS-impacted feedstock types and volumes and the associated treatment costs. PFAS destruction using SCWO is a well-demonstrated technology; however, more testing is needed to further establish treatment efficiency of various feedstocks at varying concentrations and the costs and resource usage associated with treatment.

In conclusion, the testing was a success that demonstrated the destruction of SAFF concentrate using GA's supercritical water oxidation process.

9.0 REFERENCES

McDonough, Jeffrey T.; Kirby, John; Bellona, Christopher; Quinnan, Joseph A.; Welty, Nicklaus; Follin, John; Liberty, Ken, 2022. *Validation of supercritical water oxidation to destroy per-fluoroalkyl acids*. Remediation. 2022;1-16. DOI: 10.1002/rem.21711.

Appendix 1

Aqueous Sample Analytical Result Tables

Appendix 1 - Table 1
SAFF Concentrate Sample Analytical Result Summary
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS	Units	SAFF Concentrate	MPCA SAFF Data
Per- and Polyfluorinated Substances (PFAS)				
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	ng/L	76,000 U	—
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	ng/L	77,000 U	—
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	ng/L	38,000 U	—
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	ng/L	76,000 U	—
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	812-70-4	ng/L	250,000 U	—
3-Perfluoropentylpropanoic acid (5:3 FTCA)	914637-49-3	ng/L	250,000 U	—
3-Perfluoropropylpropanoic acid (3:3 FTCA)	356-02-5	ng/L	50,000 U	—
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	ng/L	38,000 U	—
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	ng/L	38,000 U	—
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	13252-13-6	ng/L	40,000 U	—
N-ethylperfluorooctane sulfonamide (NEtFOSA)	4151-50-2	ng/L	10,000 U	—
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	1691-99-2	ng/L	100,000 U	—
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	ng/L	14,000 U	—
N-methylperfluorooctane sulfonamide (NMeFOSA)	31506-32-8	ng/L	10,000 U	—
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	24448-09-7	ng/L	100,000 U	—
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	ng/L	24,000 U	—
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	ng/L	20,000 U	—
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	ng/L	18,000 U	—
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ng/L	20,000 U	—
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	ng/L	20,000 U	—
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	10,000 U	194
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	40,000 U	463
Perfluorodecanesulfonic acid (PFDS)	335-77-3	ng/L	10,000 U	—
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	12,000 J	14,700
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	ng/L	19,000 U	—
Perfluorododecanoic acid (PFDoA)	307-55-1	ng/L	10,000 U	< 33.3
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	ng/L	52,000	—
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	100,000	84,800
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	170,000	149,000
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	10,000 U	2,650
Perfluorononanesulfonic acid (PFNS)	68259-12-1	ng/L	10,000 U	—
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	19,000 J	12,000
Perfluorooctanesulfonamide (PFOSA)	754-91-6	ng/L	10,000 U	—
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	4,600,000	4,670,000
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	2,100,000	2,440,000
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	ng/L	11,000 J	—
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	20,000 U	135
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	ng/L	10,000 U	—
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	ng/L	10,000 U	—
Perfluoroundecanoic acid (PFUnA)	2058-94-8	ng/L	10,000 U	28.1
Other				
Total Organic Carbon (TOC)	7440-44-0	mg/L	—	102
Chloride	16887-00-6	mg/L	—	210
Fluoride	16984-48-8	mg/L	—	0.11
Sulfate	14797-65-0	mg/L	—	5,500

Notes:

SAFF = Surface Active Foam Fractionation; MPCA = Minnesota Pollution Control Agency

mg/L = milligrams per liter; ng/L = nanograms per liter

Bold = Analyte detected at a concentration greater than its Detection Limit

— = Parameter not sampled

< = Analyte not detected

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD).

The LOD has been adjusted for any dilution or concentration of the sample.

J = The reported result was an estimated value with an unknown bias.

Appendix 1 - Table 2A
Quench Water Analytical Results - All Data
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	SAFF-Pre-0- Quench Water	SAFF-T1-1- Quench Water	SAFF-T1-2- Quench Water	SAFF-T1-2- Quench Water DUP	SAFF-T1-3- Quench Water	SAFF-T2-1- Quench Water	SAFF-T2-1- Quench Water DUP	Quench Water (Avg.)
Per- and Polyfluorinated Substances (PFAS)										
11-Chloroicosafuoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)	763051-92-9	ng/L	6.7 U	6.7 U	7.0 U	6.8 U	7.0 U	6.8 U	7.0 U	—
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	ng/L	6.8 U	6.8 U	7.0 U	6.9 U	7.1 U	6.9 U	7.1 U	—
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	ng/L	3.4 U	3.4 U	3.5 U	3.4 U	3.5 U	3.4 U	3.5 U	—
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	ng/L	6.7 U	6.7 U	7.0 U	6.8 U	7.0 U	6.8 U	7.0 U	—
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	812-70-4	ng/L	22 U	22 U	23 U	22 U	23 U	22 U	23 U	—
3-Perfluoropentylpropanoic acid (5:3 FTCA)	914637-49-3	ng/L	22 U	22 U	23 U	22 U	23 U	22 U	23 U	—
3-Perfluoropropylpropanoic acid (3:3 FTCA)	356-02-5	ng/L	4.4 U	4.4 U	4.6 U	4.5 U	4.6 U	4.5 U	4.6 U	—
4,8-Dioxia-3H-perfluorononanoic acid (ADONA)	919005-14-4	ng/L	3.4 U	3.4 U	3.5 U	3.4 U	3.5 U	3.4 U	3.5 U	—
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)	756426-58-1	ng/L	3.4 U	3.4 U	3.5 U	3.4 U	3.5 U	3.4 U	3.5 U	—
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	13252-13-6	ng/L	3.5 U	3.5 U	3.7 U	3.6 U	3.7 U	3.6 U	3.7 U	—
N-ethylperfluorooctane sulfonamide (NetFOSA)	4151-50-2	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
N-ethylperfluorooctane sulfonamidoethanol (NetFOSE)	1691-99-2	ng/L	8.8 U	8.9 U	9.1 U	8.9 U	9.2 U	9.0 U	9.2 U	—
N-ethylperfluorooctanesulfonamidoacetic acid (NetFOSAA)	2991-50-6	ng/L	1.2 U	1.2 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	—
N-methylperfluorooctane sulfonamide (NMeFOSA)	31506-32-8	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	24448-09-7	ng/L	8.8 U	8.9 U	9.1 U	8.9 U	9.2 U	9.0 U	9.2 U	—
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2359-31-9	ng/L	2.1 U	2.1 U	2.2 U	2.1 U	2.2 U	2.2 U	2.2 U	—
Nonafluoro-3,6-dioxahexanoic acid (NFDHA)	151772-58-6	ng/L	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	—
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESEA)	113507-82-7	ng/L	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.7 U	—
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ng/L	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	—
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	ng/L	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	—
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	1.5 J	1.4 J	1.3 J	1.4 J	1.3 J	1.3 J	1.3 J	1.4 J
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	2.3 J	2.8 J	2.7 J	2.2 J	2.8 J	2.9 J	2.7 J	2.6 J
Perfluorodecanesulfonic acid (PFDS)	335-77-3	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	ng/L	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.8 U	—
Perfluorododecanoic acid (PFDoA)	307-55-1	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	1.1 J	1.1 J	0.75 J	0.99 J	1.2 J	0.81 J	0.9 J	0.98 J
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	1.4 J	1.4 J	1.2 J	1.1 J	1.0 J	1.1 J	1.2 J	1.2 J
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	2.2	2.4	1.8	1.8	1.7 J	2.3	1.8	2.0 J
Perfluorononanesulfonic acid (PFNS)	68259-12-1	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	0.71 J	0.74 J	0.72 J	0.76 J	0.79 J	0.72 J	0.83 J	0.75 J
Perfluorooctanesulfonamide (PFOSA)	754-91-6	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	2.8	2.8	2.2	2.4	2.7	2.5	2.4	2.5 J
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	2.4	2.3	2.0	2.2	2.2	2.3	2.0	2.2
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	2.3 J	2.0 J	1.6 J	2.0 J	1.9 J	1.7 J	1.6 J	1.9 J
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
Perfluoroundecanoic acid (PFUnA)	2058-94-8	ng/L	0.88 U	0.89 U	0.91 U	0.89 U	0.92 U	0.9 U	0.92 U	—
General Chemistry										
pH	Field Parameter	s.u.	8.52	—	8.48	—	—	8.46	—	8.49
Temperature	Field Parameter	°C	22.38	—	22.89	—	—	23.64	—	22.97
Conductivity	Field Parameter	mS/cm	0.385	—	0.701	—	—	0.721	—	0.602
Oxidation-Reduction Potential	Field Parameter	mV	95.8	—	105	—	—	64.2	—	88.3
Salinity	Field Parameter	g/L	0.25	—	0.772	—	—	0.48	—	0.50
Total Suspended Solids	—	mg/L	40	60	50	70	70	70	40	57.1
Chemical Oxygen Demand	—	mg/L	60 U	—	60 U	—	—	60 U	—	—
Total Alkalinity as CaCO3 to pH 4.5	—	mg/L	92	—	92	—	—	91	—	91.7
Total Organic Carbon	—	mg/L	2.3	—	2.3	—	—	2.2	—	2.3
Adsorbable Organic Fluorine (AOF)	—	µg/L	2 U	1.1 J	1.1 J	—	500	2.3 J	—	100.9 J
Total Fluorine	—	µg/L	700	660	650	—	660	670	—	668
Anions										
Chloride	16887-00-6	mg/L	100	—	90	—	—	88 J+	—	92.7 J+
Fluoride	16984-48-8	mg/L	0.51 J	—	0.50 J	—	—	0.50 J	—	0.50 J
Nitrate as N	14797-55-8	mg/L	0.86	—	0.87	—	—	0.87 J+	—	0.87 J+
Nitrite as N	14797-65-0	mg/L	0.5 U	—	0.50 U	—	—	0.50 U	—	—
Sulfate	14797-65-0	mg/L	130	—	130	—	—	110 J+	—	123.3 J+
Metals, Cations										
Calcium	7440-70-2	µg/L	100 U	—	100 U	—	—	100 U	—	—
Chromium, Total	7440-47-3	µg/L	0.66 J	—	1.1 U	—	—	1.1 U	—	0.22 J
Iron	7439-89-6	µg/L	41 J	—	32 J	—	—	30 J	—	34.3 J
Magnesium	7439-95-4	µg/L	32 U	—	32 U	—	—	32 U	—	—
Nickel	7440-02-0	µg/L	0.80 U	—	0.80 U	—	—	0.80 U	—	—
Silicon	7440-21-3	µg/L	4,000	—	4,000	—	—	4,100	—	4,033
Sodium	7440-23-5	µg/L	150,000	—	140,000	—	—	150,000	—	146,667
Titanium	7440-32-6	µg/L	8.0 U	—	8.0 U	—	—	8.0 U	—	—
Tungsten	7440-33-7	µg/L	20 U	—	20 U	—	—	20 U	—	—
Volatile Organic Compounds (VOCs)										
1,1,1-Trichloroethane	71-55-6	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,1,2-Trichloroethane	79-00-5	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,1-Dichloroethane	75-34-3	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,1-Dichloroethene	75-35-4	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,2,4-Trichlorobenzene	120-82-1	µg/L	1.0 U	1.0 U	1.0 U	—	1.0 U	1.0 U	—	—
1,2-Dibromo-3-Chloropropane	96-12-8	µg/L	1.0 U	1.0 U	1.0 U	—	1.0 U	1.0 U	—	—
1,2-Dibromoethane (EDB)	106-93-4	µg/L	0.50 U	0.50 U	0.50 U	—	0.50 U	0.50 U	—	—
1,2-Dichlorobenzene	95-50-1	µg/L	0.50 U	0.50 U	0.50 U	—	0.50 U	0.50 U	—	—
1,2-Dichloroethane	107-06-2	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,2-Dichloropropane	78-87-5	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
1,3-Dichlorobenzene	541-73-1	µg/L	1.4 U	1.4 U	1.4 U	—	1.4 U	1.4 U	—	—
1,4-Dichlorobenzene	106-46-7	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
2-Butanone	78-93-3	µg/L	1.0 U	1.0 U	1.0 U	—	1.0 U	1.0 U	—	—
2-Hexanone	591-78-6	µg/L	1.7 U	1.7 U	1.7 U	—	1.7 U	1.7 U	—	—
4-Methyl-2-pentanone	108-10-1	µg/L	1.0 U	1.0 U	1.0 U	—	1.0 U	1.0 U	—	—
Acetone	67-64-1	µg/L	2.0 U	2.0 U	2.0 U	—	2.0 U	2.0 U	—	—

Appendix 1 - Table 2A
Quench Water Analytical Results - All Data
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	SAFF-Pre-0- Quench Water	SAFF-T1-1- Quench Water	SAFF-T1-2- Quench Water	SAFF-T1-2- Quench Water DUP	SAFF-T1-3- Quench Water	SAFF-T2-1- Quench Water	SAFF-T2-1- Quench Water DUP	Quench Water (Avg.)
Benzene	71-43-2	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Bromodichloromethane	75-27-4	µg/L	5.8	5.8	6.4	—	6.4	6.2	—	6.1
Bromoform	75-25-2	µg/L	1.3 J	1.4 J	1.4 J	—	1.5 J	1.6 J	—	1.4 J
Bromomethane	74-83-9	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Carbon disulfide	75-15-0	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Carbon tetrachloride	56-23-5	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Chlorobenzene	108-90-7	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Chloroethane	75-00-3	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Chloroform	67-66-3	µg/L	4.7 J+	4.2 J+	4.7 J+	—	4.6 J+	4.9 J+	—	4.6 J+
Chloromethane	74-87-3	µg/L	1.1 U	1.1 U	1.1 U	—	1.1 U	1.1 U	—	—
cis-1,2-Dichloroethene	156-59-2	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
cis-1,3-Dichloropropene	10061-01-5	µg/L	0.50 U	0.50 U	0.50 U	—	0.50 U	0.50 U	—	—
Cyclohexane	110-82-7	µg/L	2.0 U	2.0 U	2.0 U	—	2.0 U	2.0 U	—	—
Dibromochloromethane	124-48-1	µg/L	5.0	5.4	5.5	—	5.6	6.0	—	5.5
Dichlorodifluoromethane	75-71-8	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Ethylbenzene	100-41-4	µg/L	0.80 U	0.80 U	0.80 U	—	0.80 U	0.80 U	—	—
Isopropylbenzene	98-82-8	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Methyl acetate	79-20-9	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Methyl tert-butyl ether	1634-04-4	µg/L	0.50 U	0.50 U	0.50 U	—	0.50 U	0.50 U	—	—
Methylcyclohexane	108-87-2	µg/L	1.0 U	1.0 U	1.0 U	—	1.0 U	1.0 U	—	—
Methylene Chloride	75-09-2	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Naphthalene	91-20-3	µg/L	2.0 U	2.0 U	2.0 U	—	2.0 U	2.0 U	—	—
Styrene	100-42-5	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Tetrachloroethene	127-18-4	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Toluene	108-88-3	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
trans-1,2-Dichloroethene	156-60-5	µg/L	1.4 U	1.4 U	1.4 U	—	1.4 U	1.4 U	—	—
trans-1,3-Dichloropropene	10061-02-6	µg/L	0.50 U	0.50 U	0.50 U	—	0.50 U	0.50 U	—	—
Trichloroethene	79-01-6	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Trichlorofluoromethane	75-69-4	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Vinyl chloride	75-01-4	µg/L	0.60 U	0.60 U	0.60 U	—	0.60 U	0.60 U	—	—
Xylenes, Total	1330-20-7	µg/L	0.80 U	0.80 U	0.80 U	—	0.80 U	0.80 U	—	—

Notes:

Avg. = Average; DUP = Duplicate; Inf = Influent; SAFF = Surface Active Foam Fractionation
g/L = grams per liter; mg/L = milligrams per liter; mS/cm = millisiemens per centimeter; mV = millivolts; ng/L = nanograms per liter; s.u. = standard units; µg/L = micrograms per liter
Blue = Results are an average of multiple samples. Where a sample result was not detected at or above the method detection limit, a value of "0" was used for the average calculation.

Red = Analyte detected at a concentration greater than its Detection Limit

Italics = All final qualifiers in samples that contributed to average value

— = Parameter not sampled/not applicable/not calculable

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

J = The reported result was an estimated value with an unknown bias.

J+ = The reported result was an estimated value, but the result may be biased high.

Appendix 1 - Table 2B
Quench Water Analytical Results - Detections Summary
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	SAFF-Pre-0- Quench Water	SAFF-T1-1- Quench Water	SAFF-T1-2- Quench Water	SAFF-T1-2- Quench Water- DUP	SAFF-T1-3- Quench Water	SAFF-T2-1- Quench Water	SAFF-T2-1- Quench Water- DUP	Quench Water (Avg.)
Per- and Polyfluorinated Substances (PFAS)										
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	1.5 J	1.4 J	1.3 J	1.4 J	1.3 J	1.3 J	1.3 J	1.4 J
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	2.3 J	2.8 J	2.7 J	2.2 J	2.8 J	2.9 J	2.7 J	2.6 J
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	1.1 J	1.1 J	0.75 J	0.99 J	1.2 J	0.81 J	0.90 J	0.98 J
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	1.4 J	1.4 J	1.2 J	1.1 J	1.0 J	1.1 J	1.2 J	1.2 J
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	2.2 J	2.4 J	1.8 J	1.8 J	1.7 J	2.3 J	1.8 J	2.00 J
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	0.71 J	0.74 J	0.72 J	0.76 J	0.79 J	0.72 J	0.83 J	0.75 J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	2.8 J	2.8 J	2.2 J	2.4 J	2.7 J	2.5 J	2.4 J	2.5 J
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	2.4 J	2.3 J	2.0 J	2.2 J	2.2 J	2.3 J	2.0 J	2.2 J
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	2.3 J	2.0 J	1.6 J	2.0 J	1.9 J	1.7 J	1.6 J	1.9 J
General Chemistry										
pH	Field Parameter	s.u.	8.52	—	8.48	—	—	8.46	—	8.49
Temperature	Field Parameter	°C	22.38	—	22.89	—	—	23.64	—	22.97
Conductivity	Field Parameter	mS/cm	0.385	—	0.701	—	—	0.721	—	0.602
Oxidation-Reduction Potential	Field Parameter	mV	95.8	—	105	—	—	64.2	—	88.3
Salinity	Field Parameter	g/L	0.25	—	0.772	—	—	0.48	—	0.50
Total Suspended Solids	—	mg/L	40	60	50	70	70	70	40	57.1
Total Alkalinity as CaCO3 to pH 4.5	—	mg/L	92	—	92	—	—	91	—	91.7
Total Organic Carbon	—	mg/L	2.3	—	2.3	—	—	2.2	—	2.3
Adsorbable Organic Fluorine (AOF)	—	µg/L	2.0 U	1.1 J	1.1 J	—	500	2.3 J	—	100.9 J
Total Fluorine	—	µg/L	700	660	650	—	660	670	—	668
Anions										
Chloride	16887-00-6	mg/L	100	—	90	—	—	88 J+	—	92.7 J+
Fluoride	16984-48-8	mg/L	0.51 J	—	0.50 J	—	—	0.50 J	—	0.50 J
Nitrate as N	14797-55-8	mg/L	0.86	—	0.87	—	—	0.87 J+	—	0.87 J+
Sulfate	14797-65-0	mg/L	130	—	130	—	—	110 J+	—	123.3 J+
Metals, Cations										
Chromium, Total	7440-47-3	µg/L	0.66 J	—	1.1 U	—	—	1.1 U	—	0.22 J
Iron	7439-89-6	µg/L	41 J	—	32 J	—	—	30 J	—	34.3 J
Silicon	7440-21-3	µg/L	4,000	—	4,000	—	—	4,100	—	4,033
Sodium	7440-23-5	µg/L	150,000	—	140,000	—	—	150,000	—	146,667
Volatile Organic Compounds (VOCs)										
Bromodichloromethane	75-27-4	µg/L	5.8	5.8	6.4	—	6.4	6.2	—	6.1
Bromoform	75-25-2	µg/L	1.3 J	1.4 J	1.4 J	—	1.5 J	1.6 J	—	1.4 J
Chloroform	67-66-3	µg/L	4.7 J+	4.2 J+	4.7 J+	—	4.6 J+	4.9 J+	—	4.6 J+
Dibromochloromethane	124-48-1	µg/L	5.0	5.4	5.5	—	5.6	6.0	—	5.5

Notes:

Avg. = Average; DUP = Duplicate; Inf = Influent; SAFF = Surface Active Foam Fractionation

g/L = grams per liter; mg/L = milligrams per liter; mS/cm = millisiemens per centimeter; mV = millivolts; ng/L = nanograms per liter; s.u. = standard units; µg/L = micrograms per liter

Blue = Results are an average of multiple samples. Where a sample result was not detected at or above the method detection limit, a value of "0" was used for the average calculation.

Bold = Analyte detected at a concentration greater than its Detection Limit

Appendix 1 - Table 2B
Quench Water Analytical Results - Detections Summary
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	SAFF-Pre-0- Quench Water	SAFF-T1-1- Quench Water	SAFF-T1-2- Quench Water	SAFF-T1-2- Quench Water- DUP	SAFF-T1-3- Quench Water	SAFF-T2-1- Quench Water	SAFF-T2-1- Quench Water- DUP	Quench Water (Avg.)

Italics = All final qualifiers in samples that contributed to average value

— = Parameter not sampled/not applicable/not calculable

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

J = The reported result was an estimated value with an unknown bias.

J+ = The reported result was an estimated value, but the result may be biased high.

Appendix 1 - Table 3A
Influent and Effluent Analytical Results - All Data (less Quench Water)
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	Units	SAFF-Pre-0- Effluent Water	SAFF-Pre-0- Effluent Comp	SAFF-T1-1- SAFF Mix Inf	SAFF-T1-1- Effluent Water	SAFF-T1-2- SAFF Mix Inf	SAFF-T1-2- SAFF Mix Inf- DUP	SAFF-T1-2- Effluent Water	SAFF-T1-2- Effluent Water DUP	SAFF-T1-3- SAFF Mix Inf	SAFF-T1-3- Effluent Water	SAFF-T2-1- SAFF Mix Inf	SAFF-T2-1- SAFF Mix Inf- DUP	SAFF-T2-1- Effluent Water	SAFF-T2-1- Effluent Water DUP	SAFF Condensate		
Per- and Polyfluorinated Substances (PFAS)																			
11-Chloroeicosafuoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)	763051-92-9	ng/L	6.8	U	—	76	U	6.6	U	76	U	6.5	U	6.7	U	76	U	6.5	U
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	ng/L	6.9	U	—	26	J	6.7	U	77	U	27	J	6.6	U	770	U	770	U
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	ng/L	3.4	U	—	38	U	3.3	U	38	U	38	U	3.3	U	380	U	380	U
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	ng/L	5.4	J	—	77	J	33		66	J	63	J	5.8	J	3.2	J	58	J
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	812-70-4	ng/L	22	U	—	250	U	22	U	250	U	250	U	21	U	22	U	250	U
3-Perfluoropentylpropanoic acid (5:3 FTCA)	914637-49-3	ng/L	22	U	—	250	U	22	U	250	U	250	U	21	U	22	U	250	U
3-Perfluoropropylpropanoic acid (3:3 FTCA)	356-02-5	ng/L	45	U	—	50	U	4.3	U	50	U	50	U	4.3	U	4.4	U	50	U
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	ng/L	3.4	U	—	38	U	3.3	U	38	U	38	U	3.3	U	3.3	U	38	U
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)	756426-58-1	ng/L	3.4	U	—	38	U	3.3	U	38	U	38	U	3.3	U	3.3	U	38	U
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	13252-13-6	ng/L	3.6	U	—	40	U	3.5	U	40	U	40	U	3.4	U	3.5	U	40	U
N-ethylperfluorooctane sulfonamide (NEtFOSA)	4151-50-2	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	1691-99-2	ng/L	9.0	U	—	100	U	8.7	U	100	U	100	U	8.6	U	8.8	U	100	U
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	ng/L	1.3	U	—	14	U	1.2	U	14	U	14	U	1.2	U	1.2	U	14	U
N-methylperfluorooctane sulfonamide (NMeFOSA)	31506-32-8	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	24448-09-7	ng/L	9.0	U	—	100	U	8.7	U	100	U	100	U	8.6	U	8.8	U	100	U
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	ng/L	2.1	U	—	240	U	2.1	U	240	U	240	U	2.1	U	2.1	U	240	U
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	ng/L	1.8	U	—	20	U	1.7	U	20	U	20	U	1.7	U	1.8	U	20	U
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	ng/L	1.6	U	—	18	U	1.6	U	18	U	18	U	1.5	U	1.6	U	18	U
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ng/L	140		—	20	U	0.50	J	20	U	20	U	1.7	U	1.8	U	20	U
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	ng/L	18	U	—	20	U	1.7	U	20	U	20	U	1.7	U	1.8	U	20	U
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	20		—	360		6.9		320		330		2.8		2.6		590	
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	170	J	—	97		56	J	96		96		22	J	35	U	100	
Perfluorodecanesulfonic acid (PFDS)	335-77-3	ng/L	0.90	U	—	23		0.87	U	15	J	27	J	0.86	U	0.88	U	16	J
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	0.47	J	—	220		0.87	U	260		280		0.86	U	0.88	U	270	
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	ng/L	1.7	U	—	19	U	1.7	U	19	U	19	U	1.6	U	1.7	U	19	U
Perfluorododecanoic acid (PFDoA)	307-55-1	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	ng/L	4.8		—	2,600		0.78	J	2,500		2,700		0.86	U	0.88	U	2,600	
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	5.6		—	1,300		2.9		1,300		1,300		1.9	J	1.2	J	1,200	
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	61		—	4,000		11		4,000		4,200		2.8		2.4		4,300	
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	17		—	500		6.9		450		450		3.2	J	2.3	J	650	
Perfluorononanesulfonic acid (PFNS)	68259-12-1	ng/L	0.90	U	—	110		0.87	U	99		120		0.86	U	0.88	U	100	
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	1.1	J	—	260		0.88	J	250		250		0.76	J	0.87	J	250	
Perfluorooctanesulfonamide (PFOSA)	754-91-6	ng/L	0.90	U	—	130	J	0.87	U	120	J	120	J	0.86	U	0.88	U	130	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	250		—	120,000		44		130,000		120,000		7.4	J	4.3	J	150,000	
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	22		—	33,000		29		34,000		32,000		12		10		36,000	
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	ng/L	16		—	990		3.2		880		970		0.57	J	0.88	U	1,200	
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	18	U	—	120		2.9	J	110		120		1.7	U	1.8	U	160	
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
Perfluoroundecanoic acid (PFUnA)	2058-94-8	ng/L	0.90	U	—	10	U	0.87	U	10	U	10	U	0.86	U	0.88	U	10	U
General Chemistry																			
pH	Field Parameter	s.u.	7.78		—		—		—	8.15		—		7.73		—		—	
Temperature	Field Parameter	°C	33.2		—		—		—	22.38		—		42.25		—		22.96	
Conductivity	Field Parameter	mS/cm	3.368		—		—		—	0.701		—		2.705		—		0.737	
Oxidation-Reduction Potential	Field Parameter	mV	197		—		—		—	135.5		—		149.5		—		100.9	
Salinity	Field Parameter	g/L	2.192		—		—		—	0.48		—		1.325		—		0.497	
Total Suspended Solids	—	mg/L	50		—	50		50		40		60		60		50		70	
HEM (Oil & Grease)	—	mg/L	—	450		—		—		—		—		—		—		—	
Flashpoint	—	°F	—	>190		—		—		—		—		—		—		—	
Chemical Oxygen Demand	—	mg/L	—	—		—		—		60	U	—		60	U	—		60	U
Total Alkalinity as CaCO ₃ to pH 4.5	—	mg/L	—	—		—		—		92		—		520		—		93	
Total Organic Carbon	—	mg/L	—	—		—		—		4.3		—		3.7		—		4.7	
Adsorbable Organic Fluorine (AOF)	—	µg/L	22		—	180		2.1	J	1500		—		2.0	U	—		180	
Total Fluorine	—	µg/L	4100		—	820		3900		790									

Appendix 1 - Table 3A
Influent and Effluent Analytical Results - All Data (less Quench Water)
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	Units	SAFF-Pre-0- Effluent Water	SAFF-Pre-0- Effluent Comp	SAFF-T1-1- SAFF Mix Inf	SAFF-T1-1- Effluent Water	SAFF-T1-2- SAFF Mix Inf	SAFF-T1-2- SAFF Mix Inf- DUP	SAFF-T1-2- Effluent Water	SAFF-T1-2- Effluent Water DUP	SAFF-T1-3- SAFF Mix Inf	SAFF-T1-3- Effluent Water	SAFF-T2-1- SAFF Mix Inf	SAFF-T2-1- SAFF Mix Inf- DUP	SAFF-T2-1- Effluent Water	SAFF-T2-1- Effluent Water DUP	SAFF Condensate
Metals, Cations																	
Calcium	7440-70-2	µg/L	—	—	—	—	1,700	—	590	—	—	—	1,600	—	1,000	—	—
Chromium	7440-47-3	µg/L	—	—	—	—	0.69	J	22	—	—	—	0.65	J	9.6	—	—
Iron	7439-89-6	µg/L	—	—	—	—	260	—	100	—	—	—	260	—	130	—	—
Magnesium	7439-95-4	µg/L	—	—	—	—	600	—	240	—	—	—	610	—	290	—	—
Nickel	7440-02-0	µg/L	—	—	—	—	1.5	J+	57	—	—	—	2.0	J+	26	—	—
Silicon	7440-21-3	µg/L	—	—	—	—	4,300	—	8,500	—	—	—	4,200	—	8,700	—	—
Sodium	7440-23-5	µg/L	—	—	—	—	150,000	—	460,000	—	—	—	150,000	—	670,000	—	—
Titanium	7440-32-6	µg/L	—	—	—	—	8.0	U	8.9	J	—	—	8.0	U	4.9	J	—
Tungsten	7440-33-7	µg/L	—	—	—	—	20	U	20	U	—	—	20	U	20	U	—
Volatile Organic Compounds (VOCs)																	
1,1,1-Trichloroethane	71-55-6	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,1,2-Trichloroethane	79-00-5	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,1-Dichloroethane	75-34-3	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,1-Dichloroethene	75-35-4	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,2,4-Trichlorobenzene	120-82-1	µg/L	1.0	U	—	1.0	U	1.0	U	—	1.0	U	1.0	U	1.0	U	—
1,2-Dibromo-3-Chloropropane	96-12-8	µg/L	1.0	U	—	1.0	U	1.0	U	—	1.0	U	1.0	U	1.0	U	—
1,2-Dibromoethane (EDB)	106-93-4	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
1,2-Dichlorobenzene	95-50-1	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
1,2-Dichloroethane	107-06-2	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,2-Dichloropropane	78-87-5	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
1,3-Dichlorobenzene	541-73-1	µg/L	1.4	U	—	1.4	U	1.4	U	—	1.4	U	1.4	U	1.4	U	—
1,4-Dichlorobenzene	106-46-7	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
2-Butanone	78-93-3	µg/L	7.7	J	—	1.0	U	2.1	J	—	1.0	U	1.0	U	1.0	U	—
2-Hexanone	591-78-6	µg/L	1.2	J	—	1.7	U	1.7	U	—	1.7	U	1.7	U	1.7	U	—
4-Methyl-2-pentanone	108-10-1	µg/L	1.0	U	—	1.0	U	1.0	U	—	1.0	U	1.0	U	1.0	U	—
Acetone	67-64-1	µg/L	44	—	2.9	J	10	J	2.0	J	—	1.6	J	1.7	J	1.7	J
Benzene	71-43-2	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Bromodichloromethane	75-27-4	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
Bromoform	75-25-2	µg/L	2.0	U	—	2.0	U	2.0	U	—	2.0	U	2.0	U	2.0	U	—
Bromomethane	74-83-9	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Carbon disulfide	75-15-0	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Carbon tetrachloride	56-23-5	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Chlorobenzene	108-90-7	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Chloroethane	75-00-3	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Chloroform	67-66-3	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Chloromethane	74-87-3	µg/L	1.1	U	—	1.1	U	1.1	U	—	1.1	U	1.1	U	1.1	U	—
cis-1,2-Dichloroethene	156-59-2	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
cis-1,3-Dichloropropene	10061-01-5	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
Cyclohexane	110-82-7	µg/L	2.00	U	—	2.00	U	2.00	U	—	2.00	U	2.00	U	2.00	U	—
Dibromochloromethane	124-48-1	µg/L	0.50	U	—	0.50	U	0.50	U	0.20	J	—	0.50	U	0.50	U	—
Dichlorodifluoromethane	75-71-8	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Ethylbenzene	100-41-4	µg/L	0.80	U	—	0.80	U	0.80	U	—	0.80	U	0.80	U	0.80	U	—
Isopropylbenzene	98-82-8	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Methyl acetate	79-20-9	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Methyl tert-butyl ether	1634-04-4	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
Methylcyclohexane	108-87-2	µg/L	1.0	U	—	1.0	U	1.0	U	—	1.0	U	1.0	U	1.0	U	—
Methylene Chloride	75-09-2	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Naphthalene	91-20-3	µg/L	2.0	U	—	2.0	U	2.0	U	—	2.0	U	2.0	U	2.0	U	—
Styrene	100-42-5	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Tetrachloroethene	127-18-4	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Toluene	108-88-3	µg/L	0.60	U	—	0.93	J	0.60	U	0.92	J	—	0.60	U	0.65	J	—
trans-1,2-Dichloroethene	156-60-5	µg/L	1.4	U	—	1.4	U	1.4	U	—	1.4	U	1.4	U	1.4	U	—
trans-1,3-Dichloropropene	10061-02-6	µg/L	0.50	U	—	0.50	U	0.50	U	—	0.50	U	0.50	U	0.50	U	—
Trichloroethene	79-01-6	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Trichlorofluoromethane	75-69-4	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Vinyl chloride	75-01-4	µg/L	0.60	U	—	0.60	U	0.60	U	—	0.60	U	0.60	U	0.60	U	—
Xylenes, Total	1330-20-7	µg/L	0.80	U	—	0.80	U	0.80	U	—	0.80	U	0.80	U	0.80	U	—

Appendix 1 - Table 3A
Influent and Effluent Analytical Results - All Data (less Quench Water)
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	Units	SAFF-Pre-0- Effluent Water	SAFF-Pre-0- Effluent Comp	SAFF-T1-1- SAFF Mix Inf	SAFF-T1-1- Effluent Water	SAFF-T1-2- SAFF Mix Inf	SAFF-T1-2- SAFF Mix Inf- DUP	SAFF-T1-2- Effluent Water	SAFF-T1-2- Effluent Water DUP	SAFF-T1-3- SAFF Mix Inf	SAFF-T1-3- Effluent Water	SAFF-T2-1- SAFF Mix Inf	SAFF-T2-1- SAFF Mix Inf- DUP	SAFF-T2-1- Effluent Water	SAFF-T2-1- Effluent Water DUP	SAFF Condensate
Polycyclic Aromatic Hydrocarbons (PAHs)																	
2-Methylnaphthalene	91-57-6	µg/L	—	2.3	—	—	—	—	—	—	—	—	—	—	0.040 U	—	—
Acenaphthene	83-32-9	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Acenaphthylene	208-96-8	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Anthracene	120-12-7	µg/L	—	0.11	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[a]anthracene	56-55-3	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[a]pyrene	50-32-8	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[b]fluoranthene	205-99-2	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[g,h,i]perylene	191-24-2	µg/L	—	0.036 J	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[k]fluoranthene	207-08-9	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Chrysene	218-01-9	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Dibenz(a,h)anthracene	53-70-3	µg/L	—	0.040 U	—	—	—	—	—	—	—	—	—	—	0.040 U	—	—
Fluoranthene	206-44-0	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Fluorene	86-73-7	µg/L	—	0.030 U	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Indeno[1,2,3-cd]pyrene	193-39-5	µg/L	—	0.040 U	—	—	—	—	—	—	—	—	—	—	0.040 U	—	—
Naphthalene	91-20-3	µg/L	—	0.92	—	—	—	—	—	—	—	—	—	—	0.060 U	—	—
Phenanthrene	85-01-8	µg/L	—	0.060 U	—	—	—	—	—	—	—	—	—	—	0.060 U	—	—
Pyrene	129-00-0	µg/L	—	0.44	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—

Notes:
Avg. = Average; DUP = Duplicate; Inf = Influent; SAFF = Surface Active Foam Fractionation
g/L = grams per liter; mg/L = milligrams per liter; mS/cm = millisiemens per centimeter; mV = millivolts; ng/L = nanograms per liter; s.u. = standard units; µg/L = micrograms per liter
Bold = Analyte detected at a concentration greater than its Detection Limit
— = Parameter not sampled/not applicable
FINAL QUALIFIERS:
U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.
J = The reported result was an estimated value with an unknown bias.
J+ = The reported result was an estimated value, but the result may be biased high.
UJ = The analyte was not detected and was reported as less than the LOD, however, the associated numerical value is approximate.

Appendix 1 - Table 3B
Influent and Effluent Analytical Results - Detections Summary
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	Units	EPA Primary or Secondary MCL	MDH HRL	Quench Water (Avg.)	SAFF-Pre-0- Effluent Water	SAFF-Pre-0- Effluent Comp	SAFF-T1-1- SAFF Mix Inf	SAFF-T1-1- Effluent Water	SAFF-T1-2- SAFF Mix Inf	SAFF-T1-2- SAFF Mix Inf- DUP	SAFF-T1-2- Effluent Water	SAFF-T1-2- Effluent Water DUP	SAFF-T1-3- SAFF Mix Inf	SAFF-T1-3- Effluent Water	SAFF-T2-1- SAFF Mix Inf	SAFF-T2-1- SAFF Mix Inf- DUP	SAFF-T2-1- Effluent Water	SAFF-T2-1- Effluent Water DUP	SAFF Condensate
Per- and Polyfluorinated Substances (PFAS)																				
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	ng/L	—	—	—	6.9 U	—	26 J	6.7 U	77 U	27 J	6.6 U	6.7 U	31 J	6.7 U	770 U	770 U	7.1 U	7.2 U	6.6 U
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	ng/L	—	—	—	5.4 J	—	77 J	33	66 J	63 J	5.8 J	3.2 J	58 J	2.6 J	760 U	760 U	6.0 J	5.3 J	6.5 U
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ng/L	—	—	—	140	—	20 U	0.50 J	20 U	20 U	1.7 U	1.8 U	20 U	1.7 U	200 U	200 U	1.9 U	1.9 U	1.7 U
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	—	100	1.4 J	20	—	360	6.9	320	330	2.8	2.6	590	2.5	680 J	1,900 J	2.4	2.4	0.85 U
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	—	7,000	2.6 J	170 J	—	97	56 J	96	96	22 J	35 U	100	5.0 J	400 U	400 U	30 J	17 J	3.4 U
Perfluorodecanesulfonic acid (PFDS)	335-77-3	ng/L	—	—	—	0.90 U	—	23	0.87 U	15 J	27 J	0.86 U	0.88 U	16 J	0.87 U	100 U	100 U	0.93 U	0.94 U	0.85 U
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	—	—	—	0.47 J	—	220	0.87 U	260	280	0.86 U	0.88 U	270	0.87 U	160 J	170 J	0.93 U	0.94 U	0.85 U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	ng/L	—	—	—	4.8	—	2,600	0.78 J	2,500	2,700	0.86 U	0.88 U	2,600	0.87 U	990	1,100	0.93 U	0.94 U	0.85 U
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	—	—	0.98 J	5.6	—	1,300	2.9	1,300	1,300	1.9 J	1.2 J	1,200	0.86 J	1,500	1,800	1.1 J	0.82 J	0.85 U
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	—	47	1.2 J	61	—	4,000	11	4,000	4,200	2.8	2.4	4,300	1.8	4,100	4,600	2.2	2.00	0.94 U
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	—	200	2.0 J	17	—	500	6.9	450	450	3.2 J	2.3 J	650	1.9	670 J	1,500 J	1.8 J	1.9	0.85 U
Perfluorononanesulfonic acid (PFNS)	68259-12-1	ng/L	—	—	—	0.90 U	—	110	0.87 U	99	120	0.86 U	0.88 U	100	0.87 U	41 J	100 U	0.93 U	0.94 U	0.85 U
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	—	—	0.75 J	1.1 J	—	260	0.88 J	250	250	0.76 J	0.87 J	250	0.52 J	210	200	0.83 J	0.62 J	0.85 U
Perfluorooctanesulfonamide (PFOSA)	754-91-6	ng/L	—	—	—	0.90 U	—	130 J	0.87 U	120 J	120 J	0.86 U	0.88 U	130 J	0.87 U	130 J	120 J	0.93 U	0.94 U	0.85 U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	4 pr	300	2.5 J	250	—	120,000	44	130,000	120,000	7.4 J	4.3 J	150,000	7.6	120,000	120,000	4.9	4.6	1.3 J
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	4 pr	35	2.2	22	—	33,000	29	34,000	32,000	12	10	36,000	7.2	30,000	30,000	6.2	7.3	1.1 U
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	ng/L	—	—	—	16	—	990	3.2	880	970	0.57 J	0.88 U	1,200	0.87 U	540 J	1,000 J	0.93 U	0.94 U	0.85 U
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	—	—	1.9 J	18 U	—	120	2.9 J	110	120	1.7 U	1.8 U	160	1.8 J	200 U	200 U	1.4 J	1.9 J	1.7 U
General Chemistry																				
pH	Field Parameter	s.u.	—	—	8.49	7.78	—	—	—	8.15	—	7.73	—	—	—	8.51	—	7.92	—	—
Temperature	Field Parameter	°C	—	—	22.97	33.2	—	—	—	22.38	—	42.25	—	—	—	22.96	—	41.69	—	—
Conductivity	Field Parameter	mS/cm	—	—	0.602	3.368	—	—	—	0.701	—	2.705	—	—	—	0.737	—	3.585	—	—
Oxidation-Reduction Potential	Field Parameter	mV	—	—	88.3	197	—	—	—	135.5	—	149.5	—	—	—	100.9	—	110.9	—	—
Salinity	Field Parameter	g/L	—	—	0.50	2.192	—	—	—	0.48	—	1.325	—	—	—	0.497	—	1.757	—	—
Total Suspended Solids	—	mg/L	—	—	57.1	50	—	50	50	40	60	60	50	70	40	60	50	50	110	50
HEM (Oil & Grease)	—	mg/L	—	—	—	—	450	—	—	—	—	—	—	—	—	—	—	1.7 J	—	—
Flashpoint	—	°F	—	—	—	—	>190	—	—	—	—	—	—	—	—	—	—	>190	—	—
Chemical Oxygen Demand	—	mg/L	—	—	—	—	—	—	—	60 U	—	60 U	—	—	—	60 U	—	29 J	—	—
Total Alkalinity as CaCO ₃ to pH 4.5	—	mg/L	—	—	91.7	—	—	—	—	92	—	520	—	—	—	93	—	860	—	—
Total Organic Carbon	—	mg/L	—	—	2.3	—	—	—	—	4.3	—	3.7	—	—	—	4.7	—	3.9	—	—
Adsorbable Organic Fluorine (AOF)	—	µg/L	—	—	100.9 J	22	—	180	2.1 J	1500	—	2.0 U	—	180	2.0 U	320	—	1.0 J	—	—
Total Fluorine	—	µg/L	—	—	668	4,100	—	820	3,900	790	—	1,600	—	800	1,500	790	—	1,700	—	—
Anions																				
Chloride	16887-00-6	mg/L	250	—	92.7 J+	—	—	—	—	88	—	180	—	—	—	85	—	170	—	—
Fluoride	16984-48-8	mg/L	4, 2	—	0.50 J	—	—	—	—	0.50 J	—	1.2	—	—	—	0.51 J	—	1.4	—	—
Nitrate as N	14797-55-8	mg/L	10	10	0.87 J+	—	—	—	—	0.81	—	1.3	—	—	—	0.80	—	1.7	—	—
Sulfate	14797-65-0	mg/L	250	—	123.3 J+	—	—	—	—	120	—	260	—	—	—	110	—	220	—	—
Metals, Cations																				
Calcium	7440-70-2	µg/L	—	—	—	—	—	—	—	1,700	—	590	—	—	—	1,600	—	1,000	—	—
Chromium	7440-47-3	µg/L	100	—	0.22 J	—	—	—	—	0.69 J	—	22	—	—	—	0.65 J	—	9.6	—	—
Iron	7439-89-6	µg/L	300	—	34.3 J	—	—	—	—	260	—	100	—	—	—	260	—	130	—	—
Magnesium	7439-95-4	µg/L	—	—	—	—	—	—	—	600	—	240	—	—	—	610	—	290	—	—
Nickel	7440-02-0	µg/L	—	100	—	—	—	—	—	1.5 J+	—	57	—	—	—	2.0 J+	—	26	—	—
Silicon	7440-21-3	µg/L	—	—	4,033	—	—	—	—	4,300	—	8,500	—	—	—	4,200	—	8,700	—	—
Sodium	7440-23-5	µg/L	—	—	146,667	—	—	—	—	150,000	—	460,000	—	—	—	150,000	—	670,000	—	—
Titanium	7440-32-6	µg/L	—	—	—	—	—	—	—	8.0 U	—	8.9 J	—	—	—	8.0 U	—	4.9 J	—	—
Volatile Organic Compounds (VOCs)																				
2-Butanone	78-93-3	µg/L	—	4,000	—	7.7 J	—	1.0 U	2.1 J	1.0 U	—	1.0 U	—	1.0 U	1.0 U	1.0 U	—	1.0 U	—	—
2-Hexanone	591-78-6	µg/L	—	—	—	1.2 J	—	1.7 U	1.7 U	1.7 U	—	1.7 U	—	1.7 U	1.7 U	1.7 U	—	1.7 U	—	—
Acetone	67-64-1	µg/L	—	3,000	—	44	—	2.9 J	10.0 J	2.0 J	—	1.6 J	—	1.6 J	1.7 J	1.7 J	—	1.8 J	—	—
Bromodichloromethane	75-27-4	µg/L	80	3	6.1	0.50 U	—	0.50 U	0.50 U	0.50 U	—	0.50 U	—	0.50 U	0.50 U	0.50 U	—	0.50 U	—	—
Bromoform	75-25-2	µg/L	80	40	1.4 J	2.0 U	—	2.0 U	2.0 U	2.0 U	—	2.0 U	—	2.0 U	2.0 U	2.0 U	—	2.0 U	—	—
Chloroform	67-66-3	µg/L	80	20	4.6 J+	0.60 U	—	0.60 U	0.60 U	0.60 U	—	0.60 U	—	0.60 U	0.60 U	0.60 U	—	0.60 U	—	—
Dibromochloromethane	124-48-1	µg/L	80	10	5.5	0.50 U	—	0.50 U	0.50 U	0.20 J	—	0.50 U	—	0.50 U	0.50 U	0.50 U	—	0.50 U	—	—
Toluene	108-88-3	µg/L	1,000	70	—	0.60 U	—	0.93 J	0.60 U	0.92 J	—	0.60 U	—	0.79 J	0.60 U	0.65 J	—	0.60 U	—	—

Appendix 1 - Table 3B Influent and Effluent Analytical Results - Detections Summary October 25, 2023 SAFF Tests BW Project No. 230044																				
Parameter	CAS No.	Units	EPA Primary or Secondary MCL	MDH HRL	Quench Water (Avg.)	SAFF-Pre-0- Effluent Water	SAFF-Pre-0- Effluent Comp	SAFF-T1-1- SAFF Mix Inf	SAFF-T1-1- Effluent Water	SAFF-T1-2- SAFF Mix Inf	SAFF-T1-2- SAFF Mix Inf- DUP	SAFF-T1-2- Effluent Water	SAFF-T1-2- Effluent Water DUP	SAFF-T1-3- SAFF Mix Inf	SAFF-T1-3- Effluent Water	SAFF-T2-1- SAFF Mix Inf	SAFF-T2-1- SAFF Mix Inf- DUP	SAFF-T2-1- Effluent Water	SAFF-T2-1- Effluent Water DUP	SAFF Condensate
Polycyclic Aromatic Hydrocarbons (PAHs)																				
2-Methylnaphthalene	91-57-6	µg/L	—	—	—	—	2.3	—	—	—	—	—	—	—	—	—	—	0.040 U	—	—
Anthracene	120-12-7	µg/L	—	2,000	—	—	0.11	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Benzo[g,h,i]perylene	191-24-2	µg/L	—	—	—	—	0.036 J	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Naphthalene	91-20-3	µg/L	—	70	—	—	0.92	—	—	—	—	—	—	—	—	—	—	0.060 U	—	—
Pyrene	129-00-0	µg/L	—	50	—	—	0.44	—	—	—	—	—	—	—	—	—	—	0.030 U	—	—
Notes: EPA = United States Environmental Protection Agency; MCL = Maximum Contaminant Level (January 2017); MPCA = Minnesota Pollution Control Agency; HRL = Health Risk Limit (November 2023) "pr" = proposed value EPA MCL value in italics = secondary MCL Avg. = Average; DUP = Duplicate; Inf = Influent; SAFF = Surface Active Foam Fractionation g/L = grams per liter; mg/L = milligrams per liter; mS/cm = millisiemens per centimeter; mV = millivolts; ng/L = nanograms per liter; s.u. = standard units; µg/L = micrograms per liter Bold = Analyte detected at a concentration greater than its Detection Limit — = Parameter not sampled/not applicable FINAL QUALIFIERS: U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample. J = The reported result was an estimated value with an unknown bias. J+ = The reported result was an estimated value, but the result may be biased high. UJ = The analyte was not detected and was reported as less than the LOD. The associated numerical value is approximate.																				

Appendix 1 - Table 4
Field and Trip Blank Analytical Results
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	Field Blank- 102523	Trip Blank - 102523
Per- and Polyfluorinated Substances (PFAS)				
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11CI-PF3OUdS)	763051-92-9	ng/L	7.0 U	—
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	39108-34-4	ng/L	7.1 U	—
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	757124-72-4	ng/L	3.5 U	—
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	27619-97-2	ng/L	7.0 U	—
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	812-70-4	ng/L	23 U	—
3-Perfluoropentylpropanoic acid (5:3 FTCA)	914637-49-3	ng/L	23 U	—
3-Perfluoropropylpropanoic acid (3:3 FTCA)	356-02-5	ng/L	4.6 U	—
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	ng/L	3.5 U	—
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9CI-PF3ONS)	756426-58-1	ng/L	3.5 U	—
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	13252-13-6	ng/L	3.7 U	—
N-ethylperfluorooctane sulfonamide (NEtFOSA)	4151-50-2	ng/L	0.92 U	—
N-ethylperfluorooctane sulfonamidoethanol (NEtFOSE)	1691-99-2	ng/L	9.2 U	—
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	ng/L	1.3 U	—
N-methylperfluorooctane sulfonamide (NMeFOSA)	31506-32-8	ng/L	0.92 U	—
N-methylperfluorooctane sulfonamidoethanol (NMeFOSE)	24448-09-7	ng/L	9.2 U	—
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	ng/L	2.2 U	—
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	ng/L	1.8 U	—
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	ng/L	1.7 U	—
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ng/L	1.8 U	—
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	ng/L	1.8 U	—
Perfluorobutanesulfonic acid (PFBS)	375-73-5	ng/L	0.92 U	—
Perfluorobutanoic acid (PFBA)	375-22-4	ng/L	3.7 U	—
Perfluorodecanesulfonic acid (PFDS)	335-77-3	ng/L	0.92 U	—
Perfluorodecanoic acid (PFDA)	335-76-2	ng/L	0.92 U	—
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	ng/L	1.7 U	—
Perfluorododecanoic acid (PFDoA)	307-55-1	ng/L	0.92 U	—
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	ng/L	0.92 U	—
Perfluoroheptanoic acid (PFHpA)	375-85-9	ng/L	0.92 U	—
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	ng/L	1.0 U	—
Perfluorohexanoic acid (PFHxA)	307-24-4	ng/L	0.92 U	—
Perfluorononanesulfonic acid (PFNS)	68259-12-1	ng/L	0.92 U	—
Perfluorononanoic acid (PFNA)	375-95-1	ng/L	0.92 U	—
Perfluorooctanesulfonamide (PFOSA)	754-91-6	ng/L	0.92 U	—
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	ng/L	0.92 U	—
Perfluorooctanoic acid (PFOA)	335-67-1	ng/L	1.2 U	—
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	ng/L	0.92 U	—
Perfluoropentanoic acid (PFPA)	2706-90-3	ng/L	1.8 U	—
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	ng/L	0.92 U	—
Perfluorotridecanoic acid (PFTeDA)	72629-94-8	ng/L	0.92 U	—
Perfluoroundecanoic acid (PFUnA)	2058-94-8	ng/L	0.92 U	—
Volatile Organic Compounds (VOCs)				
1,1,1-Trichloroethane	71-55-6	µg/L	—	0.60 U
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	—	0.60 U
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/L	—	0.60 U
1,1,2-Trichloroethane	79-00-5	µg/L	—	0.60 U
1,1-Dichloroethane	75-34-3	µg/L	—	0.60 U
1,1-Dichloroethene	75-35-4	µg/L	—	0.60 U
1,2,4-Trichlorobenzene	120-82-1	µg/L	—	1.0 U
1,2-Dibromo-3-Chloropropane	96-12-8	µg/L	—	1.0 U
1,2-Dibromoethane (EDB)	106-93-4	µg/L	—	0.50 U
1,2-Dichlorobenzene	95-50-1	µg/L	—	0.50 U
1,2-Dichloroethane	107-06-2	µg/L	—	0.60 U
1,2-Dichloropropane	78-87-5	µg/L	—	0.60 U

Appendix 1 - Table 4
Field and Trip Blank Analytical Results
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Cas No.	Units	Field Blank- 102523	Trip Blank - 102523
1,3-Dichlorobenzene	541-73-1	µg/L	—	1.4 U
1,4-Dichlorobenzene	106-46-7	µg/L	—	0.60 U
2-Butanone	78-93-3	µg/L	—	1.0 U
2-Hexanone	591-78-6	µg/L	—	1.7 U
4-Methyl-2-pentanone	108-10-1	µg/L	—	1.0 U
Acetone	67-64-1	µg/L	—	2.0 U
Benzene	71-43-2	µg/L	—	0.60 U
Bromodichloromethane	75-27-4	µg/L	—	0.50 U
Bromoform	75-25-2	µg/L	—	2.00 U
Bromomethane	74-83-9	µg/L	—	0.60 U
Carbon disulfide	75-15-0	µg/L	—	0.60 U
Carbon tetrachloride	56-23-5	µg/L	—	0.60 U
Chlorobenzene	108-90-7	µg/L	—	0.60 U
Chloroethane	75-00-3	µg/L	—	0.60 U
Chloroform	67-66-3	µg/L	—	1.1
Chloromethane	74-87-3	µg/L	—	1.1 U
cis-1,2-Dichloroethene	156-59-2	µg/L	—	0.60 U
cis-1,3-Dichloropropene	10061-01-5	µg/L	—	0.50 U
Cyclohexane	110-82-7	µg/L	—	2.0 U
Dibromochloromethane	124-48-1	µg/L	—	0.50 U
Dichlorodifluoromethane	75-71-8	µg/L	—	0.60 U
Ethylbenzene	100-41-4	µg/L	—	0.80 U
Isopropylbenzene	98-82-8	µg/L	—	0.60 U
Methyl acetate	79-20-9	µg/L	—	0.60 U
Methyl tert-butyl ether	1634-04-4	µg/L	—	0.50 U
Methylcyclohexane	108-87-2	µg/L	—	1.0 U
Methylene Chloride	75-09-2	µg/L	—	0.60 U
Naphthalene	91-20-3	µg/L	—	2.0 U
Styrene	100-42-5	µg/L	—	0.60 U
Tetrachloroethene	127-18-4	µg/L	—	0.60 U
Toluene	108-88-3	µg/L	—	0.60 U
trans-1,2-Dichloroethene	156-60-5	µg/L	—	1.4 U
trans-1,3-Dichloropropene	10061-02-6	µg/L	—	0.50 U
Trichloroethene	79-01-6	µg/L	—	0.60 U
Trichlorofluoromethane	75-69-4	µg/L	—	0.60 U
Vinyl chloride	75-01-4	µg/L	—	0.60 U
Xylenes, Total	1330-20-7	µg/L	—	0.80 U

Notes:

ng/L = nanograms per liter; µg/L = micrograms per liter

Bold - Analyte detected at a concentration greater than its Detection Limit

— = Parameter not sampled

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

Appendix 2

Air Sample Analytical Result Tables

Appendix 2 - Table 1A

VOC and Fixed Gas Air Sample Analytical Results - All Data

October 25, 2023 SAFF Tests

BW Project No. 230044

Parameter	CAS No.	Units	SAFF-PRE-0- PRE HEAT EFFLUENT SUMMA	SAFF-TI-1- AMBIENT AIR SUMMA	SAFF-T2-1- AMBIENT AIR SUMMA	SAFF-PRE-0- EFFLUENT AIR SUMMA	SAFF-TI-1- EFFLUENT AIR SUMMA	SAFF-TI-2- EFFLUENT AIR SUMMA	SAFF-T1-3- EFFLUENT AIR SUMMA	SAFF-T2-1- EFFLUENT AIR SUMMA
Fixed Gases										
Carbon dioxide	124-38-9	% v/v	0.10 U	0.60 U	0.29 U	4.4	5.9	5.9	6.0	6.0
Carbon monoxide	630-08-0	% v/v	0.10 U	0.60 U	0.29 U	0.95 U	0.42 U	0.44 U	0.39 U	0.36 U
Ethane (FID)	74-84-0	% v/v	0.00010 U	0.00012 U	0.00029 U	0.00095 U	0.00042 U	0.00044 U	0.00039 U	0.00036 U
Ethylene (FID)	74-85-1	% v/v	0.00010 U	0.00012 U	0.00029 U	0.00095 U	0.00042 U	0.00044 U	0.00039 U	0.00036 U
Methane (FID)	74-82-8	% v/v	0.00010 U	0.00022	0.00029 U	0.039	0.00042 U	0.017	0.00039 U	0.00036 U
Nitrogen	7727-37-9	% v/v	1.0 U	71	64	54	64	65	64	65
Oxygen	7782-44-7	% v/v	0.20 U	20	18	8.4	9.0	9.5	8.9	9.0
Volatile Organic Compounds (VOCs)										
1,1,1-Trichloroethane	71-55-6	µg/m ³	1.1 U	1.1 U	1.1 U	2.6 U	1.6 U	1.2 U	1.1 U	1.1 U
1,1,2,2-Tetrachloroethane	79-34-5	µg/m ³	1.4 U	1.4 U	1.4 U	3.2 U	2 U	1.5 U	1.4 U	1.4 U
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/m ³	1.5 U	0.56 J	0.7 J	0.81 J	0.56 J	0.85 J	0.49 J	0.58 J
1,1,2-Trichloroethane	79-00-5	µg/m ³	1.1 U	1.1 U	1.1 U	2.6 U	1.6 U	1.2 U	1.1 U	1.1 U
1,1-Dichloroethane	75-34-3	µg/m ³	0.81 U	0.81 U	0.81 U	1.9 U	1.2 U	0.88 U	0.81 U	0.81 U
1,1-Dichloroethene	75-35-4	µg/m ³	0.79 U	0.79 U	0.79 U	1.9 U	1.1 U	0.86 U	0.79 U	0.79 U
1,2,4-Trichlorobenzene	120-82-1	µg/m ³	7.4 U	7.4 U	7.4 U	18 U	11 U	8.1 U	7.4 U	7.4 U
1,2,4-Trimethylbenzene	95-63-6	µg/m ³	0.98 U	0.98 U	0.98 U	3	1.5	0.83 J	0.72 J	0.51 J
1,2-Dibromoethane (EDB)	76-14-2	µg/m ³	1.4 U	1.4 U	1.4 U	3.3 U	2.0 U	1.5 U	1.4 U	1.4 U
1,2-Dichloro-1,1,2,2-tetrafluoroethane	106-93-4	µg/m ³	1.5 U	1.5 U	1.5 U	3.6 U	2.2 U	1.7 U	1.5 U	1.5 U
1,2-Dichlorobenzene	95-50-1	µg/m ³	2.4 U	2.4 U	2.4 U	5.7 U	1.3 J	0.69 J	0.87 J	0.56 J
1,2-Dichloroethane	107-06-2	µg/m ³	0.81 U	0.81 U	0.81 U	1.9 U	1.2 U	0.88 U	0.81 U	0.81 U
1,2-Dichloropropane	78-87-5	µg/m ³	0.92 U	0.92 U	0.92 U	2.2 U	1.3 U	1.0 U	0.92 U	0.92 U
1,3,5-Trimethylbenzene	108-67-8	µg/m ³	2.0 U	2.0 U	2.0 U	4.6 U	2.8 U	2.1 U	2.0 U	2.0 U
1,3-Butadiene	106-99-0	µg/m ³	0.88 U	0.88 U	0.88 U	2.1 U	0.29 J	0.96 U	0.88 U	0.88 U
1,3-Dichlorobenzene	541-73-1	µg/m ³	1.2 U	1.2 U	1.2 U	2.8 U	1.7 U	1.3 U	1.2 U	1.2 U
1,4-Dichlorobenzene	106-46-7	µg/m ³	1.2 U	1.2 U	1.2 U	2.8 U	0.92 J	0.42 J	0.57 J	0.36 J
2-Butanone (MEK)	78-93-3	µg/m ³	2.9 U	1.3 J	2.9 U	5.1 J	34	3.8	6.2	4.8
2-Hexanone	591-78-6	µg/m ³	2.0 U	2.0 U	2.0 U	4.8 U	9.6	1.0 J	1.3 J	0.83 J
3-Chloropropene	107-05-1	µg/m ³	0.63 U	0.63 U	0.63 U	1.5 U	0.91 U	0.68 U	0.63 U	0.63 U
4-Methyl-2-pentanone (MIBK)	108-10-1	µg/m ³	4.1 U	4.1 U	4.1 U	9.7 U	3.1 J	4.5 U	4.1 U	0.88 J
Acetone	67-64-1	µg/m ³	18 U	11 J	8.1 J	34 J	160	31	43	34
Acetonitrile	75-05-8	µg/m ³	1.7 U	0.96 J	0.71 J	4 U	2.4 U	0.89 J	1.2 J	1.0 J
Acrolein	107-02-8	µg/m ³	2.3 U	2.3 U	2.3 U	1.8 J	4.5	1.4 J	1.4 J	1.2 J
Acrylonitrile	107-13-1	µg/m ³	4.3 U	4.3 U	4.3 U	10 U	6.3 U	4.7 U	4.3 U	4.3 U
Alpha Methyl Styrene	98-83-9	µg/m ³	1.9 U	1.9 U	1.9 U	4.6 U	2.8 U	2.1 U	1.9 U	1.9 U
Benzene	71-43-2	µg/m ³	0.64 U	0.32 J	0.31 J	0.61 J	1.3	0.57 J	0.97	0.67
Benzyl chloride	100-44-7	µg/m ³	2.1 U	2.1 U	2.1 U	4.9 U	3.0 U	2.3 U	2.1 U	2.1 U
Bromodichloromethane	75-27-4	µg/m ³	1.3 U	1.3 U	1.3 U	3.2 U	1.9 U	1.1 J	1.3 U	1.3 U
Bromoform	75-25-2	µg/m ³	2.1 U	2.1 U	2.1 U	4.9 U	3.0 U	2.2 U	0.91 J	2.1 U
Bromomethane	74-83-9	µg/m ³	0.78 U	0.78 U	0.78 U	1.8 U	1.1 U	0.84 U	0.78 U	0.78 U
Butane	106-97-8	µg/m ³	2.4 U	2.4 U	2.4 U	5.6 U	3.4 U	2.6 U	0.60 J	2.4 U
Carbon disulfide	75-15-0	µg/m ³	1.2 U	0.91 J	5.0	2.9 U	0.43 J	0.62 J	0.50 J	0.28 J
Carbon tetrachloride	56-23-5	µg/m ³	1.3 U	0.47 J	0.44 J	3 U	1.8 U	1.4 U	1.3 U	1.3 U
Chlorobenzene	108-90-7	µg/m ³	0.92 U	0.92 U	0.92 U	2.2 U	2.8	1.3	1.8	1.2
Chlorodifluoromethane	75-45-6	µg/m ³	0.71 U	1.0	1.0	1.7 U	1.0 U	0.77 U	0.71 U	0.71 U
Chloroethane	75-00-3	µg/m ³	0.53 U	0.53 U	0.53 U	1.2 U	0.76 U	0.57 U	0.53 U	0.53 U
Chloroform	67-66-3	µg/m ³	0.98 U	0.98 U	0.98 U	1.1 J	1.4 U	2.5	0.89 J	0.53 J
Chloromethane	74-87-3	µg/m ³	2.1 U	1.3 J	1.4 J	4.9 U	3.0 U	2.2 U	2.1 U	2.1 U
cis-1,2-Dichloroethene	156-59-2	µg/m ³	0.79 U	0.79 U	0.79 U	1.9 U	1.1 U	0.86 U	0.79 U	0.79 U
cis-1,3-Dichloropropene	10061-01-5	µg/m ³	1.8 U	1.8 U	1.8 U	4.3 U	2.6 U	2.0 U	1.8 U	1.8 U
Cyclohexane	110-82-7	µg/m ³	1.4 U	1.4 U	1.4 U	3.3 U	2.0 U	1.5 U	1.4 U	1.4 U
Decane	124-18-5	µg/m ³	5.8 U	5.8 U	5.8 U	4.8 J	8.2	4.7 J	4.0 J	3.3 J
Dibromochloromethane	124-48-1	µg/m ³	1.7 U	1.7 U	1.7 U	4.0 U	2.5 U	0.96 J	0.32 J	1.7 U
Dibromomethane	74-95-3	µg/m ³	2.8 U	2.8 U	2.8 U	6.7 U	4.1 U	0.27 J	0.26 J	2.8 U
Dichlorodifluoromethane	75-71-8	µg/m ³	0.99 U	1.8	1.2	0.74 J	0.88 J	0.95 J	0.91 J	0.81 J
Dodecane	112-40-3	µg/m ³	7.0 U	7.0 U	7.0 U	16 U	26	15	12	11
Ethyl ether	60-29-7	µg/m ³	6.1 U	6.1 U	6.1 U	14 U	8.8 U	6.6 U	6.1 U	6.1 U
Ethylbenzene	100-41-4	µg/m ³	0.87 U	0.17 J	0.19 J	0.88 J	0.54 J	0.33 J	0.32 J	0.27 J
Heptane	142-82-5	µg/m ³	1.6 U	0.2 J	0.15 J	0.41 J	0.48 J	1.8 U	0.16 J	1.6 U
Hexachlorobutadiene	87-68-3	µg/m ³	11 U	11 U	11 U	25 U	15 U	12 U	11 U	11 U
Hexane	110-54-3	µg/m ³	1.4 U	0.26 J	0.36 J	3.3 U	1 J	0.48 J	1.4 U	0.46 J
Isopropylbenzene	98-82-8	µg/m ³	2.0 U	2.0 U	2.0 U	4.6 U	2.8 U	2.1 U	2.0 U	2.0 U
Methyl tert-butyl ether	1634-04-4	µg/m ³	3.6 U	3.6 U	3.6 U	8.5 U	5.2 U	3.9 U	3.6 U	3.6 U
Methylene Chloride	75-09-2	µg/m ³	3.8	3.8	5.1 J+	10	3.6 J	4.4 J+	3.0 J	3.5 U
m-Xylene & p-Xylene	179601-23-1	µg/m ³	0.87 U	0.35 J	0.46 J	4.7	1.4	0.94	0.87	0.77 J
Naphthalene	91-20-3	µg/m ³	2.1 U	2.1 U	2.1 U	5 U	1.7 J	0.84 J	0.75 J	0.59 J
Nonane	111-84-2	µg/m ³	2.1 U	2.1 U	2.1 U	3.2 J	2.9 J	1.7 J	1.6 J	1.1 J
Octane	111-65-9	µg/m ³	1.9 U	1.9 U	1.9 U	1.4 J	1.2 J	2.0 U	0.93 J	1.9 U
o-Xylene	95-47-6	µg/m ³	0.87 U	0.87 U	0.18 J	2.4	1.4	0.73 J	0.84 J	0.67 J
Pentane	109-66-0	µg/m ³	7.4 U	7.4 U	7.4 U	17 U	11 U	8 U	7.4 U	7.4 U
Propylbenzene	103-65-1	µg/m ³	2.0 U	2.0 U	2.0 U	0.65 J	1.7 J	0.76 J	1.2 J	0.72 J
Styrene	100-42-5	µg/m ³	0.85 U	0.85 U	0.85 U	2.0 U	1.2 U	0.93 U	0.85 U	0.85 U

Appendix 2 - Table 1A
VOC and Fixed Gas Air Sample Analytical Results - All Data
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	Units	SAFF-PRE-0- PRE HEAT EFFLUENT SUMMA	SAFF-TI-1- AMBIENT AIR SUMMA	SAFF-T2-1- AMBIENT AIR SUMMA	SAFF-PRE-0- EFFLUENT AIR SUMMA	SAFF-TI-1- EFFLUENT AIR SUMMA	SAFF-TI-2- EFFLUENT AIR SUMMA	SAFF-T1-3- EFFLUENT AIR SUMMA	SAFF-T2-1- EFFLUENT AIR SUMMA
Tetrachloroethene	127-18-4	µg/m ³	1.4 U	1.4 U	1.4 U	0.53 J	2.0 U	1.5 U	1.4 U	1.4 U
Toluene	108-88-3	µg/m ³	0.59 J	0.76 J	3.8 U	3.8 J	5.0 J	3.2 J	3.5 J	2.6 J
trans-1,2-Dichloroethene	156-60-5	µg/m ³	0.79 U	0.79 U	0.79 U	1.9 U	1.1 U	0.86 U	0.79 U	0.79 U
trans-1,3-Dichloropropene	10061-02-6	µg/m ³	0.91 U	0.91 U	0.91 U	2.1 U	1.3 U	0.99 U	0.91 U	0.91 U
Trichloroethene	79-01-6	µg/m ³	1.1 U	1.1 U	1.1 U	0.46 J	1.6 U	1.2 U	1.1 U	1.1 U
Trichlorofluoromethane	75-69-4	µg/m ³	1.1 U	1.2	1.2	0.57 J	0.52 J	0.65 J	0.68 J	0.61 J
Undecane	1120-21-4	µg/m ³	6.4 U	6.4 U	6.4 U	6.7 J	17	9.3	8.3	6.6
Vinyl acetate	108-05-4	µg/m ³	3.5 U	3.5 U	3.5 U	8.3 U	5.1 U	3.8 U	3.5 U	3.5 U
Vinyl chloride	75-01-4	µg/m ³	1.0 U	1.0 U	1.0 U	2.4 U	1.5 U	1.1 U	1.0 U	1.0 U

Notes:
FID = flame ionization detector; % v/v = percent volume per volume; µg/m³ = micrograms per cubic meter
Bold = Analyte detected at a concentration greater than its Detection Limit
blue shade = compound was only detected in ambient air
tan shade = detected compound was also detected in ambient air
grey shade = detected compound was not detected in ambient air

FINAL QUALIFIERS:
U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.
J = The reported result was an estimated value with an unknown bias.
J+ = The reported result was an estimated value, but the result may be biased high.

Appendix 2 - Table 1B

VOC and Fixed Gas Air Sample Analytical Results - Detected Compounds Summary

October 25, 2023 SAFF Tests

BW Project No. 230044

Parameter	CAS No.	Units	SUMMA BLANK ¹ (SAFF-PRE-0- PRE HEAT EFFLUENT SUMMA)	SAFF-TI-1- AMBIENT AIR SUMMA	SAFF-T2-1- AMBIENT AIR SUMMA	SAFF-PRE-0- EFFLUENT AIR SUMMA	SAFF-TI-1- EFFLUENT AIR SUMMA	SAFF-TI-2- EFFLUENT AIR SUMMA	SAFF-T1-3- EFFLUENT AIR SUMMA	SAFF-T2-1- EFFLUENT AIR SUMMA
Fixed Gases										
Carbon dioxide	124-38-9	% v/v	0.10 U	0.60 U	0.29 U	4.4	5.9	5.9	6.0	6.0
Methane (FID)	74-82-8	% v/v	0.0001 U	0.00022	0.00029 U	0.039	0.00042 U	0.017	0.00039 U	0.00036 U
Nitrogen	7727-37-9	% v/v	1.0 U	71	64	54	64	65	64	65
Oxygen	7782-44-7	% v/v	0.20 U	20	18	8.4	9.0	9.5	8.9	9.0
Volatile Organic Compounds (VOCs)										
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	µg/m ³	1.5 U	0.56 J	0.70 J	0.81 J	0.56 J	0.85 J	0.49 J	0.58 J
1,2,4-Trimethylbenzene	95-63-6	µg/m ³	0.98 U	0.98 U	0.98 U	3.0	1.5	0.83 J	0.72 J	0.51 J
1,2-Dichlorobenzene	95-50-1	µg/m ³	2.4 U	2.4 U	2.4 U	5.7 U	1.3 J	0.69 J	0.87 J	0.56 J
1,3-Butadiene	106-99-0	µg/m ³	0.88 U	0.88 U	0.88 U	2.1 U	0.29 J	0.96 U	0.88 U	0.88 U
1,4-Dichlorobenzene	106-46-7	µg/m ³	1.2 U	1.2 U	1.2 U	2.8 U	0.92 J	0.42 J	0.57 J	0.36 J
2-Butanone (MEK)	78-93-3	µg/m ³	2.9 U	1.3 J	2.9 U	5.1 J	34	3.8	6.2	4.8
2-Hexanone	591-78-6	µg/m ³	2.0 U	2.0 U	2.0 U	4.8 U	9.6	1.0 J	1.3 J	0.83 J
4-Methyl-2-pentanone (MIBK)	108-10-1	µg/m ³	4.1 U	4.1 U	4.1 U	9.7 U	3.1 J	4.5 U	4.1 U	0.88 J
Acetone	67-64-1	µg/m ³	18 U	11 J	8.1 J	34 J	160	31	43	34
Acetonitrile	75-05-8	µg/m ³	1.7 U	0.96 J	0.71 J	4.0 U	2.4 U	0.89 J	1.2 J	1.0 J
Acrolein	107-02-8	µg/m ³	2.3 U	2.3 U	2.3 U	1.8 J	4.5	1.4 J	1.4 J	1.2 J
Benzene	71-43-2	µg/m ³	0.64 U	0.32 J	0.31 J	0.61 J	1.3	0.57 J	0.97	0.67
Bromodichloromethane	75-27-4	µg/m ³	1.3 U	1.3 U	1.3 U	3.2 U	1.9 U	1.1 J	1.3 U	1.3 U
Bromoform	75-25-2	µg/m ³	2.1 U	2.1 U	2.1 U	4.9 U	3.0 U	2.2 U	0.91 J	2.1 U
Butane	106-97-8	µg/m ³	2.4 U	2.4 U	2.4 U	5.6 U	3.4 U	2.6 U	0.6 J	2.4 U
Carbon disulfide	75-15-0	µg/m ³	1.2 U	0.91 J	5	2.9 U	0.43 J	0.62 J	0.5 J	0.28 J
Carbon tetrachloride	56-23-5	µg/m ³	1.3 U	0.47 J	0.44 J	3 U	1.8 U	1.4 U	1.3 U	1.3 U
Chlorobenzene	108-90-7	µg/m ³	0.92 U	0.92 U	0.92 U	2.2 U	2.8	1.3	1.8	1.2
Chlorodifluoromethane	75-45-6	µg/m ³	0.71 U	1.0	1.0	1.7 U	1.0 U	0.77 U	0.71 U	0.71 U
Chloroform	67-66-3	µg/m ³	0.98 U	0.98 U	0.98 U	1.1 J	1.4 U	2.5	0.89 J	0.53 J
Chloromethane	74-87-3	µg/m ³	2.1 U	1.3 J	1.4 J	4.9 U	3.0 U	2.2 U	2.1 U	2.1 U
Decane	124-18-5	µg/m ³	5.8 U	5.8 U	5.8 U	4.8 J	8.2	4.7 J	4.0 J	3.3 J
Dibromochloromethane	124-48-1	µg/m ³	1.7 U	1.7 U	1.7 U	4.0 U	2.5 U	0.96 J	0.32 J	1.7 U
Dibromomethane	74-95-3	µg/m ³	2.8 U	2.8 U	2.8 U	6.7 U	4.1 U	0.27 J	0.26 J	2.8 U
Dichlorodifluoromethane	75-71-8	µg/m ³	0.99 U	1.8	1.2	0.74 J	0.88 J	0.95 J	0.91 J	0.81 J
Dodecane	112-40-3	µg/m ³	7.0 U	7.0 U	7.0 U	16 U	26	15	12	11
Ethylbenzene	100-41-4	µg/m ³	0.87 U	0.17 J	0.19 J	0.88 J	0.54 J	0.33 J	0.32 J	0.27 J
Heptane	142-82-5	µg/m ³	1.6 U	0.2 J	0.15 J	0.41 J	0.48 J	1.8 U	0.16 J	1.6 U
Hexane	110-54-3	µg/m ³	1.4 U	0.26 J	0.36 J	3.3 U	1.0 J	0.48 J	1.4 U	0.46 J
Methylene Chloride	75-09-2	µg/m ³	3.8	3.8	5.1 J+	10	3.6 J	4.4 J+	3.0 J	3.5 U
m-Xylene & p-Xylene	179601-23-1	µg/m ³	0.87 U	0.35 J	0.46 J	4.7	1.4	0.94	0.87	0.77 J
Naphthalene	91-20-3	µg/m ³	2.1 U	2.1 U	2.1 U	5.0 U	1.7 J	0.84 J	0.75 J	0.59 J
Nonane	111-84-2	µg/m ³	2.1 U	2.1 U	2.1 U	3.2 J	2.9 J	1.7 J	1.6 J	1.1 J
Octane	111-65-9	µg/m ³	1.9 U	1.9 U	1.9 U	1.4 J	1.2 J	2.0 U	0.93 J	1.9 U
o-Xylene	95-47-6	µg/m ³	0.87 U	0.87 U	0.18 J	2.4	1.4	0.73 J	0.84 J	0.67 J
Propylbenzene	103-65-1	µg/m ³	2.0 U	2.0 U	2.0 U	0.65 J	1.7 J	0.76 J	1.2 J	0.72 J
Tetrachloroethene	127-18-4	µg/m ³	1.4 U	1.4 U	1.4 U	0.53 J	2.0 U	1.5 U	1.4 U	1.4 U
Toluene	108-88-3	µg/m ³	0.59 J	0.76 J	3.8 U	3.8 J	5.0 J	3.2 J	3.5 J	2.6 J
Trichloroethene	79-01-6	µg/m ³	1.1 U	1.1 U	1.1 U	0.46 J	1.6 U	1.2 U	1.1 U	1.1 U
Trichlorofluoromethane	75-69-4	µg/m ³	1.1 U	1.2	1.2	0.57 J	0.52 J	0.65 J	0.68 J	0.61 J
Undecane	1120-21-4	µg/m ³	6.4 U	6.4 U	6.4 U	6.7 J	17	9.3	8.3	6.6
TOTAL Detected VOCs		µg/m ³	4.39	26.4	26.5	87.7	293.8	92.2	101.1	76.9

Notes:

1 = No sample was collected in the summa can. The summa was meant for sampling the Pre-Heater exhaust stack but was never collected. Can was mistakenly analyzed by laboratory. Results are used as a summa can blank.

FID = flame ionization detector; % v/v = percent volume per volume; µg/m³ = micrograms per cubic meter

Purple Font = fluorinated compound

Bold = Analyte detected at a concentration greater than its Detection Limit

blue shade = compound was only detected in ambient air

tan shade = detected compound was also detected in ambient air

grey shade = detected compound was not detected in ambient air

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

J = The reported result was an estimated value with an unknown bias.

J+ = The reported result was an estimated value, but the result may be biased high.

Appendix 2 - Table 2
Fluoride Air Sample Analytical Results
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	Units	SAMPLE AREA AMBIENT INDOOR AIR	SAFF-PRE-0- EFFLUENT AIR	SAFF-TI-1- EFFLUENT AIR	SAFF-TI-2- EFFLUENT AIR	SAFF-T1-3- EFFLUENT AIR	SAFF-T2-1- EFFLUENT AIR
Fluoride							
Gaseous Fluoride	mg/m ³	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U	5.2 U
Particulate Fluoride	mg/m ³	5 U	5 U	5 U	5 U	5 U	5 U
Total Fluoride	mg/m ³	10.2 U	10.2 U	10.2 U	10.2 U	10.2 U	10.2 U

Notes:

mg/m³ = milligrams per cubic meter

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

Appendix 2 - Table 3A
PFAS Air Sample Analytical Results - All Data
October 25, 2023 SAFF Tests
BW Project No. 230044

Parameter	CAS No.	A-1929 OTM-45 MEDIA CHECK PUF	AIR SAMPLING AREA AMBIENT INDOOR AIR PUF FRONT	AIR SAMPLING AREA AMBIENT INDOOR AIR PUF BACK	SAFF-PRE-0-AMBIENT AIR PUF FRONT	SAFF-PRE-0-AMBIENT AIR PUF FRONT BACK	SAFF-PRE-0-EFFLUENT AIR PUF FRONT	SAFF-PRE-0-EFFLUENT AIR PUF BACK	SAFF-TI-1-AMBIENT AIR PUF FRONT	SAFF-TI-1-AMBIENT AIR PUF BACK	SAFF-TI-1-EFFLUENT AIR PUF FRONT	SAFF-TI-1-EFFLUENT AIR PUF BACK	SAFF-TI-2-AMBIENT AIR PUF FRONT	SAFF-TI-2-AMBIENT AIR PUF BACK	SAFF-TI-2-EFFLUENT AIR PUF FRONT	SAFF-TI-2-EFFLUENT AIR PUF BACK	SAFF-TI-3-AMBIENT AIR PUF FRONT	SAFF-TI-3-AMBIENT AIR PUF BACK	SAFF-TI-3-EFFLUENT AIR PUF FRONT	SAFF-TI-3-EFFLUENT AIR PUF BACK	SAFF-T2-1-AMBIENT AIR PUF FRONT	SAFF-T2-1-AMBIENT AIR PUF BACK	SAFF-T2-1-EFFLUENT AIR PUF FRONT	SAFF-T2-1-EFFLUENT AIR PUF BACK
All results reported as nanograms																								
10:2 FTS	120226-60-0	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
11-Chloroicosafuoro-3-oxaundecane-1-sulfonic acid	763051-92-9	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	1691-99-2	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
2-(N-methylperfluoro-1-octanesulfonamido) ethanol	24448-09-7	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
4:2 FTS	757124-72-4	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
6:2 FTS	27619-97-2	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
8:2 FTS	39108-34-4	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
DNDA	919005-14-4	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U
HFPO-DA	13252-13-6	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U	20 U
N-ethylperfluoro-1-octanesulfonamide	4151-50-2	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
N-ethylperfluorooctanesulfonamidoacetic acid (NtFOSAA)	2991-50-6	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
NMeFOSA	31506-32-8	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorobutanoic acid (PFBA)	375-22-4	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Perfluorodecanesulfonic acid (PFDS)	335-77-3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorodecanoic acid (PFDA)	335-76-2	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorododecanoic acid (PFDoA)	307-55-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluoroheptanoic acid (PFHpA)	375-85-9	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U
Perfluorohexadecanoic acid	67905-19-5	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorohexanoic acid (PFHxA)	307-24-4	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorononanesulfonic acid (PFNS)	68259-12-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorononanoic acid (PFNA)	375-95-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorooctadecanoic acid	16517-11-6	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorooctanesulfonamide (FOSA)	754-91-6	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	0.16 J	0.21 J	1.0 U	1.0 U	1.0 U	0.16 J	0.35 J	1.0 U	0.15 J	1.0 U	1.0 U	1.0 U	1.0 U	0.72 J	1.4	1.0 U	1.0 U	0.51 J	0.29 J	1.0 U	1.0 U	0.41 J	0.47 J
Perfluorooctanoic acid (PFOA)	335-67-1	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluoropentanoic acid (PFPeA)	2706-90-3	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorotetradecanoic acid (PFTeA)	376-06-7	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluorotridecanoic acid (PFTriA)	72629-94-8	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Perfluoroundecanoic acid (PFUnA)	2058-94-8	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U

Notes:
Bold = Analyte detected at a concentration greater than its Detection Limit
FINAL QUALIFIERS:
U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.
J = The reported result was an estimated value with an unknown bias.

Appendix 2 - Table 3B
PFAS Air Sample Analytical Results for PFOS
October 25, 2023 SAFF Tests
BW Project No. 230044

Sample ID	PFOS Mass (ng)	Volume per Sample (L)	PFOS Conc. (ng/L) ^a
A-1929 OTM-45 MEDIA CHECK PUF (Field Blank) ¹	0.16 J	0.0	—
AIR SAMPLING AREA AMBIENT INDOOR AIR PUF FRONT	0.21 J	6.0	0.035
AIR SAMPLING AREA AMBIENT INDOOR AIR PUF BACK	1.0 U	6.0	—
AIR SAMPLING AREA AMBIENT INDOOR AIR PUF TOTAL			0.035
SAFF-PRE-0-AMBIENT AIR PUF FRONT FRONT	1.0 U	6.0	—
SAFF-PRE-0-AMBIENT AIR PUF FRONT BACK	1.0 U	6.0	—
SAFF-PRE-0-AMBIENT AIR PUF TOTAL			0.000
SAFF-PRE-0-EFFLUENT AIR PUF FRONT	0.16 J	6.0	0.027
SAFF-PRE-0-EFFLUENT AIR PUF BACK	0.35 J	6.0	0.058
SAFF-PRE-0-EFFLUENT AIR PUF TOTAL			0.085
SAFF-TI-1-AMBIENT AIR PUF FRONT	1.0 U	7.03	—
SAFF-TI-1-AMBIENT AIR PUF BACK	0.15 J	7.03	0.021
SAFF-TI-1-AMBIENT AIR PUF TOTAL			0.021
SAFF-TI-1-EFFLUENT AIR PUF FRONT	1.0 U	6.0	—
SAFF-TI-1-EFFLUENT AIR PUF BACK	1.0 U	6.0	—
SAFF-TI-1-EFFLUENT AIR PUF TOTAL			0.000
SAFF-TI-2-AMBIENT AIR PUF FRONT	1.0 U	6.03	—
SAFF-TI-2-AMBIENT AIR PUF BACK	1.0 U	6.03	—
SAFF-TI-2-AMBIENT AIR PUF TOTAL			0.000
SAFF-TI-2-EFFLUENT AIR PUF FRONT	0.72 J	6.07	0.119
SAFF-TI-2-EFFLUENT AIR PUF BACK	1.4	6.07	0.231
SAFF-TI-2-EFFLUENT AIR PUF TOTAL			0.349
SAFF-TI-3-AMBIENT AIR PUF FRONT	1.0 U	6.03	—
SAFF-TI-3-AMBIENT AIR PUF BACK	1.0 U	6.03	—
SAFF-TI-3-AMBIENT AIR PUF TOTAL			0.000
SAFF-T1-3-EFFLUENT AIR PUF FRONT	0.51 J	6.06	0.084
SAFF-T1-3-EFFLUENT AIR PUF BACK	0.29 J	6.06	0.048
SAFF-T1-3-EFFLUENT AIR PUF TOTAL			0.132
SAFF-T2-1-AMBIENT AIR PUF FRONT	1.0 U	6.07	—
SAFF-T2-1-AMBIENT AIR PUF BACK	1.0 U	6.07	—
SAFF-T2-1-AMBIENT AIR PUF TOTAL			0.000
SAFF-T2-1-EFFLUENT AIR PUF FRONT	0.41 J	6.2	0.066
SAFF-T2-1-EFFLUENT AIR PUF BACK	0.47 J	6.2	0.076
SAFF-T2-1-EFFLUENT AIR PUF TOTAL			0.142

Notes:

PFOS = Perfluorooctanesulfonic acid

ng = nanograms; L = liter; ng/L = nanograms per liter

1 = No air was pulled through the sampler tube. Sampler tube was left opened at both ends near the effluent air sampling station during the duration of the SAFF Tests

— = not applicable

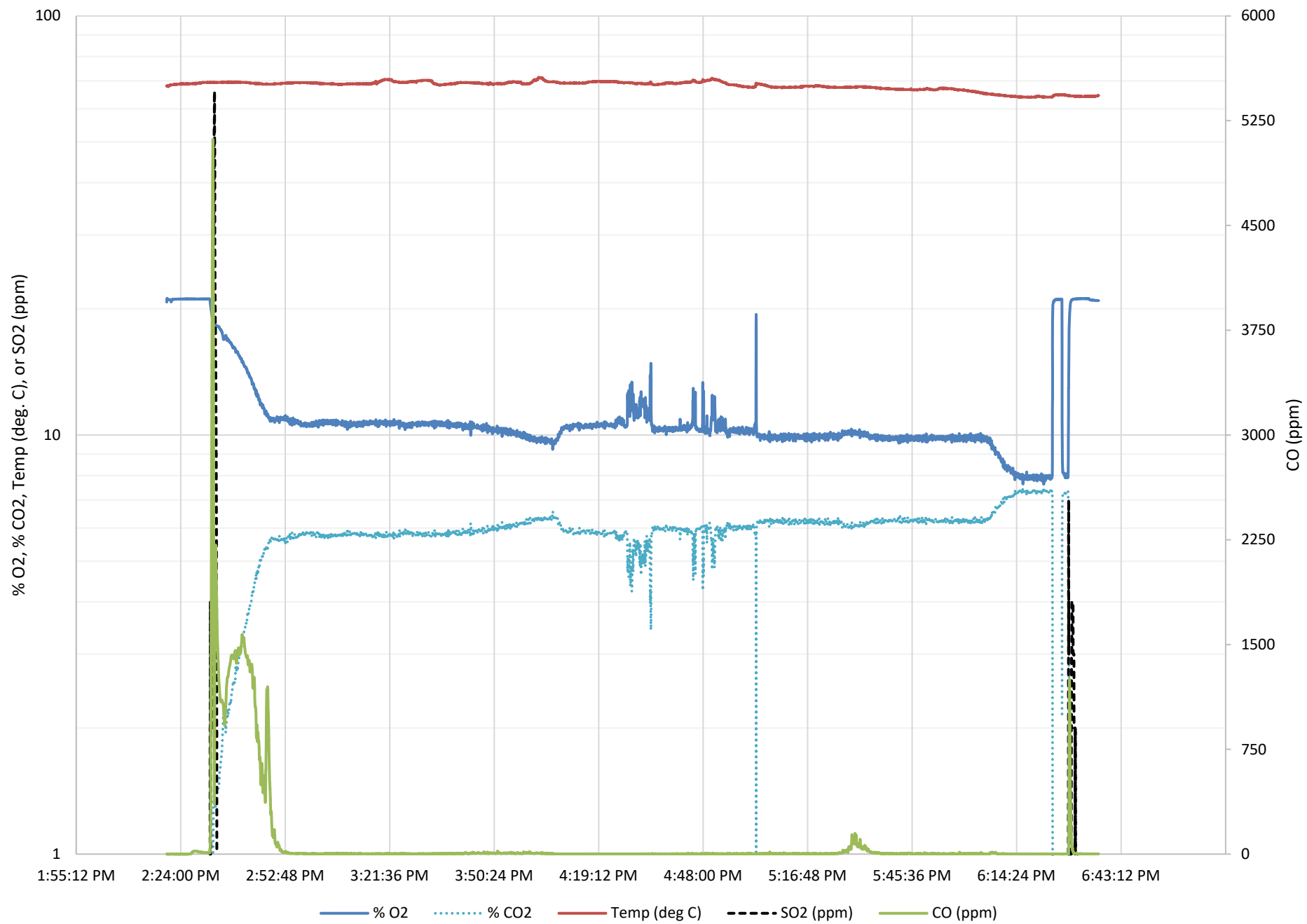
Highlighted boldface font = parameter detected above the Detection Limit

FINAL QUALIFIERS:

U = The analyte was not detected or considered non-detected from blank related contamination and was reported as less than the Limit of Detection (LOD). The LOD has been adjusted for any dilution or concentration of the sample.

J = The reported result was an estimated value with an unknown bias.

SAFF TEST - TESTO COMBUSTION GAS ANALYZER AIR EMISSION READINGS



Appendix 3

Destruction Efficiency Evaluation

Appendix 3 - Table 1
PFAS Destruction Efficiency Summary
October 25, 2023 SAFF Tests 2021 AFFF Tests
BW Project No. 230044

SAFF Mix Test Round T1-1		Flow Rate	INDIVIDUAL PFAS ANALYTES																														Total PFAS							
Time:	15:41:12 to 16:08:10		8:2 FTS		6:2 FTS		PFMPA		PFBS		PFBA		PFDS		PFDA		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFNA		PFOSA		PFOS				PFOA		PFPeS		PFPA	
Direction	Flow Source	LPM	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min		
In	Est. Air	19,822																																						
In	Process Feed Rate	5.26																																						
In	Diesel Feed Rate	1.52																																						
In	SAFF Mix Feed Rate	3.74	26	97	77	288	0	360	1,346	97	363	23	86	220	823	2,600	9,724	1,300	4,862	4,000	14,960	500	1,870	110	411	260	972	130	486	120,000	448,801	33,000	123,420	990	3,703	120	449	163,813	612,662	
In	SAFF Conc Feed Rate			0			0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0	
In	Quench Feed Rate	13.47		0			0	1.36	18	2.63	35		0		0		0	0.98	13	1.2	16	2	27		0	0.75	10		2.54	34	2.2	30		0	1.87	25	16	209		
In Total				97		288	0	1,365		398		86		823		9,724		4,875		14,976		1,897		411		983		486		448,836		123,450		3,703		474		612,872		
Out	Effluent Water Rate	1.86		0	33	62	0.5	1	6.9	13	56	104	0	0	0	0.78	1	2.9	5	11	21	6.9	13		0	0.88	2		44	82	29	54	3.2	6	2.9	5	198	369		
Out	Est. Air	19,822		0			0		0		0		0		0		0		0		0		0		0		0		0		0		0		0		0			
Out	Est. Condensate	16.86		0			0		0		0		0		0		0		0		0		0		0		0		1.3	22		0		0		0	1.3	22		
Out Total				0.0		61.5	0.9	12.9		104.4		0.0		0.0		1.5		5.4		20.5		12.9		0.0		1.6		0.0		103.9		54.1		6.0		5.4		390.9		
DRE				100.000%		78.642%			99.058%		73.788%		100.000%		100.000%		99.985%		99.889%		99.863%		99.322%		100.000%		99.833%		100.000%		99.977%		99.956%		99.839%		98.860%		99.936%	

SAFF Mix Test Round T1-2		Flow Rate	INDIVIDUAL PFAS ANALYTES																														Total PFAS							
Time: 16:12:40 to 16:40:00	8:2 FTS		6:2 FTS		PFMPA		PFBS		PFBA		PFDS		PFDA		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFNA		PFOSA		PFOS		PFOA				PFPeS		PFPA			
Direction	Flow Source	LPM	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min		
In	Est. Air	19,822																																						
In	Process Feed Rate	5.26																																						
In	Diesel Feed Rate	1.46																																						
In	SAFF Mix Feed Rate	3.80		0	65	245	0	325	1,236	96	365	21	80	270	1,027	2,600	9,888	1,300	4,944	4,100	15,592	450	1,711	110	416	250	951	120	456	125,000	475,370	33,000	125,498	925	3,518	115	437	168,746	641,734	
In	SAFF Conc Feed Rate			0		0	0	0	0		0		0		0	0	0		0		0		0		0		0		0		0	0	0	0	0	0	0	0		
In	Quench Feed Rate	22.36		0		0		1.36	30	2.63	59		0		0	0	0	0.98	22	1.2	27	2	45		0	0.75	17		2.54	57	2.2	49		0	1.87	42	16	347		
In Total				0		245		0		1,266		80		1,027		9,888		4,966		15,619		1,756		416		968		456		475,426		125,547		3,518		479		642,081		
Out	Effluent Water Rate	9.47		0	4.5	43	0	2.7	26	11	104	0	0	0	0	0	1.55	15	2.6	25	2.75	26	0	0	0.815	8	0	5.85	55	11	104	0.285	3	0	43	408				
Out	Est. Air	19,822		0		0	0	0	0		0		0		0	0	0	0	0	0	0	0	0	0	0	0	0.349	6,918	0	0	0	0.349	6,918	0	0	0	0			
Out	Est. Condensate	18.15		0		0	0	0	0		0		0		0	0	0	0	0	0	0	0	0	0	0	0	1.3	24	0	0	0	1.3	24	0	1.3	24				
Out Total				0.0		42.6	0.0	25.6		104.1		0.0		0.0		0.0		14.7		24.6		26.0		0.0		7.7		0.0		6,996.8		104.1		2.7		0.0		7,349.0		
DRE						82.633%				97.982%		75.434%		100.000%		100.000%		100.000%		99.705%		99.842%		98.517%		100.000%		99.203%		100.000%		98.528%		99.917%		99.923%		100.000%		98.855%

SAFF Mix Test Round T1-3		Flow Rate	INDIVIDUAL PFAS ANALYTES																														Total PFAS							
Time:	16:40:01 to 17:20:59		8:2 FTS		6:2 FTS		PFMPA		PFBS		PFBA		PFDS		PFDA		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFNA		PFOSA		PFOS				PFOA		PFPeS		PFPA	
Direction	Flow Source	LPM	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min		
In	Est. Air	19,822																																						
In	Process Feed Rate	5.26																																						
In	Diesel Feed Rate	1.50																																						
In	SAFF Mix Feed Rate	3.76	31	116	58	218	0	590	2,217	100	376	16	60	270	1,014	2,600	9,768	1,200	4,509	4,300	16,155	650	2,442	100	376	250	939	130	488	150,000	563,563	36,000	135,255	1,200	4,509	160	601	197,655	742,607	
In	SAFF Conc Feed Rate			0		0	0	0	0		0		0		0		0		0		0		0		0		0		0		0		0		0		0			
In	Quench Feed Rate	22.36		0		0		1.36	30	2.63	59		0		0		0	0.98	22	1.2	27	2	45		0	0.75	17		0	2.54	57	2.2	49		0	1.87	42	16	347	
In Total				116		218		0		2,247		435		60		1,014		9,768		4,530		16,182		2,487		376		956		488		563,620		135,304		4,509		643		742,954
Out	Effluent Water Rate	8.91		0	2.6	23	0	2.5	22	5	45	0	0	0	0.86	8	1.8	16	1.9	17	0	0	0.52	5	0	7.6	68	7.2	64	0	1.8	16	32	283						
Out	Est. Air	19,822		0		0	0	0	0		0		0		0		0		0		0		0		0		0.132	2,616	0	0	0	0	0.132	2,616	0	0				
Out	Est. Condensate	18.71		0		0	0	0	0		0		0		0		0		0		0		0		0		1.3	24	0	0	0	1	24							
Out Total				0.0		23.2	0.0	22.3		44.5		0.0		0.0		7.7		16.0		16.9		0.0		4.6		0.0		2,708.5		64.1		0.0		16.0		2,923.8				
DRE				100.000%		89.374%				99.009%		89.752%		100.000%		100.000%		100.000%		99.831%		99.901%		99.320%		100.000%		99.516%		100.000%		99.519%		99.953%		100.000%		97.507%		99.606%

Appendix 3 - Table 1
PFAS Destruction Efficiency Summary
October 25, 2023 SAFF Tests 2021 AFFF Tests
BW Project No. 230044

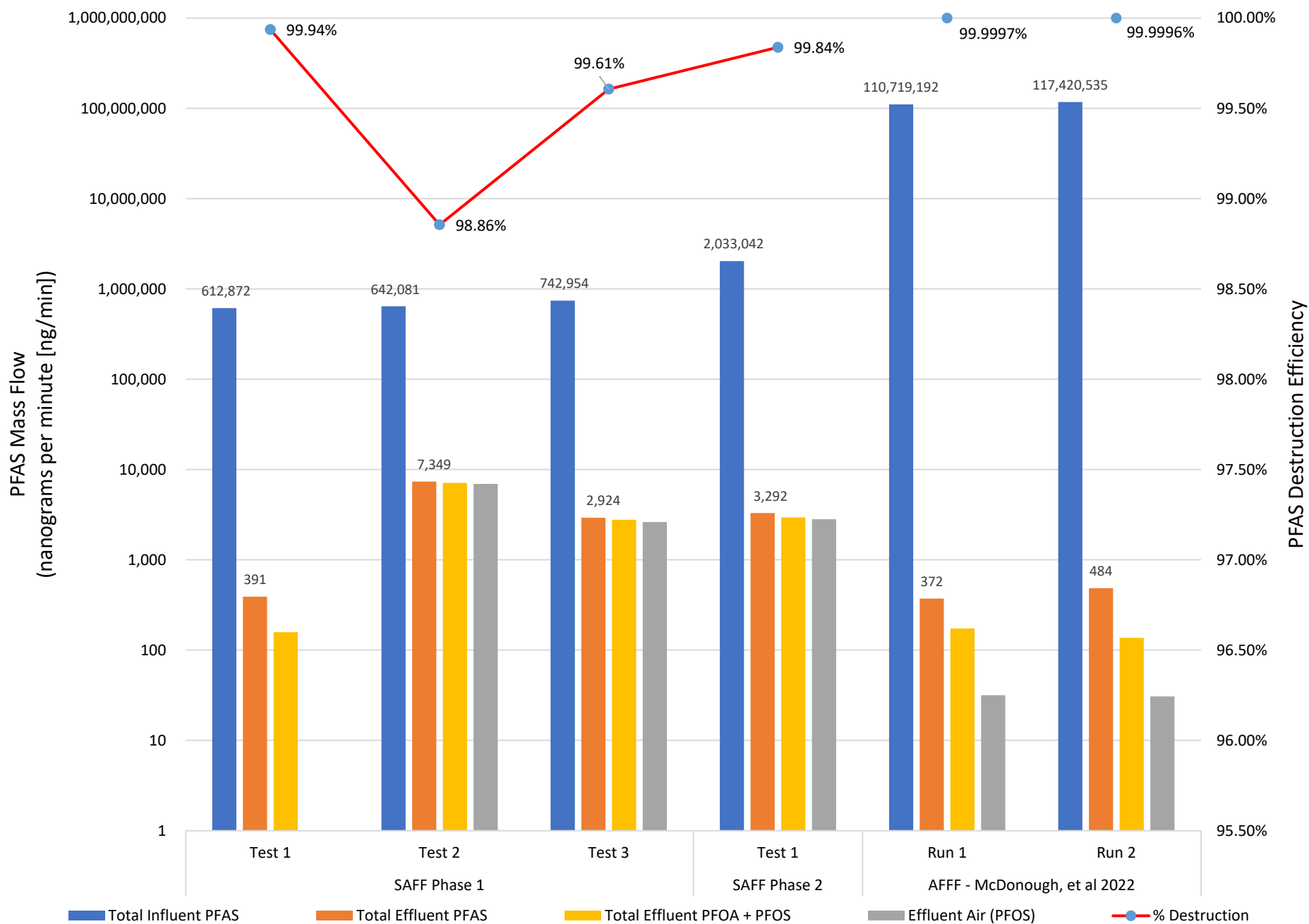
SAFF Mix + Conc. Test T2-1			INDIVIDUAL PFAS ANALYTES																												Total														
Time:	17:21:03 to 18:00:00		8:2 FTS		6:2 FTS		PFMPA		PFBS		PFBA		PFDS		PFDA		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFNA		PFOSA		PFOS		PFOA		PFPeS		PFPeA		PFPA		PFuNA		PFAS		
Direction	Flow Source	LPM	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min	ng/L	ng/min			
In	Est. Air	19,822																																											
In	Process Feed Rate	5.38																																											
In	Diesel Feed Rate	1.53																																											
In	SAFF Mix Feed Rate	3.85		0		0		0	1,290	4,970		0		0	165	636	1,045	4,026		1,650	6,357	4,350	16,761	1,085	4,181	21	79		205	790	125	482	120,000	462,362	30,000	115,591	770	2,967		0		0			
In	SAFF Conc Feed Rate	0.20		0		0		0	194	38.8		463	92.6	0	12,000	2,400	52,000	10,400		100,000	20,000	170,000	34,000	2,650	530		0	19,000	3,800		0	4,600,000	920,000	2,100,000	420,000	11,000	2,200	135	27		0	28.1	5.62	7,067,470	1,413,494
In	Quench Feed Rate	22.36		0		0		0	1.36	30		2.63	59	0		0		0		0.98	22	1.2	27	2	45		0	0.75	17		0	2.54	57	2.2	49		0	2	42		0		0	15.53	347.28
In Total				0		0		0		5,040		151		0		3,036		14,426		26,379		50,787		4,755		79		4,607		482		1,382,419		535,640		5,167		27		42		5.62			2,033,042
Out	Effluent Water Rate	8.99		0		5.65	51		0	2.4	22	23.5	211			0	0	0		0.96	9	2.1	19	1.85	17		0	0.725	7		0	4.75	43	6.75	61	0	0		0	2	15		0	50.335	452.33
Out	Est. Air	19,822		0			0		0				0			0		0			0			0			0			0		0	0.142	2,815		0		0		0		0		2,815	
Out	Est. Condensate	18.96		0			0		0				0			0		0			0			0			0			0		1.3	25		0		0		0		0		1.3	24.64	
Out Total				0.0		50.8		0.0		21.6		211.2		0.0		0.0		0.0		8.6		18.9		16.6		0.0		6.5		0.0		2,882.0		60.7		0.0		0.0		14.8		0.0			3,291.7
DRE										99.572%		-39.474%				100.000%		100.000%		99.967%		99.963%		99.650%		100.000%		99.859%		100.000%		99.792%		99.989%		100.000%		100.000%		64.541%		1			99.838%

2022 McDonough et al AFFF Run 1		Flow Rate	INDIVIDUAL PFAS ANALYTES																		Total PFAS							
			PFBS		PFBA		PFDS		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFOS		PFOA		PFPeS		PFPA			
Direction	Flow Source	LPM	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m
In	Influent Air Flow Rate	19,255																										
In	Process Feed Rate	9.99																										
In	Diesel Feed Rate	0.89																										
In	AFFF Mix Feed Rate	9.1	146,900	1,336,790	35,140	319,774	0	85,890	781,599	37,930	345,163	717,100	6,525,610	86,600	788,060	10,560	96,096	10,780,000	98,098,000	72,210	657,111	159,400	1,450,540	35,170	320,047	12,166,900	110,718,790	
In	Quench Feed Rate	23.7	1.13	27	2.60	62	0		0	0.895	21	1.52	36	1.93	46		0	4.3	102	2.1	50		2.5	59		17	402	
In Total				1,336,817		319,836	0		781,599		345,184		6,525,646		788,106		96,096		98,098,102		657,161		1,450,540		320,106		110,719,192	
Out	Effluent Water Rate	11.3	2.0	23	2.8	32	0	0	0	0.961	11	1.67	19	2.4	27		0	5.6	63	2.2	25		0		0	18	199	
Out	Effluent Air Flow Rate	20,181		0		0			0	0.0009	17	0.00072	15	0.0019	38		0	0.00157	32	0.0012	24		0	0.0008	17	0	143	
Out	Est. Condensate	22.39		0		0			0				0		0		0	1.3	29		0		0		0	1	29	
Out Total				22.6		31.6	0.0		0.0		28.2		33.4		65.5		0.0		124.1		49.3		0.0		17.0		371.6	
		DRE		99.998%		99.990%			100.000%		99.992%		99.999%		99.992%		100.000%		100.000%		99.993%		100.000%		99.995%		99.997%	

2022 McDonough et al AFFF Run 2		Flow Rate	INDIVIDUAL PFAS ANALYTES																		Total PFAS								
			PFBS		PFBA		PFDS		PFHpS		PFHpA		PFHxS		PFHxA		PFNS		PFOS		PFOA		PFPeS		PFPA				
Direction	Flow Source	LPM	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	ng/L	ng/m	
In	Influent Air Flow Rate	19,255																											
In	Process Feed Rate	9.18																											
In	Diesel Feed Rate	0.88																											
In	AFFF Mix Feed Rate	8.3	147,800	1,226,740	35,130	291,579		0	91,990	763,517	28,710	238,293	855,600	7,101,480	100,300	832,490	14,020	116,366		12,590,000	104,497,000	83,220	690,726	167,300	1,388,590	32,930	273,319	14,147,000	117,420,100
In	Quench Feed Rate	23.1	1.14	26	2.50	58	2	46		0	0.746	17	0.914	21	1.87	43	2	46		3.1	72	1.48	34		3.1	72	19	435	
In Total				1,226,766		291,637		46		763,517		238,310		7,101,501		832,533		116,412		104,497,072		690,760		1,388,590		273,391		117,420,535	
Out	Effluent Water Rate	10.9	1.7	19	3	33		0	0	0	0.771	8	2.3	25	2.5	27		0	4.6	50	1.79	20		0	2.4	26	19	208	
Out	Effluent Air Flow Rate	19,512		0	0.0042	81		0		0	0.001	20	0.0008	16	0.00096	19		0	0.00157	31	0.0019	36	0.00061		12	0.0011	21	0	236
Out	Est. Condensate	21.38		0		0								0		0				0		0		1.9	41	2	41		
Out Total				19.0		113.7		0.0		0.0		28.3		40.7		46.0		0.0		80.8		56.0		11.9		88.1		484.3	
DRE				99.998%		99.961%		100.000%		100.000%		99.988%		99.999%		99.994%		100.000%		100.000%		99.992%		99.999%		99.968%		99.996%	

Notes:
LPM = liters per minute; ng/L = nanograms per liter; ng/min = nanograms per minute; Est. = estimated; DRE = Destruction and Removal Efficiency
SAFF = surface active foam fractionation; AFFF = aqueous film forming foam
Italics = estimated or calculated flow. For Estimated Air flow - the flow rate is based on knowledge of air compressor system operations and previous operations. For Estimated Condensate (water as steam) - the flow is calculated based on the sum of process feed, SAFF Concentrate and Quench Feed minus Effluent Water Rate
Quench water PFAS data are based on average concentrations across seven samples collected during the SAFF Tests
Only one composite condensate water sample was able to be collected during the SAFF Tests. The data for the that sample was applied to each of the DRE tables above.
Red Font = PFAS analyte only detected in the effluent, or detected at a higher effluent mass flow than influent mass flow. This is the likely the result of elevated detection limits for the SAFF Concentrate sample in Phase 2, Test 1.
Reference: McDonough, Jeffrey T.; Kirby, John; Bellona, Christopher; Quinman, Joseph A.; Welty, Nicklaus; Follin, John; Liberty, Ken, 2022. *Validation of supercritical water oxidation to destroy perfluoroalkyl acids*. Remediation. 2022;1-16. DOI: 10.1002/rem.21711. Wiley Periodicals LLC, 20 January, 2022.

iSCWO SAFF and AFFF PFAS Destruction Efficiency



Attachment G4: Claros Technologies Final Report



We solve problems
without creating
new ones



An advanced materials company
developing sustainable
materials and solutions
for a circular economy

A landscape photograph showing a calm lake in the foreground, a dense forest of trees on a small island in the middle ground, and rolling hills in the background under a cloudy sky.

PFAS Destruction
Technology

A close-up, slightly blurred image of a periodic table of elements, with various chemical symbols like 'La', 'Ce', 'P', 'U', and 'Np' visible.

PFAS Analytical
Services

Report
Minnesota Pollution Control Agency Treatability Bench Study
12-15-23

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Legal Disclaimer

All information contained in this proposal is proprietary and confidential and provided for the sole purpose of enabling the customers' evaluation of Claros' services. The contents of this proposal should not be duplicated, used, or disclosed in whole or in part for any other purposes.



Claros Background

Claros Technologies Inc. is an advanced materials company that designs and develops sustainable materials and solutions for a circular economy. Spun out of the University of Minnesota in 2018 the Claros team has focused on applying our platform technologies to the environmental market with an initial focus on the destruction of per- and poly-fluoroalkyl substances (PFAS) and the analytical expertise to measure these complicated compounds. PFAS are a group of synthetic chemicals that have been widely used in various industrial and consumer products. Due to the chemical nature of PFAS, they are persistent, ubiquitous, bio-accumulative, and potentially toxic to humans, wildlife, and the environment. PFAS has been detected in various environmental media and human tissues around the world. Claros facilities and team of chemists, materials scientists, environmental engineers, and analytical professional are well resourced and able to provide treatability studies for PFAS destruction. These studies are used to define the capability of available technologies, including Claros' Elemental™ PFAS destruction technology, to client-specific water, generate optimized process conditions, and estimate costs for running a field trial to evaluate larger volumes and waste stream variations over time. These tests will also provide insight into the type of pre-treatment and post-treatment processes that may be required depending on the client's wastewater and current treatment processes.

Background

The Minnesota Pollution Control Agency (MPCA) provided a sample of Surface Active Foam Fractionate (SAFF) - treated landfill leachate, originating from the East Metro of the Minneapolis - St. Paul area. Claros Technologies subsequently tested the sample's water quality characteristics, such as solids, hardness, turbidity, pH, and UV Transmittance (UVT). These metrics are outlined in **Table 1**.

Parameter	Value
pH	7
Total Alkalinity (ppm)	140
Total Suspended Solids (ppm)	0.06
Turbidity (NTU)	144
UVT (%)	0
Hardness (ppm)	425
NaCl (ppm)	100
Zinc (ppm)	5

Table 1 - MPCA SAFF sample background water characteristics

In addition to the water quality metrics, the presence of PFAS was screened internally on LC-MS by Claros Technologies' ISO/IEC 17025-accredited analytical lab, using a modified EPA Draft Method 1633 protocol. This analysis indicated that, of the 40 screened PFAS compounds in EPA Draft Method 1633, 4 were present in the initial sample - PFOA, PFHxS, PFHpS, and PFOS. Of these present compounds, PFOA and PFOS were by far the primary constituents, with concentrations of ~1.7ppm (mg/L) and ~5ppm respectively, as compared to only ~200ppb (µg/L) PFHxS and ~75ppb PFHpS.

PFAS Compound	PFOA	PFHxS	PFHpS	PFOS
Concentration (ppb, µg/L)	1700 ±340	200 ±40	75 ±15	5000 ± 1000

Table 2 - Concentration of MPCA SAFF-treated leachate. Error in Table 2 is a result of an accepted 20% measurement error in the analytical instruments.

As Claros Technologies' PFAS destruction method relies on UV irradiation of photosensitizers, the extremely poor UV transmittance of the provided sample was of concern. Correspondingly, Claros evaluated various pre-treatment techniques to ameliorate the UV transmittance. It was decided that the best approach for this aim was a 1:5 dilution of the SAFF-leachate sample. Upon dilution, the UV-transmittance increased to about 40% in a 1 cm path length. While the 1:5 dilution of the SAFF-leachate sample brought the UV transmittance past an acceptable threshold for photochemical treatability, it resulted in a commensurate decrease in the initial PFAS concentration. The initial concentration of various PFAS compounds after 1:5 dilution is outlined in **Table 3**.

PFAS Compound	PFOA	PFHxS	PFHpS	PFOS
Concentration (ppb, µg/L)	345 ± 69	40 ± 8	15 ± 3	1050 ± 210

Table 3 - Concentration of 1:5-dilute MPCA SAFF-treated leachate.

Destruction of MPCA SAFF-Leachate Sample with Claros Technologies' Elemental Destruction Technology

1:5-dilute samples of the MPCA SAFF leachate water were treated by Claros' proprietary Elemental destruction, in both a standard and modified form. Under both of these conditions, the MPCA SAFF sample was treated in triplicate (n=3) to ensure reproducibility. Notably, only Elemental Condition 1 samples were submitted to 3rd party labs for analysis.

The following data was collected and analyzed internally by Claros Technologies on LC-MS instruments via a direct injection method. Between 0 - 8 hours, samples were diluted 1:100x prior to analysis on instrumentation. For samples between 10 - 24 hours, samples were diluted 1:2x prior to analysis. The corresponding Limit of Quantitation (LOQ) for respective PFAS compounds is listed in Appendix 1.

The PFAS concentration (average of n=3 replicates) throughout the destruction procedure for Condition 1 and Condition 2 are shown in **Table 4** and **Table 5**, respectively. In cases wherein the concentration of a particular compound is below the Limit of Quantitation described above, the data is supplemented with a marker (LOQ).

Time (hours)	Condition 1 PFOA (ppb)	Condition 1 PFHxS (ppb)	Condition 1 PFHpS (ppb)	Condition 1 PFOS (ppb)
0	338.1 ± 12.71	36.5 ± 3.16	13.5 ± 1.72	930.7 ± 114.6
1	298.3 ± 8.24	36.5 ± 0.25	16.8 ± 4.46	972.8 ± 392.3

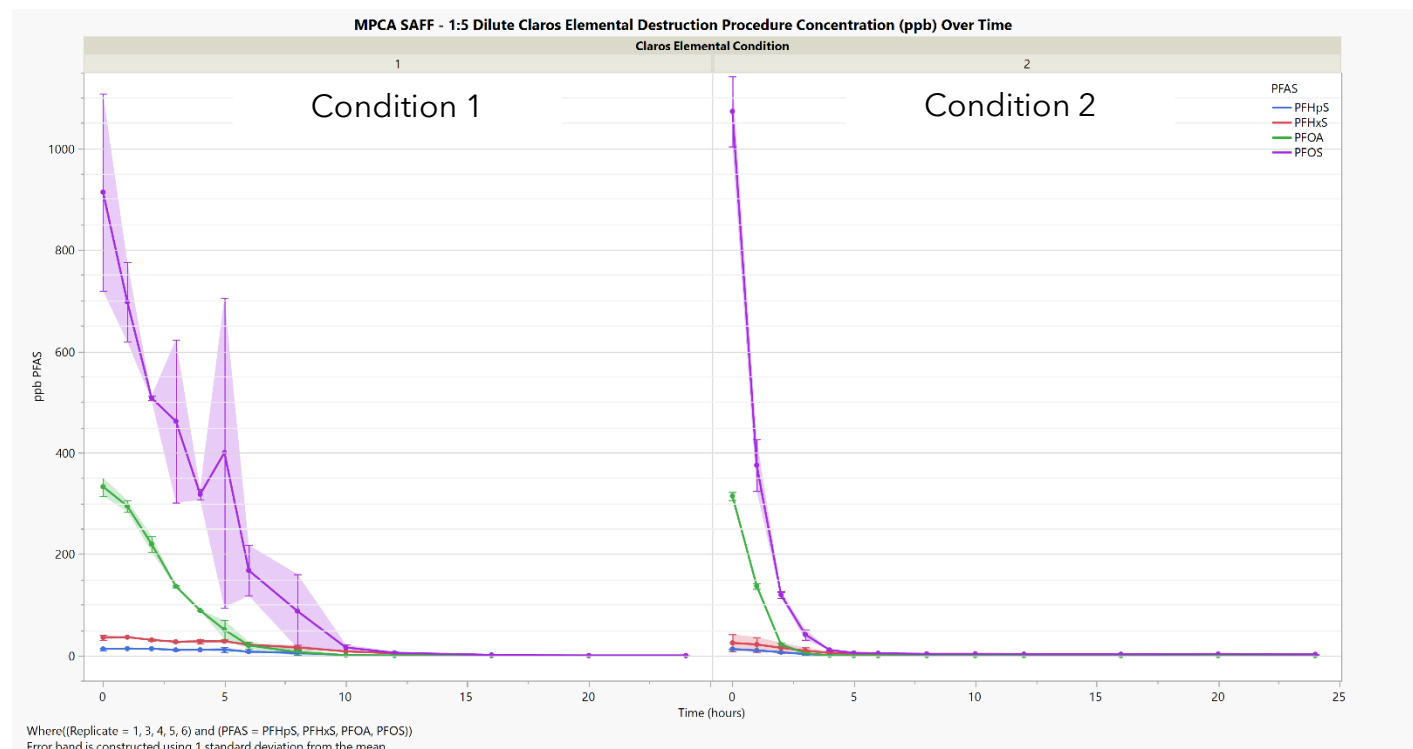
2	218.4 ± 9.14	31.2 ± 1.26	13.8 ± 0.53	504.5 ± 5.4
3	137.6 ± 1.81	27.7 ± 0.90	11.2 ± 0.86	434.1 ± 100.8
4	111.9 ± 32.41	28.8 ± 2.36	16.5 ± 7.4	598.5 ± 396.9
5	70.9 ± 30.25	29.5 ± 2.17	14.6 ± 4.85	645.6 ± 389.4
6	31.1 ± 16.14	22.9 ± 2.48	7.9 ± 0.45	196.1 ± 49.0
8	12.2 ± 8.66	18.1 ± 3.93	6.1 ± 2.74	103.2 ± 47.3
10	1.4 ± 0.90	9.4 ± 1.74	1.2 ± 0.48	20.7 ± 7.6
12	0.16 (LOQ)	4.7 ± 0.57	0.41 ± 0.06	5.75 ± 1.36
16	0.07 (LOQ)	0.71 ± 0.32	0.07 (LOQ)	1.17 ± 0.47
20	0.02 (LOQ)	0.15 (LOQ)	0.03 (LOQ)	0.25 ± 0.03
24	0.02 (LOQ)	0.07 (LOQ)	0.00 (LOQ)	0.23 ± 0.1

Table 4 - PFAS Concentration (ppb, µg/L) of MPCA SAFF sample during treatment under Condition 1 in Claros Technologies' Elemental PFAS Destruction procedure. Error is included as the standard deviation of each compound at respective timepoints produced through the triplicate run of the respective condition.

Time (hours)	Condition 2 PFOA (ppb)	Condition 2 PFHxS (ppb)	Condition 2 PFHpS (ppb)	Condition 2 PFOS (ppb)
0	314.6 ± 6.3	33.3 ± 1.2	12.8 ± 0.6	1,072.9 ± 56.4
1	137.2 ± 4.7	29.2 ± 1.3	10.1 ± 0.4	375.4 ± 41.8
2	22.0 ± 2.7	20.3 ± 1.1	6.6 (LOQ)	120.0 ± 5.0
3	4.6 ± 2.0	12.8 ± 1.7	2.7 (LOQ)	41.5 ± 8.3
4	0.44 (LOQ)	6.81 (LOQ)	0.79 (LOQ)	11.1 ± 0.4
5	0.10 (LOQ)	5.22 (LOQ)	0.42 (LOQ)	5.3 (LOQ)
6	0.08 (LOQ)	4.49 (LOQ)	0.31 (LOQ)	4.5 (LOQ)
8	0.07 (LOQ)	3.76 (LOQ)	0.25 (LOQ)	3.4 (LOQ)
10	0.07 (LOQ)	4.06 ± 0.9	0.23 ± 0.1	3.5 ± 0.8
12	0.07 (LOQ)	3.42 ± 0.3	0.18 (LOQ)	2.7 ± 0.3
16	0.07 (LOQ)	3.18 ± 0.5	0.16 (LOQ)	2.6 ± 0.3
20	0.07 (LOQ)	3.23 ± 0.7	0.17 (LOQ)	3.0 ± 0.4
24	0.07 (LOQ)	2.79 ± 0.5	0.16 (LOQ)	2.4 ± 0.5

Table 5 - PFAS Concentration (ppb, $\mu\text{g/L}$) of MPCA SAFF sample during treatment under Condition 2 in Claros Technologies' Elemental PFAS Destruction procedure. Error is included as the standard deviation of each compound at respective timepoints produced through the triplicate run of the respective condition.

This same concentration (ppb) over time throughout the Elemental PFAS Destruction procedure is represented in **Graph 1**.



Graph 1 - PFAS Concentration (ppb) over time in Condition 1 (left) and Condition 2 (right) throughout Claros Technologies' Elemental PFAS Destruction Procedure. Data is represented as a mean average of the triplicate data set produced for each condition. Error bars and bands represent the standard deviation of data points collected in the destruction trial ($n=3$).

Of note in the comparison between Condition 1 and Condition 2, is the much more rapid initial destruction of PFAS under Condition 2, and its significantly greater consistency between replicates. By 4 hours, this condition has achieved destruction of PFOA, PFHpS and PFHxS to below the Limit of Quantitation (roughly 10 ppb). The concentration of the primary constituent, PFOS, has been reduced by roughly 2 orders of magnitude; from about 1,050 ppb to 11 ppb.

Condition 1 meanwhile demonstrates a slower initial rate of PFAS destruction, and much greater variability in its initial treatment between replicates. However, despite this attenuated initial rate of destruction, Condition 1 does achieve a greater final extent of PFAS destruction, and greater consistency in endpoint destruction as compared to Condition 2. Save PFOS, Condition 1 achieved a final PFAS treatment below the LOQ for all compounds, and correspondingly the final concentration of PFAS in this treatment is no greater than 0.842 ppb, or 842 ppt (ng/L). In contrast, Condition 2 achieved a final extent of PFAS destruction below the LOQ for only PFOA and PFHpS, with a higher variability between replicates than observed in Condition 1 at the latter timepoints.

Samples treated under Condition 1 were also sent to a 3rd party laboratory, Pace Analytical, for analysis of PFAS concentration to supplement and verify the data collected internally by Claros Technologies. In the

case of the third-party samples, PFAS concentration data was collected only for the start (time 0), midpoint (6 hours), and endpoint (24 hours) of the destruction procedure. In contrast to Claros Technologies' analysis of PFAS concentration by direct-injection on the LC-MS using a modified EPA Draft Method 1633 protocol, Pace Analytical uses an unmodified EPA Draft Method 1633. This standard protocol entails the use of Solid Phase Extraction (SPE), a procedure wherein PFAS samples undergo a concentration step via absorption to, and subsequent solvent extraction from, a capture media prior to LC-MS analysis. This concentration of the samples before LC-MS analysis correspondingly allows for accurate quantification of PFAS at a significantly lower presence in the sample solution. An instrument with a Limit of Quantification of 100 ppt (ng/L) running a sample that has been concentrated 100x by SPE for instance, allows for accurate quantification of PFAS content as low as 1 ppt (ng/L) in the initial sample.

The 3rd party analytical data for Claros' destruction of the MPCA-SAFF leachate therefore provides enhanced resolution of the minute PFAS concentration remaining at the endpoint of the procedure, while also demonstrating the generation and subsequent destruction of shorter-chain destruction byproducts. The full report from Pace Analytical is included as a supplementary file to this report, though pertinent data has been copied as below in **Table 6** for comparison. 3rd party LC-MS data was reported to Claros Technologies in ppt (ng/L); for consistency in the comparison with Claros Technologies' internal data, this has been converted into ppb (µg/L).

PFAS Compound	Time 0	Time 6 Hour	Time 24 Hour
PFBA (ppb)	ND	4.32	0.0717
PFPeA (ppb)	ND	1.37	0.0143
PFHxA (ppb)	ND	1.37	ND
PFHpA (ppb)	ND	2.04	ND
PFOA (ppb)	382	34.8	0.0138
PFBS (ppb)	ND	ND	0.0185
PFPeS (ppb)	ND	1.29	0.0784
PFHxS (ppb)	36.9	16.6	0.0589
PFHpS (ppb)	ND	4.77	ND
PFOS (ppb)	1000	131	0.285

Table 6 - Concentration PFAS (ppb, ug/L) as provided to Claros Technologies by PACE Analytical. "ND" Indicates a non-detect value of the respective PFAS compounds in the LC-MS analysis.

The data furnished to Claros Technologies by Pace Analytical is in general agreement with our internal LC-MS analysis, with initial PFAS concentrations of roughly 1,000 ppb PFOs, 380 ppb PFOA, and 35 ppb PFHxS. Notably however, whereas Claros Technologies detected ~15 ppb of PFHpS in the initial MPCA-SAFF leachate, this does not appear in the Pace Analytical data. As previously mentioned, the Pace Analytical data also demonstrates intermediate generation and subsequent destruction of shorter-chain PFAS compounds during the destruction process. PFBA, PFPeA, PFHxA, PFHpA, PFPeS, and PFHpS are all observed at the 6 hour timepoint of the destruction procedure despite their absence in the initial MPCA-SAFF leachate. The generation of these compounds is minor across the board, with single-digit ppb presence at the midpoint of the procedure, and subsequent destruction of these intermediates resulting in

10s of parts per trillion (ppt, ng/L) present at the endpoint of the reaction. PFBS, notably, was observed only at the endpoint of the destruction procedure at a concentration of 18.5ppt (ng/L), indicating a minute generation of this compound as a byproduct. In addition to the enhanced clarity of the 3rd party data as concerns the generation of these byproducts and the PFAS concentrations at the endpoint of the reaction, the data is in good agreement with Claros Technologies' internal LC-MS. The concentration of PFOS, for instance, was measured at 230 ppt (ng/L) by Claros Technologies, and 285 ppt (ng/L) by Pace Analytical, which is in good agreement considering the different analytical methods and their respective error ($\pm 20\%$). All other PFAS compounds had presented below Claros Technologies' Limit of Quantitation at 24 hours, and thus we defer to the measurements provided to us by Pace Analytical.

Table 7 presents the total PFAS concentration (ppb, ug/L) from the sum of all present PFAS compounds as provided in the PACE Analytical data, alongside the calculated total destruction percentage at the midpoint (6 hours) and endpoint (24 hours) of Claros Technologies' Elemental Destruction procedure. In accordance with the PACE Analytical data, Claros' Elemental Destruction procedure achieved a cumulative 86% PFAS destruction at 6 hours, and 99.96% destruction of total PFAS at 24 hours.

Time (hours)	PFAS (ppb, Total)	PFAS Destruction (%)
0	1,418.9	N/A
6	197.56	86.07%
24	0.5406	99.96%

Table 7 - Concentration (ppb, total) of PFAS and resultant %Destruction at the midpoint (6 hours) and endpoint (24 hours) of Claros Technologies' Elemental destruction procedure, using data provided by PACE Analytical.

Claros used a third party lab, Eurofins Lancaster Laboratories, to test for Adsorbable Organofluorine (AOF) content. This analysis was performed on Condition 1 samples as well. AOF and its companion analysis Total Organofluorine (TOF) measure organofluorine - an organic compound that has a carbon fluorine bond, which includes non-target PFAS compounds - those for which the LC-MS analytical method does not have internal standards. Non-target methods like AOF are critical to determine the extent of defluorination - breaking the carbon fluorine bond - achieved by a destruction technique. **Table 8** reproduces the data provided to Claros Technologies by Eurofins for ease of evaluation alongside a calculation for the percentage of defluorination indicated by the change in AOF. The full report from Eurofins is available as supplementary document to this report. Through this 3rd party analysis, Claros Technologies demonstrates a significant extent of defluorination, at 85%.

Time (hours)	Adsorbable OrganoFluorine (ppb)	Defluorination (%)
0	1,200.00	N/A
6	440.00	63.33%
24	180.00	85.00%

Table 8 - Adsorbable OrganoFluorine (AOF) data in parts per billion (ppb) as provided to Claros Technologies by Eurofins Lancaster Laboratories. Defluorination (%) has been calculated by Claros Technologies in accordance with the concentrations provided by Eurofins' AOF analysis.

Conclusion

Claros Technologies has successfully and thoroughly treated the 1:5 diluted MPCA SAFF-leachate sample under two different conditions in its Elemental™ PFAS Destruction process. 3rd party analysis indicates a total PFAS Destruction percentage of 99.96% at the endpoint of Claros Technologies' Elemental™ Destruction (Condition 1) process, and a substantial defluorination of 85%. Through LCMS analysis, we have shown that the Claros Elemental™ PFAS destruction process does not generate short chain materials.

The MPCA project did not specify any specific goals or final effluent chemistry required for our evaluation. We have demonstrated that the Claros Elemental™ destruction process can achieve high destruction and defluorination levels. Each water source or waste stream will have different requirements for their final effluent goals. However, it is always the goal to meet all requirements in the most efficient and cost-effective way. By using the Claros Elemental™ process, we can optimize the destruction process to be compatible to any downstream process that may be used before final discharge. The Claros process can significantly reduce the concentration of fluorinated species in the water and minimize the size and maximize the lifetime/performance of all downstream processes. The Claros Elemental™ process allows optimization of the entire system which will produce the most cost effective, efficient system for any type of water source or waste stream processed.

Appendix

	LOQ	PFOA (ppb)	PFHXS (ppb)	PFHpS (ppb)	PFOS (ppb)
Timepoint	cal1	0.114	0.096	0.096	0.1
0	100	11.4	9.6	9.6	10
1	100	11.4	9.6	9.6	10
2	100	11.4	9.6	9.6	10
3	100	11.4	9.6	9.6	10
4	100	11.4	9.6	9.6	10
5	100	11.4	9.6	9.6	10
6	100	11.4	9.6	9.6	10
8	100	11.4	9.6	9.6	10
10	2	0.228	0.192	0.192	0.2
12	2	0.228	0.192	0.192	0.2
16	2	0.228	0.192	0.192	0.2
20	2	0.228	0.192	0.192	0.2
24	2	0.228	0.192	0.192	0.2

Table S1 - Limit of Quantitation (LOQ) in parts per billion (ppb, µg/L) for Claros Technologies' internal LC-MS analysis, accounting for dilution factor in sample preparation for respective PFAS compounds at various timepoints.

Attachment G5: Enspired Solutions Final Report



ENSPIRED
SOLUTIONS™

FINAL REPORT

SWIFT Contract number: 230420

Photoactivated Reductive Defluorination PFAS Destruction in
Groundwater Concentrate

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October 2023

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ACRONYMS

Acronym	Definition
4:2FTS	1H,1H, 2H, 2H-Perfluorohexane sulfonic acid
6:2FTS	1H,1H, 2H, 2H-Perfluorooctane sulfonic acid
8:2FTS	1H,1H, 2H, 2H-Perfluorodecane sulfonic acid
3:3FTCA	3-Perfluoropropyl propanoic acid
5:3FTCA	2H,2H,3H,3H-Perfluorooctanoic acid
7:3FTCA	3-Perfluoroheptyl propanoic acid
9Cl-PF3ONS	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid
11Cl-PF3OUdS	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
ADONA	4,8-Dioxa-3H-perfluorononanoic acid
AOF	Adsorbable organic fluorine
ASTM	American Society for Testing and Materials
CAPEX	Capital expenditure
CTA+	Positively charged cetyltrimethylammonium ion
CTAB	Cetyltrimethylammonium bromide
CIC	Combustion ion chromatography
eDonor	Electron donor
EEO	Electrical energy per order
EPA	U.S. Environmental Protection Agency
[F] _{max}	Maximum fluoride ion concentration that can be produced from complete defluorination
ft	feet
gal	gallons
GPD	Gallons per day
GPM	Gallons per minute
h	hour
HFPO-DA	Hexafluoropropylene oxide dimer acid
IC	Ion chromatography
IP	Intellectual property
ISE	Ion-selective electrode
<i>k</i>	PRD rate constant
kW	Kilowatt
kWh	kilowatt-hour
L	Liters
LC-MS/MS	Liquid chromatography with tandem mass spectrometry
LOD	Limit of detection
m ³	Cubic meters
MCL	Maximum contaminant limit
MDL	Method detection limit
MPCA	Minnesota Pollution Control Agency
mg/L	Milligrams per liter
mL	Milliliter
N/A	Not applicable

NEtFOSA	N-ethyl perfluorooctanesulfonamide
NEtFOSAA	N-ethyl perfluorooctanesulfonamidoacetic acid
NEtFOSE	N-ethyl perfluorooctanesulfonamidoethanol
NFDHA	Nonafluoro-3,6-dioxahexanoic acid
ng/L	Nanograms per liter
nm	Nanometers
NMeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid
NMeFOSA	N-methyl perfluorooctanesulfonamide
NMeFOSE	N-methyl perfluorooctanesulfonamidoethanol
OPEX	Operating expenditure
PFAS	Per and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutanesulfonic acid
PFCA	Perfluorocarboxylic acid
PFDA	Perfluorodecanoic acid
PFD _o A	Perfluorododecanoic acid
PFDS	Perfluorodecanesulfonic acid
PFD _o S	Perfluorododecanesulfonic acid
PFEESA	Perfluoro(2-ethoxyethane)sulfonic acid
PFHpA	Perfluoroheptanoic acid
PFHpS	Perfluoroheptanesulfonic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFMPA	Perfluoro-3-methoxypropanoic acid
PFMBA	Perfluoro-4-methoxybutanoic acid
PFNA	Perfluorononanoic acid
PFNS	Perfluorononanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PFOSA	Perfluorooctanesulfonamide
PFPeA	Perfluoropentanoic acid
PFPeS	Perfluoropentanesulfonic acid
PFSa	Perfluorosulfonic acid
PFTeDA	Perfluorotetradecanoic acid
PFT _r DA	Perfluorotridecanoic acid
PFUnA	Perfluoroundecanoic acid
ppb	parts-per-billion
ppm	parts-per-million
ppt	parts-per-trillion
PRD	Photoactivated reductive defluorination
SAFF	Surface active foam fractionation
TDS	Total dissolved solids
TF	Total fluorine
U	Non-detect
UV	Ultraviolet
µg/L	Micrograms per liter

$\mu\text{S}/\text{cm}$
V

Microsiemens per centimeter
Volume

FIGURES

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APPENDICES

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EXECUTIVE SUMMARY

Introduction and Objectives

Enspired Solutions™ has developed a per- and polyfluoroalkyl substances (PFAS) destruction technology, **photoactivated reductive defluorination (PRD)**, that efficiently destroys PFAS at atmospheric temperature and pressure, and without formation of undesirable byproducts. The objectives of this project were to demonstrate the efficacy and provide a cost projection for the destruction of PFAS with PRD in surface active foam fractionation (SAFF) concentrated groundwater from a State of Minnesota site. Bench-scale treatability testing was conducted on small sample aliquots of the SAFF concentrate. The data obtained from these tests were used to generate energy consumption and cost estimates for full-scale implementation of Enspired Solutions' commercial reactor, the PFASigator™. The combination of SAFF and PRD provides a complete solution from concentration to destruction, preventing PFAS reintroduction to the environment. The effort described herein determined the commercial feasibility of PRD to destruct concentrated PFAS in SAFF-treated groundwater.

Technology Description

The PRD process is based on a patented chemical reaction that breaks fluorine-carbon bonds and disassembles PFAS molecules in a linear fashion beginning with the hydrophilic functional groups and proceeds through shorter molecules to complete mineralization. The PRD reaction is facilitated by adding cetyl trimethylammonium bromide (CTAB) to form a surfactant micelle cage that traps PFAS. A non-toxic proprietary chemical is added to solution which associates with the micelle surface and produces hydrated electrons when stimulated with ultraviolet (UV) light. These highly-reactive hydrated electrons have the energy required to cleave fluorine-carbon resulting in the final products of fluoride, water, and simple carbon molecules (e.g., formic acid and acetic acid). The self-assembled micelle creates a confined space that plays a key role for the comparatively high PFAS destruction efficiency. The negatively charged electron donor associates with the positively charged cetyltrimethylammonium ion (CTA⁺) which form the surfactant micelle to trap molecules with similar structures, selectively mineralizing compounds with both hydrophobic and hydrophilic groups, such as PFAS.

Performance Assessment

Results are discussed in terms of applied UV dose, which is the UV lamp wattage applied for a **fixed time per unit volume (kWh/m³)**. This can be a more informative parameter to report than reaction time since the UV dose can be modified by employing a higher or lower wattage lamp, as is the case when transitioning from bench-scale to commercial-scale systems. Of the 40 PFAS compounds analyzed in treated and untreated samples of SAFF-concentrated groundwater, 16 compounds were detected in at least one sample. The major contributors to the total PFAS concentration were perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), which accounted for 95% of total PFAS. **Both PFOA and PFOS were degraded by over 99% within 800 kWh/m³ applied UV dose at the bench scale.** In addition, five other compounds, perfluorodecanoic acid (PFDA), perfluorononanoic acid (PFNA), perfluoroheptane sulfonic acid (PFHpS), perfluorohexane sulfonic acid (PFHxS), and perfluoropentane sulfonic acid (PFPeS), were degraded by at least 90% within 800 kWh/m³ of UV dose. **The reaction was allowed to continue for a total of 5,400 kWh/m³ cumulative UV dose to establish a UV dose beyond which the release of free fluoride ion was no longer detected.** By the end of the reaction, eight out of 16

detected compounds were degraded by over 99%, and one additional compound, perfluorohexanoic acid (PFHxA), was degraded by 98%.

Four compounds, perfluoroheptanoic acid (PFHpA), PFHxA, perfluoropentanoic acid (PFPeA), and perfluorobutanoic acid (PFBA), exhibited transient increases over the course of the reaction. This aligns with our understanding of the PRD mechanism, in that longer chain perfluorocarboxylic acids (PFCA) and perfluorosulfonic acids (PFSA) are first converted to shorter chain PFCA. These shorter chain intermediates are subsequently degraded, which agrees with the changes in their concentrations over the course of the experiment. At the time the reaction was stopped, PFPeA (five-carbon chain) and PFBA (four-carbon chain) remained as the major contributors to the total PFAS mass at concentrations of 1,500 ng/L and 12,000 ng/L, respectively.

Throughout the experiment, samples were also collected for measurement of fluoride ion concentration using an ion selective electrode (ISE). The release of fluoride ion in solution during the reaction is an indicator of PFAS defluorination/destruction. The amount of fluoride ion released in solution reached ~6,600 micrograms per liter ($\mu\text{g/L}$), which exceeded the calculated decrease in organic fluorine based on the measured PFAS compounds by ~53%. This may be due to the presence of unidentified PFAS or PFAS precursors present in the original sample.

Additionally, select samples were analyzed for total fluorine (TF) and adsorbable organic fluorine (AOF). Collectively, the TF and AOF values showed an increase in inorganic fluoride and a decrease in organic fluorine over the course of the reaction. This is in alignment with the change in organic fluorine as calculated from the individual PFAS concentrations from initial to final samples, as well as the inorganic fluoride concentrations measured during the reaction by ISE. Comparison of TF, AOF, and calculated organic fluorine in the untreated sample shows an additional ~1,000 $\mu\text{g/L}$ of organic fluorine that was not anticipated based on the reported PFAS concentrations in the initial sample, which provides a second line of evidence that undetected and unreported fluorinated compounds were present in the initial sample.

Overall, treatment by PRD reduced the total PFAS concentration from 4,100,000 ng/L to 15,000 ng/L, or by over 99%, within 5,400 kWh/m^3 cumulative UV dose. The sum of Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) list PFAS (PFNA, PFOA, PFOS, PFHxS, perfluorobutane sulfonic acid [PFBS], and hexafluoropropylene oxide dimer acid [HFPO-DA]) was reduced from 4,000,000 ng/L to 320 ng/L, or by over 99.99%, during treatment.

Cost Assessment

Developing cost estimates for PFAS treatment by PRD are highly dependent PFASigator influent flow rate, PFASigator influent PFAS concentration, and PFASigator effluent PFAS concentration (or order of magnitude destruction targets). For this project, we provide a range of site-specific cost estimate scenarios that illustrate the capability of PRD to destroy PFAS.

The cost estimate of field-scale application comprises the capital cost of constructing or deploying a field-ready PFAS destruction system, and the cost of daily operation. A reaction kinetics model for PFAS decrease and fluoride generation was developed and used to calculate the PRD energy efficiency for treating the SAFF-concentrated groundwater provided by the State of Minnesota. The data collected from the benchtop test were used to fit the models to calculate the electrical

energy per order of magnitude PFAS destruction (EEO), which was the key parameter to determine the treatment capacity demand and energy usage for destruction. The results, serving as a basis for the field-scale cost estimate, were used to estimate the energy usage demand, chemical reagents usage rate and treatment capacity demand for the PRD equipment. Note that the UV doses used in model fitting were direct electricity usages recorded from the lamp systems. Therefore, the EEOs calculated from the test data were direct indicators of the electrical demand.

For SAFF-concentrated groundwater and surface water, the PFAS destruction cost was estimated within a range of \$3.25/gal to \$16.26/gal, depending on the site-specific remediation objective. The remediation targets range from treating all EPA MCL PFAS (PFNA, PFOA, PFOS, PFHxS, PFBS, HFPO-DA; low-end cost), treating all 40 PFAS compounds analyzed in this study (mid-range cost), or treating all known and unknown PFAS compounds and precursors (high-end cost). For an assumed PFASigator influent flow rate of 50 gallons per day (GPD), the energy usage for PFAS destruction ranged from 156 kW/day to 780 kW/day, approximately \$30-\$148/day.

Using PRD technology to destroy two to three orders of magnitude (99 - 99.9%) of concentrated PFAS can be considered optimum conditions for high efficiency PFAS destruction. PRD efficiency is optimized when concentrations of PFAS in PFASigator influent are high and the ratio of PFAS mass destroyed per UV dose is high, and small amounts of PFAS are discharged back to the SAFF for re-concentration.

Commercial-scale Equipment Readiness

Enspired Solutions has designed and manufactured fully automatic commercial-scale equipment called the PFASigator™ to implement PRD PFAS destruction. The PFASigator has been tested on PRD efficiency, operational parameters, and key metrics were proven to be consistent with benchtop studies. PFASigator has multiple usage and design advantages, including:

- A small footprint with a modular design, which makes plugging into existing water treatment systems and scaleup easy.
- No special health and safety concerns given that it operates at atmospheric pressure and temperature.
- Minimum labor required given its fully automated design and safe operating environment. The equipment generates real-time fluoride data fed to a cloud-based web portal which enables remote monitoring and control.
- Tunable reaction by changing the reaction duration, therefore treatment processes can be adjusted with remediation target changes.
- Robust water treatment equipment with low long-term maintenance cost given no concerns on equipment corrosion during reaction and long usage history of UV equipment in the water industry.

A pilot study using PFASigator to treat foam-fractionate from PFAS-contaminated groundwater is scheduled to begin November 1, 2023 at a site near Grand Rapids, MI.

1 INTRODUCTION

1.1 BACKGROUND

Addressing and managing per- and polyfluoroalkyl substances (PFAS) in contaminated groundwater is a pressing issue facing the United States and entire world. Full destruction of PFAS molecules is a preferred solution over PFAS capture because it mitigates lingering risks to human health and the environment. Progress has been made and challenges remain for PFAS destruction technologies, such as high energy requirement and low treatment efficiencies for short-chain fluorinated compounds. Additional challenges include fabrication of novel equipment, safety of high temperature and high-pressure equipment, functionality limitations due to strict reaction conditions, and generation of undesirable byproducts such as perfluorinated carboxylic acids from oxidizable precursors, perchlorate, hydrofluoric acid, and hydrogen fluoride gas. Enspired Solutions™ has developed a PFAS destruction technology, photoactivated reductive defluorination (PRD), that surmounts these limitations.

The application potential of PFAS destruction technologies to treat highly concentrated PFAS waste, such as foamate resulting from foam fractionation, has been recognized. However, the commercial readiness and cost effectiveness of destruction technologies are still in question. The objectives of this project were to demonstrate the efficacy and provide a cost projection for the destruction of PFAS with PRD in surface active foam fractionation (SAFF) concentrated groundwater from a State of Minnesota site. The combination of SAFF and PRD provides a complete solution from concentration to destruction, preventing PFAS reintroduction to the environment. The effort described herein determined the commercial feasibility of PRD to destruct concentrated PFAS in SAFF-treated groundwater.

1.2 OBJECTIVES OF THE DEMONSTRATION

The objectives of this demonstration were to assess the feasibility for destroying PFAS in SAFF concentrated groundwater from the State of Minnesota using Enspired Solutions' PRD technology, and to develop a cost estimate for full scale technology implementation. Bench-scale treatability testing was conducted on small sample aliquots of the SAFF concentrate. The data obtained from these tests were used to generate energy consumption and cost estimates for full-scale implementation of PRD to treat PFAS in SAFF-concentrated groundwater represented by the sample.

2 TECHNOLOGY

The PRD process is based on a patented chemical reaction that breaks fluorine-carbon bonds and disassembles PFAS molecules in a linear fashion beginning with the hydrophilic functional groups and proceeds through shorter molecules to complete mineralization. **Figure 2-1** shows how PRD is facilitated by adding cetyl trimethylammonium bromide (CTAB) to form a surfactant micelle cage that traps PFAS. A non-toxic proprietary chemical (i.e. electron donor or eDonor) is added to solution which associates with the micelle surface and produces hydrated electrons when stimulated with UV light. These highly-reactive hydrated electrons have the energy required to cleave fluorine-carbon and other molecular bonds resulting in the final products of fluoride, water, and simple carbon molecules (e.g., formic acid and acetic acid). The chemical reaction does not require further validation. The methods, mechanisms, theory, and reactions described herein have been published.¹⁻³

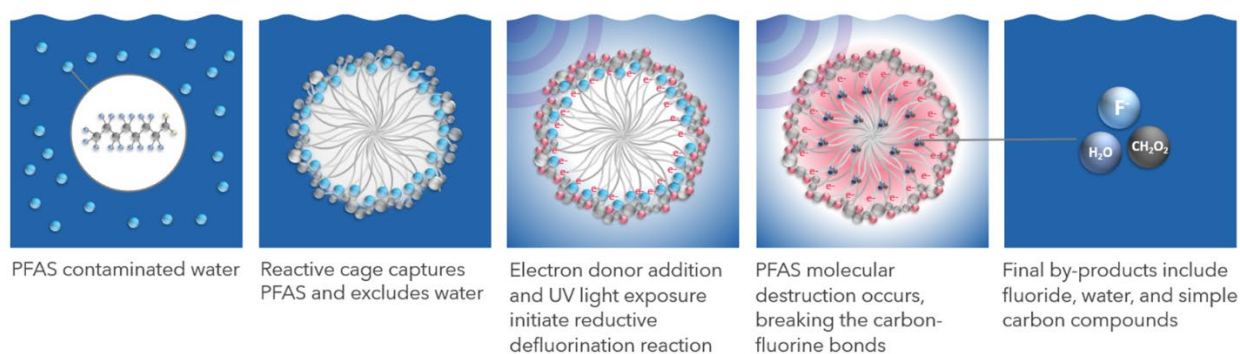


Figure 2-1. Mechanism schematic.

3 DESTRUCTIVE TEST PROCEDURE

3.1 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

All samples were treated at Enspired Solutions' laboratory in a laboratory-built benchtop reactor (**Figure 3-1**). The benchtop tests conducted in columns containing 300 mL of reaction mixture each. A 36 W low-pressure mercury lamp that produces monochromatic radiation at 254 nm wavelength is inserted at the center of the column to provide *in-situ* UV irradiation. The reaction temperature was controlled between 35 °C to 40 °C by an external, non-circulating water jacket surrounding the column.

The liquid reagents added to the reaction included hexadecyltrimethylammonium bromide (CTAB, 98% purity, purchased from Fisher Scientific [Hampton, NH]) and the environmentally benign electron donor (proprietary knowledge, purchased from Amazon [Seattle, WA]). Sodium hydroxide solution was used for pH adjustments. All chemicals were used without any further purification.



Figure 3-1. Benchtop test reactor set up for small scale treatability studies.

3.2 SAMPLING METHODS

The SAFF concentrated groundwater sample was shipped to Enspired Solutions in a plastic container and stored at 4 °C when not in use. Throughout the PRD reaction, the fluoride end-product concentration was measured in real-time in 2 mL sample aliquots using an ion selective electrode (ISE) according to EPA method 9214. The Thermo Scientific (Waltham, MA, USA) Orion 9609BNWP fluoride ISE was calibrated daily per the manufacturer's instructions. Meanwhile, samples were collected in polypropylene or high-density polyethylene containers at pre-determined UV doses during the reaction for third-party analysis of PFAS, total fluorine (TF) and adsorbable organic fluorine (AOF). Analysis of PFAS was conducted at Merit Laboratories in East Lansing, MI, and TF and AOF were analyzed at Eurofins Scientific in Sacramento, CA. Samples were kept on ice during transit to third-party laboratories. The list of analytes, analytical methods, and quality assurance (QA)/quality control (QC) procedures are provided in **Appendix A and B**. In brief, the analytical chemistry analysis included using ASTM Method D7979 - 19 Modified (Isotopic Dilution) to analyze the full suite of 40 PFAS compounds identified in EPA method 1633, and also combustion ion chromatography (CIC) to measure TF and AOF.

4 RESULTS

4.1 PFAS DESTRUCTION EFFICIENCIES

Results are discussed in terms of applied UV dose, which is the **UV lamp wattage applied for a fixed time per unit volume (kWh/m³)**. This can be a more informative parameter to report than reaction time since the UV dose may be modified by employing a higher or lower wattage lamp, as is the case when transitioning from bench-scale to commercial-scale systems. Samples were collected for PFAS analysis at UV dosages of 0 kWh/m³, 100 kWh/m³, 200 kWh/m³, 400 kWh/m³, 800 kWh/m³, 5,400 kWh/m³. Concentrations of PFAS compounds detected in at least one sample are shown at each UV dose in **Figure 4-1**. The concentrations are plotted on a logarithmic scale to improve data visibility over a wide range of PFAS concentrations. **Table 4-1** shows detections

and degradation percentages for only those PFAS detected in at least one sample. For a full list of PFAS analytical results, see **Appendix A**.

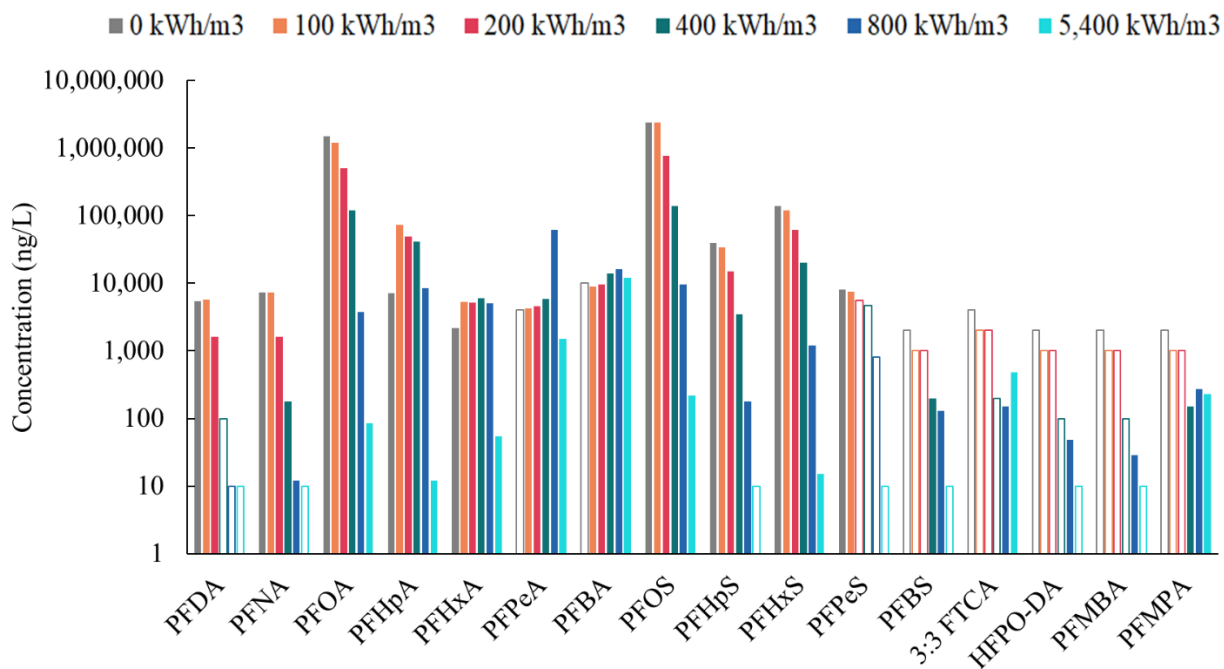


Figure 4-1. Concentrations of detected PFAS compounds at each UV dose plotted on a logarithmic (base 10) scale. Hollow bars represent non-detected values.

Table 4-1. Concentrations and degradation percentages of PFAS compounds detected in at least one sample.

PFAS	0 kWh/m ³ (untreated)		100 kWh/m ³		200 kWh/m ³		400 kWh/m ³		800 kWh/m ³		5,400 kWh/m ³	
	ng/L	ng/L	ng/L	% decrease from untreated	ng/L	% decrease from untreated	ng/L	% decrease from untreated	ng/L	% decrease from untreated	ng/L	% decrease from untreated
PFNA	7,300	7,300	1,600	N/A	180	98%	12	>99%	10 U	>99%		
PFOA	1,500,000	1,200,000	510,000	20%	120,000	92%	3,800	>99%	86	>99%		
PFOS	2,400,000	2,400,000	760,000	N/A	140,000	94%	9,700	>99%	220	>99%		
PFHxS	140,000	120,000	62,000	14%	20,000	86%	1,200	99%	15	>99%		
PFBS	2,000 U	1,000 U	1,000 U	N/A	200	N/A	130	N/A	10 U	N/A		
HFPO-DA	2,000 U	1,000 U	1,000 U	N/A	100 U	N/A	48	N/A	10 U	N/A		
Sum EPA MCL list PFAS	4,000,000	3,700,000	1,300,000	8%	280,000	93%	15,000	>99%	320	>99%		
PFDA	5,500	5,700	1,600	N/A	100 U	>99%	10 U	>99%	10 U	>99%		
PFHpA	7,200	74,000	49,000	N/A	41,000	N/A	8,600	N/A	12	>99%		
PFHxA	2,200	5,300	5,200	N/A	6,000	N/A	5,100	N/A	54	98%		
PFPeA	4,000 U	4,300	4,600	N/A	5,900	N/A	62,000	N/A	1,500	N/A		
PFBA	10,000 U	9,000	9,700	N/A	14,000	N/A	16,000	N/A	12,000	N/A		
PFHpS	39,000	34,000	15,000	13%	3,500	91%	180	>99%	10 U	>99%		
PFPeS	8,100	7,500	5,600	7%	4,700	42%	820	90%	10 U	>99%		
3:3 FTCA	4,000 U	2,000 U	2,000 U	N/A	200 U	N/A	150	N/A	480	N/A		
PFMBA	2,000 U	1,000 U	1,000 U	N/A	100 U	N/A	29	N/A	10 U	N/A		
PFMPA	2,000 U	1,000 U	1,000 U	N/A	150	N/A	270	N/A	230	N/A		
Total PFAS	4,100,000	3,900,000	1,400,000	5%	360,000	91%	110,000	97%	15,000	>99%		

U = non-detected

N/A = not applicable; analyte did not decrease in concentration

Total PFAS = sum of all analytes excluding non-detected

EPA MCL list PFAS = PFNA, PFOA, PFOS, PFHxS, PFBS, HFPO-DA; sum excludes non-detected analytes

Of the 40 PFAS compounds analyzed in treated and untreated samples of SAFF-concentrated groundwater, 16 compounds were detected in at least one sample. The major contributors to the total PFAS concentration were perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which were present at concentrations of 1,500,000 ng/L and 2,400,000 ng/L, respectively, and accounted for 95% of total PFAS. The results of cumulative PFAS degradation success at each sample point and applied UV dose are discussed below.

100 kWh/m³ Applied Dose – Up to 20% degradation was detected for four compounds, PFOA, perfluorohexane sulfonic acid (PFHxS), perfluoroheptane sulfonic acid (PFHpS), and perfluoropentane sulfonic acid (PFPeS) during this period. The sum of Environmental Protection Agency's (EPA's) Maximum Contaminant Level (MCL) list of six PFAS (perfluorononanoic acid [PFNA], PFOA, PFOS, PFHxS, perfluorobutane sulfonic acid [PFBS], and hexafluoropropylene oxide dimer acid [HFPO-DA]) was decreased by 8%, or from 4,000,000 ng/L to 3,700,000 ng/L. Total PFAS was decreased by 5%, or from 4,100,000 ng/L to 3,900,000 ng/L.

200 kWh/m³ Applied Dose – Over 50% degradation was detected for six compounds, PFNA, PFOA, PFOS, PFHxS, perfluorodecanoic acid (PFDA), and PFHpS for this period. The sum of EPA's MCL list of six PFAS was decreased by 68%, or from 4,000,000 ng/L to 1,300,000 ng/L. Total PFAS was decreased by 66%, or from 4,100,000 ng/L to 1,400,000 ng/L.

400 kWh/m³ Applied Dose - Over 90% degradation was detected for five compounds, PFNA, PFOA, PFOS, PFDA, and PFHpS for this period. The sum of EPA's MCL list of six PFAS was decreased by 93%, or from 4,000,000 ng/L to 280,000 ng/L. Total PFAS was decreased by 91%, or from 4,100,000 ng/L to 360,000 ng/L.

800 kWh/m³ Applied Dose – 99% or more degradation was detected for six compounds, PFNA, PFOA, PFOS, PFHxS, PFDA, and PFHpS for this period. Perfluoropentane sulfonic acid (PFPeS) also reached 90% degradation during this period. The sum of EPA's MCL list of six PFAS was decreased by over 99%, or from 4,000,000 ng/L to 15,000 ng/L. Total PFAS was decreased by 97%, or from 4,100,000 ng/L to 110,000 ng/L.

5,400 kWh/m³ Applied Dose - The reaction was allowed to continue to establish a maximum UV dose for the period during which the reaction yielded measurable increases in free fluoride ion concentration. At 5,400 kWh/m³ cumulative UV dose, the release of free fluoride ion was no longer detectable and the UV lamp was turned off and the reaction stopped. Eight (PFNA, PFOA, PFOS, PFHxS, PFDA, perfluoroheptanoic acid [PFHpA], PFHpS, and PFPeS) out of 16 detected compounds were degraded by over 99% during the full reaction period, and one additional compound, perfluorohexanoic acid (PFHxA), was degraded by 98%. The sum of EPA's MCL list of six PFAS was decreased by over 99.99%, or from 4,000,000 ng/L to 320 ng/L. Total PFAS was decreased by over 99%, or from 4,100,000 ng/L to 15,000 ng/L. It should be noted that between 800 kWh/m³ and 5,400 kWh/m³ UV dose, the amount of additional known PFAS destroyed was minimal. This indicates that the majority of known PFAS destruction occurred within a UV dose of ~800 kWh/m³, and additional dose beyond this point was used to destruct a very small amount of remaining PFAS concentration (< 3% of total known PFAS and < 1% of total EPA MCL PFAS).

Degradation percentages could not be determined for perfluoropentanoic acid (PFPeA), perfluorobutanoic acid (PFBA), perfluorobutane sulfonic acid (PFBS), 3-perfluoropropyl propanoic acid (3:3 FTCA), hexafluoropropylene oxide dimer acid (HFPO-DA), perfluoro-3-methoxybutanoic acid (PFMBA), or perfluoro-3-methoxypropanoic acid (PFMPA) because these compounds were not detected in the untreated (0 kWh/m³) sample. Due to the high concentrations of PFAS in the untreated sample, detection limits for individual compounds were high (thousands of ng/L). Over the course of the reaction, as the PFAS concentration decreased, detection limits also decreased, which allowed for the quantification of additional compounds. Therefore, changes in concentration of the PFAS listed above that were present at relatively low concentrations could not be determined.

Four compounds, PFHpA, PFHxA, PFPeA, and PFBA, exhibited transient increases over the course of the reaction (**Figure 4-1**). This aligns with our understanding of the PRD mechanism, in that longer chain perfluorocarboxylic acids (PFCA) and perfluorosulfonic acids (PFSA) are first converted to shorter chain PFCA. These shorter chain intermediates are subsequently degraded, which agrees with the changes in their concentrations over the course of the experiment.

4.2 OTHER SAMPLE ANALYSES

The initial sample was analyzed at Enspired Solutions for the following parameters summarized in **Table 4-2**: pH, fluoride ion concentration, total dissolved solids (TDS), and UV transmissivity. The reaction is conducted at pH 10 – 11, thus the initial sample pH is measured when performing the pH adjustment. Initial fluoride ion concentration is measured to determine the background fluoride level in the sample. The TDS and UV transmissivity were measured because these parameters have historically been strong indicators of PRD reaction success. High TDS (e.g. >10,000 milligrams per liter [mg/L]) samples can be problematic for the PRD reaction because excess salts in the solution inhibit the interaction between the eDonor and the micelle surface, decreasing the reaction rate. Low UV transmissivity (e.g. <10%) can also decrease the reaction rate by preventing sufficient transmission of UV light into the solution. The TDS and UV transmissivity values for the SAFF concentrated groundwater sample were well within these limits and were not of concern for the reaction performance.

Table 4-2. Physiochemical properties of SAFF concentrated groundwater.

Parameter	Unit	Value
pH	-	6
Fluoride	µg/L	120
Total dissolved solids (TDS)	mg/L	480
UV transmissivity	-	43%

A useful feature of the PRD technology is the ability to measure the increase in fluoride ion concentration in real time as PFAS destruction proceeds. During the PRD reaction, fluorine-carbon bonds of PFAS molecules are cleaved, therefore release of fluoride ion in solution during the reaction is an indicator of PFAS defluorination/destruction. To illustrate this feature, throughout the experiment, samples were collected for real-time measurement of fluoride ion concentration using an ISE. In **Figure 4-2**, the fluoride ion release curve (black line with dots) is plotted on top of the calculated organic fluorine contributions from individual PFAS classes (colored bars).

Empty bars represent the calculated decrease in organic fluorine as PFAS concentrations decreased during treatment. The amount of fluoride ion release to solution reached $\sim 6,600 \mu\text{g/L}$, which exceeded the calculated decrease in organic fluorine based on the measured PFAS compounds by $\sim 53\%$. This may be due to the presence of undetected and unreported fluorinated compounds (PFAS or PFAS precursors) in the original sample.

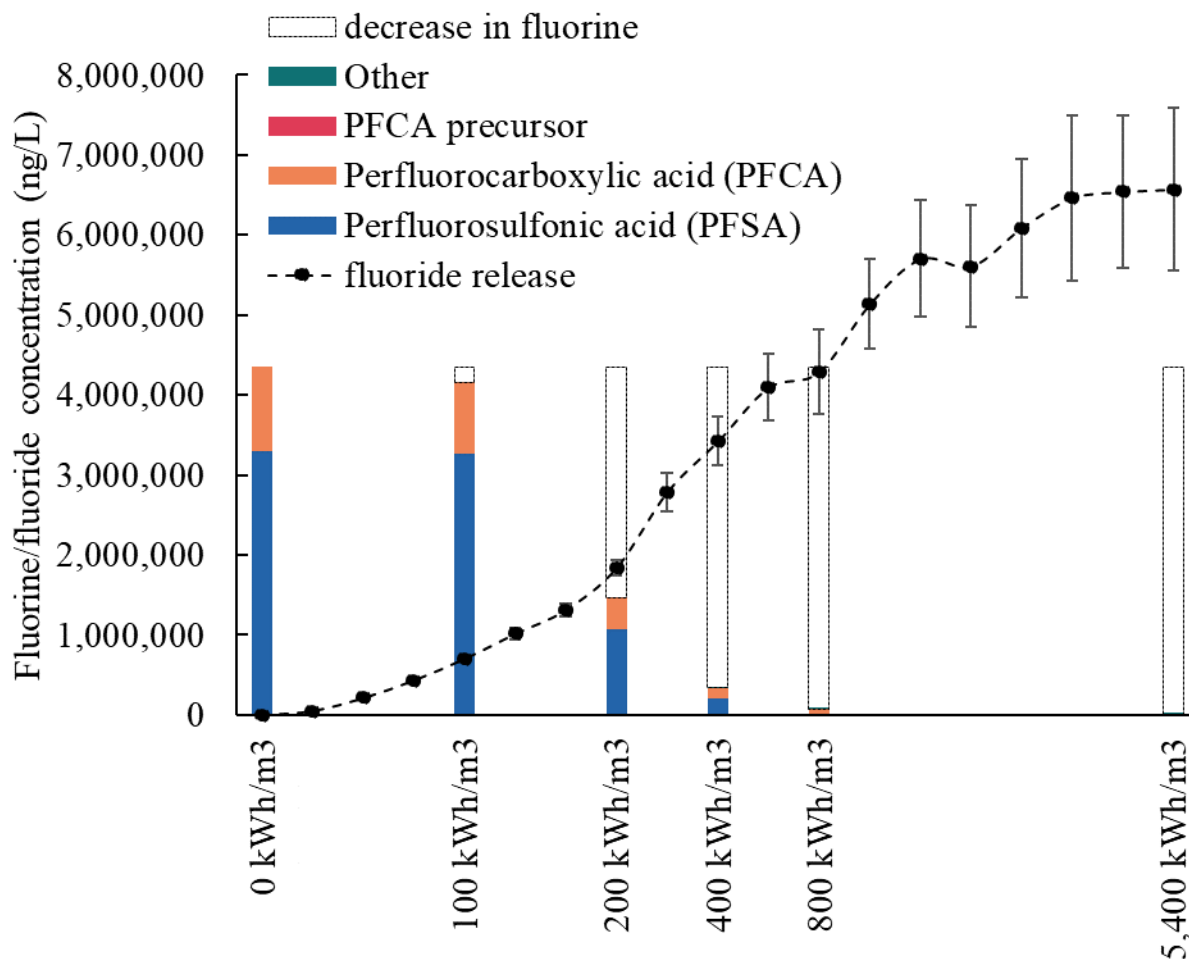


Figure 4-2. Fluoride ion release based on real-time ISE data (black line with dots) and calculated organic fluorine based on measured PFAS compounds (colored bars) as a function of PRD UV dose. Error bars on fluoride release plot represent standard deviation of triplicate experiments.

Additionally, the 0 kWh/m^3 , 200 kWh/m^3 , and $5,400 \text{ kWh/m}^3$ samples were analyzed for TF and AOF by a third-party commercial laboratory. The results are summarized in **Table 4-3** and full analytical reports can be found in **Appendix B**. The TF value represents the sum of organic fluorine and inorganic fluoride concentrations, while the AOF value represents only the organic fluorine concentration. Collectively, the TF and AOF values show an increase in inorganic fluoride and a decrease in organic fluorine over the course of the reaction. This is in alignment with the change in organic fluorine as calculated from the individual PFAS concentrations in these same samples, as well as the inorganic fluoride concentrations measured during the reaction by ISE.

Comparison of TF, AOF, and calculated organic fluorine in the 0 kWh/m³ sample shows an additional ~1,000 µg/L of organic fluorine that was not anticipated based on the reported PFAS concentrations in the initial sample. There are several reasons for the higher-than-expected inorganic fluoride present at the end of the reaction as measured by both TF analysis and ISE:

- The presence of unidentified PFAS and precursors in solution
- Variable precision when comparing data across analytical techniques
- Changing sample composition over time during treatment that can lead to lower detection limits and better data accuracy

The observed discrepancy highlights the need to understand these limitations when interpreting analytical data.

Table 4-3. Summary of organic fluorine and inorganic fluoride concentrations throughout the PRD reaction.

Analysis	Units	0 kWh/m ³	200 kWh/m ³	5,400 kWh/m ³
Total fluorine (TF)	µg/L	5,200	4,100	6,600
Adsorbable organic fluorine (AOF)	µg/L	5,400	1,600	450
Calculated organic fluorine ¹	µg/L	4,400	1,500	9
Fluoride by ISE	µg/L	120	2,000	6,700

¹Sum of fluorine masses from individual PFAS. Non-detected PFAS were excluded from calculation.

4.3 POTENTIAL BYPRODUCT FORMATION

PFCA compounds with seven and fewer carbon atoms exhibited transient concentration increases over the course of the reaction due to shortening of longer chain PFCA, PFSA, PFCA precursors, and other compounds. As individual fluorine-carbon bonds are broken by the PRD technology, PFAS molecules are disassembled in a linear fashion beginning with the hydrophilic functional groups and proceeding through shorter molecules to complete mineralization. Decreases in concentrations of these transient shorter chain PFCA were observed at longer reaction durations. By the time the reaction was stopped, PFPeA (five-carbon chain) and PFBA (four-carbon chain) remained as the major contributors to the total PFAS mass at concentrations of 1,500 ng/L and 12,000 ng/L, respectively. Any PFAS remaining at the time the reaction was stopped, including these short chain PFAS, could be further degraded by continuing the UV dose.

Another constituent remaining at the end of treatment is the added surfactant, CTAB, which has aquatic toxicity. If this is a discharge concern, CTAB can be broken down at the end of the reaction using a UV oxidation process prior to discharging the water from the reactor. The Enspired Solutions team is also currently exploring less toxic surfactant options to form the micelle necessary for optimum PRD reaction efficiency.

The eDonor used in the PRD reaction is proprietary, however it is a completely non-toxic chemical and does not form toxic byproducts during the reaction.

4.4 ENERGY CONSUMPTION AND TREATMENT COST PROJECTIONS

4.4.1 Energy Consumption

Figure 4-3 depicts a scaled-up process that is applicable for high flow rate groundwater and surface water streams such as those found at this State of Minnesota site and analogous to the bench-scale testing conducted within this project. In this scenario, the PFASigator is paired with the SAFF unit that brings lower-concentration, higher volume waters into concentrated PFAS wastes with a significantly reduced volume. The PFASigator then destroys the PFAS in the concentrate by two to three orders of magnitude. After PFAS is destroyed in the PFASigator, the PFASigator effluent is looped back to the SAFF unit to be re-concentrated along with additional system influent. Using this method, PFASigator energy efficiency can be optimized by destructing the majority of PFAS at high concentrations, where the ratio of PFAS mass destroyed per UV dose is high, and discharging small amounts of PFAS back to the SAFF for re-concentration. In this model, the SAFF unit is the compliance stage that controls final discharge of treated water from the combined treatment system.

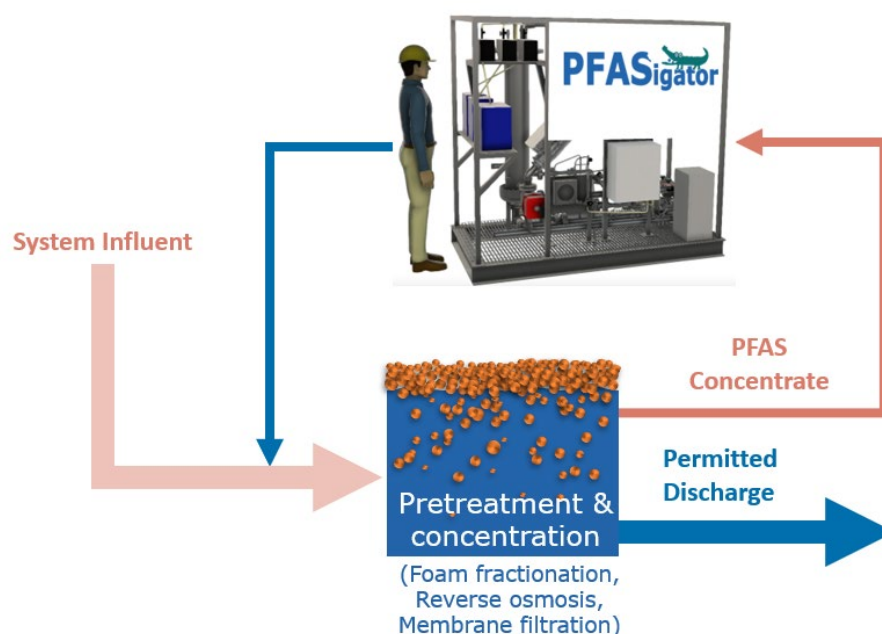


Figure 4-3. Process scenario for groundwater and surface water PFAS destruction

The energy costs associated with PFAS destruction in this scenario were determined first by plotting PFAS concentrations, as determined by LC-MS/MS analysis, as a function of UV dose to generate best-fit curves and then using those modeled curves to calculate the electrical energy per order of magnitude PFAS destruction (EEO) for different remediation targets. EEO values were calculated for individual and groups of PFAS compounds. An EEO value was also calculated using a modeled curve fit to the fluoride release data and represents energy usage for total PFAS destruction, including both known and unknown fluoroalkyl chemicals in the matrix. The inorganic fluoride ion measurement *via* ISE along the reaction is a much less expensive alternative than laboratory analysis of individual PFAS compounds and precursors. More data points can be collected in real-time for a quick assessment of energy demand needed for the PRD reaction.

Plots of PFAS concentrations as a function of UV dose and fluoride measurement data for the benchtop tests were fitted to models written in programming language R,⁴ and the results are shown in **Table 4-4**. Individual fitted curves are included in **Appendix C**. Please note that the UV doses used in model fitting were direct electricity usages recorded from the lamp systems. Therefore, the EEOs calculated from the test data were direct indicators of the electrical demand to destruct PFAS in SAFF-concentrated groundwater using a commercial UV system.

Table 4-4. Model fitting for benchtop test data

PFAS Degradation Model Fitting			
Analyte	k (m³/kWh)	p-value	EEO (kWh/m³-order)
PFNA	8.1E-03	9.0E-05 ****	280
PFOA	7.1E-03	5.9E-05 ****	320
PFOS	6.8E-03	6.6E-05 ****	340
PFHxS	5.6E-03	9.2E-05 ****	410
EPA MCL PFAS ^a	6.8E-03	4.8E-05 ****	340
Total PFAS ^b	4.8E-03	2.3E-04 *	480
Fluoride Production Model Fitting			
Analyte	[F⁻]_{max} (ppb)	p-value ([F⁻]_{max})	EEO (kWh/m³-order)
Fluoride Ion	6,060	3.0E-19 ****	1,300
	k (m³/kWh)	p-value (k)	
	1.7E-03	3.8E-11 ****	

* p-value ≤ 0.05

**** p-value ≤ 0.0001

^aEPA MCL PFAS = PFNA, PFOA, PFOS, PFHxS, PFBS, HFPO-DA

^bTotal PFAS = Sum of 40 measured compounds

[F⁻]_{max} = maximum fluoride ion concentration that can be produced from complete defluorination

k = rate constant

4.4.2 Treatment Cost Projections

Developing cost estimates for PFAS treatment by PRD are highly dependent on PFASigator influent flow rate, PFASigator influent PFAS concentration, and target PFASigator effluent PFAS concentration (or order of magnitude destruction targets). For this project, we made the following assumptions to provide a range of site-specific cost estimate scenarios that illustrate the capability of PRD to destroy PFAS:

- SAFF concentrate (i.e. PFASigator influent) flow rate is 50 gallons per day (GPD)
- SAFF concentrate (i.e. PFASigator influent) PFAS concentrations are those in the sample provided
- Post treatment (i.e. PFASigator effluent) concentration objective for multiple targets of individual PFAS and PFAS groups is two to three orders of magnitude (99-99.9%) lower than in the SAFF concentrate. This objective was selected as a conservative estimate to ensure that the energy used would destroy the majority of selected PFAS.

Note that all cost calculations presented are directly related to the treated volumes of SAFF-concentrate and not raw groundwater.

As shown in **Table 4-4**, the EEO value is heavily dependent on the analyte or group of analytes for which it was calculated. For example, the energy consumption for treating all PFAS (known and unknown, as determined by fluoride release measurements, 1,300 kWh/m³-order) is 2.7 to 4.6 times higher than treating specific, measured PFAS compounds or groups of compounds. With this in mind, cost projections were calculated for destruction of a variety of groups of target compounds (Targets 1, 2 and 3 in **Table 4-5**). The calculated EEOs were used to estimate the appropriate number of PFASigator systems and energy consumption required to achieve each target. Results are presented in **Table 4-5**.

The target scenarios presented in **Table 4-5** are listed with increasingly stringent requirements, from Target 1 to Target 3. The targets represent a variety of potential regulatory requirements and cleanup objectives as the PFASigator can be tuned to achieve the selected target:

Target 1: EPA MCL PFAS – This scenario provides a cost projection for destroying the sum of all six EPA MCL PFAS by 99.9%. The model suggests 1,020 kWh/m³ UV dose will achieve this objective.

Target 2: Total Known PFAS – This scenario provides a cost projection for destroying the sum of all 40 PFAS by 99%. This grouping includes more compounds and more short-chain compounds than Target 1. The model suggests 1,400 kWh/m³ UV dose will achieve this objective.

Target 3: Total Known PFAS + Unknown Precursors – This scenario provides a cost projection for destroying all 40 PFAS as in Target 2 plus the unknown precursors present in the original sample (as represented by the fluoride release, TF, and AOF data) by 99%. The model suggests 4,000 kWh/m³ UV dose will achieve this objective.

In addition, **Table 4-5** presents the capital cost of purchasing a field-ready PFAS destruction system, and the cost of daily operation for field-scale application:

- **Capital Expenditure (CAPEX):** Given that PFASigator is commercial-scale equipment designed and manufactured for field application, the bench-scale testing results are used to estimate the number of PFASigator needed and the associated capital cost of purchase and installation.
- **Operating Expenditure (OPEX):** The estimated operation cost includes itemized costs in energy, chemical reagents, analytical chemistry, safety protection, and labor. The energy, chemical reagents, and materials usage rates are estimated by the quantified reaction rates shown in the previous discussion.

A summary of cost drivers for full-scale implementation of the PFASigator is provided in **Appendix D**.

Table 4-5. Cost estimate for groundwater and surface water PFAS destruction scenario

		Target 1: EPA MCL PFAS	Target 2: Total known PFAS	Target 3 Total known PFAS + unknown precursors
Destruction Targets	Remediation Targets	PFNA, PFOA, PFOS, PFHxS, PFBS, HFPO-DA	All 40 PFAS analytical compounds	All 40 PFAS analytical compounds + unknown PFAS precursors/ compounds
	Destruction % Targets	99.9%	99%	99%
	EEO (kWh/m ³ -order) ⁽¹⁾	340	480	1,300
	Destruction Energy Usage (kWh/gal)	3.9	5.5	14.8
Example Scenarios	PFAS Concentrate Flow Rate	50 GPD		
	\$/gallon ⁽²⁾⁽³⁾⁽⁴⁾	\$3.25	\$6.50	\$16.26
	\$/gallon (CAPEX)	\$1.28	\$2.56	\$6.39
	\$/gallon (OPEX)	\$1.97	\$3.95	\$9.86
	# of PFASigators™ Needed	1	2	5
	24-hour Total Energy Use (Cost) ⁽⁵⁾	156 kW (\$30)	312 kW (\$59)	780 kW (\$148)

(1) EEO values are from Table 4-4.

(2) Cost includes both CAPEX and OPEX. PFASigator™ lifetime is assumed as 15 years as a robust water treatment equipment. Monthly PFASigator OPEX includes all reagents and delivery to site, and IP sublicense. Routine maintenance, discharge compliance sampling and analysis, and energy costs not included.

(3) Equipment price and monthly subscription price for applied PFASigator™ model are obtained from Enspired Solutions™.

(4) PFASigator™ is fully automated such that minimum labor is anticipated to operate it. Real-time end-product fluoride data can be accessed remotely via a web-based data portal.

(5) Based on 2023 residential electric supply rate for Michigan, \$0.19 per KW.

Under this process scenario for SAFF-concentrated groundwater and surface water, the PFAS destruction cost is within a range of \$3.25/gal to \$16.26/gal. Not surprisingly, with more stringent requirements (i.e. more target compounds as in Targets 2 and 3), the PFAS destruction cost increases. For a given SAFF concentrate flow rate of 50 GPD, the energy usage for PFAS destruction ranges from 156 kW/day to 780 kW/day or approximately \$30-\$148/day.

Using PRD technology to destroy two to three orders of magnitude (99 - 99.9%) of concentrated PFAS as in Targets 1 through 3 of **Table 4-5** can be considered optimum conditions for high efficiency PFAS destruction. PRD efficiency is optimized when concentrations of PFAS in PFASigator influent are high and the ratio of PFAS mass destroyed per UV dose is high, and small amounts of PFAS are discharged back to the SAFF for re-concentration.

To establish site-specific treatment costs for scenarios with PFAS treatment targets greater than two to three orders of magnitude reduction in PFAS, addition testing can be conducted to increase the UV dose beyond 5,400 kWh/m³, then fit a model curve to the new data set to predict energy use to achieve the new target.

5 COMMERCIAL READINESS OF PFASIGATOR



Figure 5-1. Commercial-scale PFASigator photo.

Note: The footprint of the equipment is 9' (Length) x 7' (Height) x 4' (Width). Co-founders of Enspired Solutions™, Dr. Meng Wang (left) and Dr. Denise Kay (right) stand in front of the equipment.

In late 2022, Enspired Solutions' commercial-scale PFAS treatment equipment was factory-commissioned (**Figure 5-1**). The fully automated equipment that executes our PRD chemistry is called the PFASigator. The PFASigator has been tested on operational parameters and PRD efficiency, and key metrics were proven to be consistent with benchtop studies. PFASigator has multiple usage and design advantages, including:

- A small footprint with a modular design, which makes it easy to plug into existing water treatment systems and scaleup.
- No special health and safety concerns given that it operates at atmospheric pressure and temperature and has multiple sensors for leakage, temperature, water levels et al.
- Minimum labor required given its fully automated design and safe operating environment. The equipment generates real-time fluoride data fed to a cloud-based web portal which enables remote monitoring and control.
- Tunable reaction by changing the reaction duration, therefore treatment processes can be adjusted with remediation target changes.

- Robust water treatment equipment with low long-term maintenance cost given that there are no concerns over equipment corrosion during the reaction and a long history of UV equipment usage in the water industry.

A pilot study using PFASigator to treat foam-fractionate from PFAS-contaminated groundwater is scheduled to begin November 1, 2023 at a site near Grand Rapids, MI.

6 REFERENCES

- (1) Tian, H.; Gao, J.; Li, H.; Boyd, S. A.; Gu, C. Complete Defluorination of Perfluorinated Compounds by Hydrated Electrons Generated from 3-Indole-Acetic-Acid in Organomodified Montmorillonite. *Sci Rep* **2016**, 6. <https://doi.org/10.1038/srep32949>.
- (2) Chen, Z.; Tian, H.; Li, H.; Li, J. S.; Hong, R.; Sheng, F.; Wang, C.; Gu, C. Application of Surfactant Modified Montmorillonite with Different Conformation for Photo-Treatment of Perfluorooctanoic Acid by Hydrated Electrons. *Chemosphere* **2019**, 235, 1180–1188. <https://doi.org/10.1016/j.chemosphere.2019.07.032>.
- (3) Chen, Z.; Li, C.; Gao, J.; Dong, H.; Chen, Y.; Wu, B.; Gu, C. Efficient Reductive Destruction of Perfluoroalkyl Substances under Self-Assembled Micelle Confinement. *Environ Sci Technol* **2020**, 54 (8), 5178–5185. <https://doi.org/10.1021/acs.est.9b06599>.
- (4) R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing: Vienna, Austria 2022. <https://www.R-project.org/> (accessed 2023-08-10).

APPENDIX A – PFAS ANALYTICAL PROCEDURES, RESULTS, AND QA/QC PROCEDURES



Analytical Laboratory Report

Report ID: S51877.01(01)
Generated on 09/07/2023

Report to
Attention: Suzanne Witt
Ensired Solutions
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East Lansing, MI 48823

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Report Summary
Lab Sample ID(s): S51877.01-S51877.03
Project: Monitoring
Collected Date(s): 08/01/2023 - 08/04/2023
Submitted Date/Time: 08/07/2023 11:50
Sampled by: Erin Hoffman
P.O. #:

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Maya Murshak
Technical Director



Analytical Laboratory Report

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.

Methods may be modified for improved performance.

Results reported on a dry weight basis where applicable.

'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).

When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.

40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.

QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.

Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.

Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.

Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.

Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)

PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."

Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.

Wisconsin PFAS analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched

Method Summary

Method	Version
ASTMD7979-19M	ASTM Method D7979 - 19 Modified (Isotopic Dilution)

Parameter Summary

Parameter	Synonym	Cas #
PFBA	Perfluorobutanoic Acid	375-22-4
PFPeA	Perfluoropentanoic Acid	2706-90-3
4:2 FTSA	4:2 Fluorotelomer Sulfonic Acid	757124-72-4
PFHxA	Perfluorohexanoic Acid	307-24-4
PFBS	Perfluorobutane sulfonic Acid	375-73-5
PFFHpA	Perfluoroheptanoic Acid	375-85-9
PFPeS	Perfluoropentane Sulfonic Acid	2706-91-4
6:2 FTSA	6:2 Fluorotelomer Sulfonic Acid	27619-97-2
PFOA	Perfluorooctanoic Acid	335-67-1
PFHxS	Perfluorohexane Sulfonic Acid	355-46-4
PFFHxS-LN	Perfluorohexane Sulfonic Acid - LN	355-46-4-LN
PFFHxS-BR	Perfluorohexane Sulfonic Acid - BR	355-46-4-BR
PFNA	Perfluorononanoic Acid	375-95-1
8:2 FTSA	8:2 Fluorotelomer Sulfonic Acid	39108-34-4
PFFHpS	Perfluoroheptane Sulfonic Acid	375-92-8
PFDA	Perfluorodecanoic Acid	335-76-2
N-MeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid	2355-31-9
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid	2991-50-6
PFOS	Perfluorooctane Sulfonic Acid	1763-23-1
PFOS-LN	Perfluorooctane Sulfonic Acid - LN	1763-23-1-LN
PFOS-BR	Perfluorooctane Sulfonic Acid - BR	1763-23-1-BR
PFUnDA	Perfluoroundecanoic Acid	2058-94-8
PFNS	Perfluorononane Sulfonic Acid	68259-12-1
PFDODA	Perfluorododecanoic Acid	307-55-1
PFDS	Perfluorodecane Sulfonic Acid	335-77-3
PFTTrDA	Perfluorotridecanoic Acid	72629-94-8
FOSA	Perfluorooctane Sulfonamide	754-91-6
PFTeDA	Perfluorotetradecanoic Acid	376-06-7
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone1-sulfonic acid	756426-58-1
ADONA	4,8-dioxa-3H-perfluorononanoic acid	919005-14-4
HFPO-DA	Hexafluoropropylene oxide dimer	13252-13-6
FHpPA (7:3 FTCA)	3-Perfluoroheptyl propanoic acid	812-70-4
FPePA (5:3 FTCA)	3-Perfluoropentyl propanoic acid	914637-49-3
FPrPA (3:3 FTCA)	3-Perfluoropropyl propanoic acid	356-02-5
NFDHA	Nonafluoro-3,6-dioxaheptanoic acid	151772-58-6
PFEESA	Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7
PFMBA	Perfluoro-4-methoxybutanoic acid	863090-89-5
PFMPA	Perfluoro-3-methoxypropanoic acid	377-73-1
NMeFOSAM	N-Methylperfluorooctanesulfonamide	31506-32-8
NMeFOSE	N-Methylperfluorooctanesulfonamidoethanol	24448-09-7
NEtFOSAM	N-Ethylperfluorooctanesulfonamide	4151-50-2
NEtFOSE	N-Ethylperfluorooctanesulfonamidoethanol	1691-99-2
PFDoS	Perfluorododecanesulfonic acid	79780-39-5



Analytical Laboratory Report

Sample Summary (3 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S51877.01	013A2023_t0	Wastewater	08/01/23 14:40
S51877.02	013A2023_t2h	Wastewater	08/01/23 16:40
S51877.03	013A2023_t54	Wastewater	08/04/23 17:30



Analytical Laboratory Report

Lab Sample ID: S51877.01

Sample Tag: 013A2023_t0

Collected Date/Time: 08/01/2023 14:40

Matrix: Wastewater

COC Reference: 164191

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep#)	7.050/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:40, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	Not detected	10,000		ng/L	2000	375-22-4	Y1
PFPeA*	Not detected	4,000		ng/L	2000	2706-90-3	Y1
4:2 FTSA*	Not detected	2,000		ng/L	2000	757124-72-4	Y1
PFHxA*	2,200	2,000		ng/L	2000	307-24-4	Y1
PFBS*	Not detected	2,000		ng/L	2000	375-73-5	Y1
PFHpA*	72,000	2,000		ng/L	2000	375-85-9	Y1
PFPeS*	8,100	2,000		ng/L	2000	2706-91-4	Y1
6:2 FTSA*	Not detected	2,000		ng/L	2000	27619-97-2	Y1
PFOA*	1,500,000	2,000		ng/L	2000	335-67-1	Y1
PFHxS*	140,000	2,000		ng/L	2000	355-46-4	Y1
PFHxS-LN*	120,000	2,000		ng/L	2000	355-46-4-LN	Y1
PFHxS-BR*	22,000	2,000		ng/L	2000	355-46-4-BR	Y1
PFNA*	7,300	2,000		ng/L	2000	375-95-1	Y1
8:2 FTSA*	Not detected	2,000		ng/L	2000	39108-34-4	Y1
PFHpS*	39,000	2,000		ng/L	2000	375-92-8	Y1
PFDA*	5,500	2,000		ng/L	2000	335-76-2	Y1
N-MeFOSAA*	Not detected	2,000		ng/L	2000	2355-31-9	Y1
EtFOSAA*	Not detected	4,000		ng/L	2000	2991-50-6	Y1
PFOS*	2,400,000	2,000		ng/L	2000	1763-23-1	Y1
PFOS-LN*	1,200,000	2,000		ng/L	2000	1763-23-1-LN	Y1
PFOS-BR*	1,200,000	2,000		ng/L	2000	1763-23-1-BR	Y1
PFUnDA*	Not detected	2,000		ng/L	2000	2058-94-8	Y1
PFNS*	Not detected	2,000		ng/L	2000	68259-12-1	Y1
PFDODA*	Not detected	2,000		ng/L	2000	307-55-1	Y1
PFDS*	Not detected	2,000		ng/L	2000	335-77-3	Y1
PFTTrDA*	Not detected	2,000		ng/L	2000	72629-94-8	Y1
FOSA*	Not detected	2,000		ng/L	2000	754-91-6	Y1
PFTeDA*	Not detected	4,000		ng/L	2000	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	2,000		ng/L	2000	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	2,000		ng/L	2000	756426-58-1	Y1
ADONA*	Not detected	2,000		ng/L	2000	919005-14-4	Y1
HFPO-DA*	Not detected	2,000		ng/L	2000	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	4,000		ng/L	2000	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	4,000		ng/L	2000	914637-49-3	Y1
FPrPA (3:3 FTCA)*	Not detected	4,000		ng/L	2000	356-02-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51877.01 (continued)
Sample Tag: 013A2023_t0

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:40, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
NFDHA*	Not detected	2,000		ng/L	2000	151772-58-6	Y1
PFEESA*	Not detected	2,000		ng/L	2000	113507-82-7	Y1
PFMBA*	Not detected	2,000		ng/L	2000	863090-89-5	Y1
PFMPA*	Not detected	2,000		ng/L	2000	377-73-1	Y1
NMeFOSAM*	Not detected	2,000		ng/L	2000	31506-32-8	Y1
NMeFOSE*	Not detected	4,000		ng/L	2000	24448-09-7	Y1
NEtFOSAM*	Not detected	2,000		ng/L	2000	4151-50-2	Y1
NEtFOSE*	Not detected	4,000		ng/L	2000	1691-99-2	Y1
PFDoS*	Not detected	6,000		ng/L	2000	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51877.02

Sample Tag: 013A2023_t2h

Collected Date/Time: 08/01/2023 16:40

Matrix: Wastewater

COC Reference: 164191

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep#)	7.050/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:59, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	9,700	5,000		ng/L	1000	375-22-4	Y1
PFPeA*	4,600	2,000		ng/L	1000	2706-90-3	Y1
4:2 FTSA*	Not detected	1,000		ng/L	1000	757124-72-4	Y1
PFHxA*	5,200	1,000		ng/L	1000	307-24-4	Y1
PFBS*	Not detected	1,000		ng/L	1000	375-73-5	Y1
PFHpA*	49,000	1,000		ng/L	1000	375-85-9	Y1
PFPeS*	5,600	1,000		ng/L	1000	2706-91-4	Y1
6:2 FTSA*	Not detected	1,000		ng/L	1000	27619-97-2	Y1
PFOA*	510,000	1,000		ng/L	1000	335-67-1	Y1
PFHxS*	62,000	1,000		ng/L	1000	355-46-4	Y1
PFHxS-LN*	57,000	1,000		ng/L	1000	355-46-4-LN	Y1
PFHxS-BR*	4,900	1,000		ng/L	1000	355-46-4-BR	Y1
PFNA*	1,600	1,000		ng/L	1000	375-95-1	Y1
8:2 FTSA*	Not detected	1,000		ng/L	1000	39108-34-4	Y1
PFHpS*	15,000	1,000		ng/L	1000	375-92-8	Y1
PFDA*	1,600	1,000		ng/L	1000	335-76-2	Y1
N-MeFOSAA*	Not detected	1,000		ng/L	1000	2355-31-9	Y1
EtFOSAA*	Not detected	2,000		ng/L	1000	2991-50-6	Y1
PFOS*	760,000	1,000		ng/L	1000	1763-23-1	Y1
PFOS-LN*	560,000	1,000		ng/L	1000	1763-23-1-LN	Y1
PFOS-BR*	190,000	1,000		ng/L	1000	1763-23-1-BR	Y1
PFUnDA*	Not detected	1,000		ng/L	1000	2058-94-8	Y1
PFNS*	Not detected	1,000		ng/L	1000	68259-12-1	Y1
PFDODA*	Not detected	1,000		ng/L	1000	307-55-1	Y1
PFDS*	Not detected	1,000		ng/L	1000	335-77-3	Y1
PFTTrDA*	Not detected	1,000		ng/L	1000	72629-94-8	Y1
FOSA*	Not detected	1,000		ng/L	1000	754-91-6	Y1
PFTeDA*	Not detected	2,000		ng/L	1000	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	1,000		ng/L	1000	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	1,000		ng/L	1000	756426-58-1	Y1
ADONA*	Not detected	1,000		ng/L	1000	919005-14-4	Y1
HFPO-DA*	Not detected	1,000		ng/L	1000	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	2,000		ng/L	1000	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	2,000		ng/L	1000	914637-49-3	Y1
FPrPA (3:3 FTCA)*	Not detected	2,000		ng/L	1000	356-02-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51877.02 (continued)
Sample Tag: 013A2023_t2h

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:59, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
NFDHA*	Not detected	1,000		ng/L	1000	151772-58-6	Y1
PFEESA*	Not detected	1,000		ng/L	1000	113507-82-7	Y1
PFMBA*	Not detected	1,000		ng/L	1000	863090-89-5	Y1
PFMPA*	Not detected	1,000		ng/L	1000	377-73-1	Y1
NMeFOSAM*	Not detected	1,000		ng/L	1000	31506-32-8	Y1
NMeFOSE*	Not detected	2,000		ng/L	1000	24448-09-7	Y1
NEtFOSAM*	Not detected	1,000		ng/L	1000	4151-50-2	Y1
NEtFOSE*	Not detected	2,000		ng/L	1000	1691-99-2	Y1
PFDoS*	Not detected	3,000		ng/L	1000	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51877.03

Sample Tag: 013A2023_t54

Collected Date/Time: 08/04/2023 17:30

Matrix: Wastewater

COC Reference: 164191

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep#)	7.000/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 01:19, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	12,000	50		ng/L	10	375-22-4	Y1
PFPeA*	1,500	20		ng/L	10	2706-90-3	Y1
4:2 FTSA*	Not detected	10		ng/L	10	757124-72-4	Y1
PFHxA*	54	10		ng/L	10	307-24-4	Y1
PFBS*	Not detected	10		ng/L	10	375-73-5	Y1
PFHpA*	12	10		ng/L	10	375-85-9	Y1
PFPeS*	Not detected	10		ng/L	10	2706-91-4	Y1
6:2 FTSA*	Not detected	10		ng/L	10	27619-97-2	Y1
PFOA*	86	10		ng/L	10	335-67-1	Y1
PFHxS*	15	10		ng/L	10	355-46-4	Y1
PFHxS-LN*	12	10		ng/L	10	355-46-4-LN	Y1
PFHxS-BR*	Not detected	10		ng/L	10	355-46-4-BR	Y1
PFNA*	Not detected	10		ng/L	10	375-95-1	Y1
8:2 FTSA*	Not detected	10		ng/L	10	39108-34-4	Y1
PFHpS*	Not detected	10		ng/L	10	375-92-8	Y1
PFDA*	Not detected	10		ng/L	10	335-76-2	Y1
N-MeFOSAA*	Not detected	10		ng/L	10	2355-31-9	Y1
EtFOSAA*	Not detected	20		ng/L	10	2991-50-6	Y1
PFOS*	220	10		ng/L	10	1763-23-1	Y1
PFOS-LN*	150	10		ng/L	10	1763-23-1-LN	Y1
PFOS-BR*	66	10		ng/L	10	1763-23-1-BR	Y1
PFUnDA*	Not detected	10		ng/L	10	2058-94-8	Y1
PFNS*	Not detected	10		ng/L	10	68259-12-1	Y1
PFDoDA*	Not detected	10		ng/L	10	307-55-1	Y1
PFDS*	Not detected	10		ng/L	10	335-77-3	Y1
PFTTrDA*	Not detected	10		ng/L	10	72629-94-8	Y1
FOSA*	Not detected	10		ng/L	10	754-91-6	Y1
PFTeDA*	Not detected	20		ng/L	10	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	10		ng/L	10	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	10		ng/L	10	756426-58-1	Y1
ADONA*	Not detected	10		ng/L	10	919005-14-4	Y1
HFPO-DA*	Not detected	10		ng/L	10	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	20		ng/L	10	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	20		ng/L	10	914637-49-3	Y1
FPrPA (3:3 FTCA)*	480	20		ng/L	10	356-02-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51877.03 (continued)

Sample Tag: 013A2023_t54

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 01:19, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
NFDHA*	Not detected	10		ng/L	10	151772-58-6	Y1
PFEESA*	Not detected	10		ng/L	10	113507-82-7	Y1
PFMBA*	Not detected	10		ng/L	10	863090-89-5	Y1
PFMPA*	230	10		ng/L	10	377-73-1	Y1
NMeFOSAM*	Not detected	10		ng/L	10	31506-32-8	Y1
NMeFOSE*	Not detected	20		ng/L	10	24448-09-7	Y1
NEtFOSAM*	Not detected	10		ng/L	10	4151-50-2	Y1
NEtFOSE*	Not detected	20		ng/L	10	1691-99-2	Y1
PFDoS*	Not detected	30		ng/L	10	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis

Merit Laboratories Login Checklist

Lab Set ID:S51877

Client:ENSPIRED (Enspired Solutions)

Project: Monitoring

Submitted:08/07/2023 11:50 Login User: BJB

Attention: Suzanne Witt

Address: Enspired Solutions
4942 Dawn Avenue, Suite 104
East Lansing, MI 48823

Phone: 937-470-9461

FAX:

Email: suzanne.witt@enspiredsolutions.com

Selection	Description	Note
Sample Receiving		
01.	☐ Yes ☒ No ☐ N/A	Samples are received at 4C +/- 2C Thermometer # IR 8.4
02.	☒ Yes ☐ No ☐ N/A	Received on ice/ cooling process begun
03.	☐ Yes ☒ No ☐ N/A	Samples shipped
04.	☐ Yes ☒ No ☐ N/A	Samples left in 24 hr. drop box
05.	☐ Yes ☐ No ☒ N/A	Are there custody seals/tape or is the drop box locked
Chain of Custody		
06.	☒ Yes ☐ No ☐ N/A	COC adequately filled out
07.	☒ Yes ☐ No ☐ N/A	COC signed and relinquished to the lab
08.	☒ Yes ☐ No ☐ N/A	Sample tag on bottles match COC
09.	☐ Yes ☒ No ☐ N/A	Subcontracting needed? Subcontacted to:
Preservation		
10.	☒ Yes ☐ No ☐ N/A	Do sample have correct chemical preservation
11.	☐ Yes ☐ No ☒ N/A	Completed pH checks on preserved samples? (no VOAs)
12.	☐ Yes ☒ No ☐ N/A	Did any samples need to be preserved in the lab?
Bottle Conditions		
13.	☒ Yes ☐ No ☐ N/A	All bottles intact
14.	☒ Yes ☐ No ☐ N/A	Appropriate analytical bottles are used
15.	☒ Yes ☐ No ☐ N/A	Merit bottles used
16.	☒ Yes ☐ No ☐ N/A	Sufficient sample volume received
17.	☐ Yes ☒ No ☐ N/A	Samples require laboratory filtration
18.	☒ Yes ☐ No ☐ N/A	Samples submitted within holding time
19.	☐ Yes ☐ No ☒ N/A	Do water VOC or TOX bottles contain headspace

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

REPORT TO

CONTACT NAME Suzanne Witt			
COMPANY Enspired Solutions			
ADDRESS 3610 Forest Road, Suite 136			
CITY Lansing		STATE MI	ZIP CODE 48910
PHONE NO. 937-470-9461		CELL NO.	P.O. NO.
E-MAIL ADDRESS Suzanne.witt@enspiredsolutions.com		QUOTE NO.	

CHAIN OF CUSTODY RECORD

CONTACT NAME		Meng Wang		☐ SAME	
COMPANY					
Enspired Solutions					
ADDRESS					
9047 W Scenic Lake Drive					
CITY				STATE	ZIP CODE
Laingsburg				MI	48848
PHONE NO.			E-MAIL ADDRESS		
434-825-8361			meng.wang@enspiredsolutions.com		

INVOICE TO

PROJECT NO./NAME	SAMPLER(S) - RELEASE PRINT/IGN NAME Erin Hoffman
TURNAROUND TIME REQUIRED ☐ 1 DAY ☐ 2 DAYS ☐ 3 DAYS ☒ STANDARD ☐ OTHER _____	
DELIVERABLES REQUIRED ☐ STD ☒ LEVEL II ☐ LEVEL III ☐ LEVEL IV ☐ EDD ☐ OTHER _____	

MATRIX CODE:	W=WATER	GW=GROUNDWATER	WW=WASTEWATER	S=SOIL	L=LIQUID	SD=SOLID
	SL=SLUDGE	DW=DRINKING WATER	O=OIL	WP=WIPE	A=AIR	WS=WASTE

Containers & Preservatives

Certifications

☐ OHIO VAP ☐ Drinking Water
☐ DoD ☐ NPDES

Project Locations

☐ Detroit ☐ New York☐ Other _____

Special Instructions

[illegible]

RELINQUISHED BY:	Erin Hoffman	X Sampler	DATE	TIME
SIGNATURE/ORGANIZATION			8/7/23	11:50
RECEIVED BY:	Johna Munn		DATE	TIME
SIGNATURE/ORGANIZATION			8/7/23	11:50
RELINQUISHED BY:			DATE	TIME
SIGNATURE/ORGANIZATION				
RECEIVED BY:			DATE	TIME
SIGNATURE/ORGANIZATION				

RELINQUISHED BY:			DATE	TIME
SIGNATURE/ORGANIZATION				
RECEIVED BY:			DATE	TIME
SIGNATURE/ORGANIZATION				
SEAL NO.	SEAL INTACT YES ☐ NO ☐	INITIALS	NOTES: TEMP. ON ARRIVAL _____ 8.4	
SEAL NO.	SEAL INTACT YES ☐ NO ☐	INITIALS		



Analytical Laboratory Report

Report ID: S51876.01(01)
Generated on 09/07/2023

Report to
Attention: Suzanne Witt
Ensired Solutions
4942 Dawn Avenue, Suite 104
East Lansing, MI 48823

Phone: 937-470-9461 FAX:
Email: suzanne.witt@ensiredsolutions.com

Report produced by
Merit Laboratories, Inc.
2680 East Lansing Drive
East Lansing, MI 48823

Phone: (517) 332-0167 FAX: (517) 332-6333

Contacts for report questions:
John Lavery (johnlavery@meritlabs.com)
Barbara Ball (bball@meritlabs.com)

Report Summary
Lab Sample ID(s): S51876.01-S51876.03
Project: Monitoring
Collected Date(s): 08/01/2023 - 08/04/2023
Submitted Date/Time: 08/07/2023 11:50
Sampled by: Erin Hoffman
P.O. #:

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- Sample Summary (Page 5)


Maya Murshak
Technical Director



Analytical Laboratory Report

General Report Notes

Analytical results relate only to the samples tested, in the condition received by the laboratory.

Methods may be modified for improved performance.

Results reported on a dry weight basis where applicable.

'Not detected' indicates that parameter was not found at a level equal to or greater than the reporting limit (RL).

When MDL results are provided, then 'Not detected' indicates that parameter was not found at a level equal to or greater than the MDL.

40 CFR Part 136 Table II Required Containers, Preservation Techniques and Holding Times for the Clean Water Act specify that samples for acrolein and acrylonitrile, and 2-chloroethylvinyl ether need to be preserved at a pH in the range of 4 to 5 or if not preserved, analyzed within 3 days of sampling.

QA/QC corresponding to this analytical report is a separate document with the same Merit ID reference and is available upon request.

Full accreditation certificates are available upon request. Starred (*) analytes are not NELAP accredited.

Samples are held by the lab for 30 days from the final report date unless a written request to hold longer is provided by the client.

Report shall not be reproduced except in full, without the written approval of Merit Laboratories, Inc.

Limits for drinking water samples, are listed as the MCL Limits (Maximum Contaminant Level Concentrations)

PFAS requirement: Section 9.3.8 of U.S. EPA Method 537.1 states "If the method analyte(s) found in the Field Sample is present in the

FRB at a concentration greater than 1/3 the MRL, then all samples collected with that FRB are invalid and must be recollected and reanalyzed."

Samples submitted without an accompanying FRB may not be acceptable for compliance purposes.

Wisconsin PFAS analysis: MDL = LOD; RL = LOQ. LOD and LOQ are adjusted for dilution.

Report Narrative

There is no additional narrative for this analytical report

Laboratory Certifications

Authority	Certification ID
Michigan DEQ	#9956
DOD ELAP & ISO/IEC 17025:2017	#69699
WBENC	#2005110032
Ohio VAP	#CL0002
Indiana DOH	#C-MI-07
New York NELAC	#11814
North Carolina DENR	#680
North Carolina DOH	#26702
Pennsylvania DEP	#68-05884
Wisconsin DNR	FID# 399147320

Qualifier Descriptions

Qualifier	Description
!	Result is outside of stated limit criteria
B	Compound also found in associated method blank
E	Concentration exceeds calibration range
F	Analysis run outside of holding time
G	Estimated result due to extraction run outside of holding time
H	Sample submitted and run outside of holding time
I	Matrix interference with internal standard
J	Estimated value less than reporting limit, but greater than MDL
L	Elevated reporting limit due to low sample amount
M	Result reported to MDL not RDL
O	Analysis performed by outside laboratory. See attached report.
R	Preliminary result
S	Surrogate recovery outside of control limits
T	No correction for total solids
X	Elevated reporting limit due to matrix interference
Y	Elevated reporting limit due to high target concentration
b	Value detected less than reporting limit, but greater than MDL
e	Reported value estimated due to interference
j	Analyte also found in associated method blank
p	Benzo(b)Fluoranthene and Benzo(k)Fluoranthene integrated as one peak.
x	Preserved from bulk sample

Glossary of Abbreviations

Abbreviation	Description
RL/RDL	Reporting Limit
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SW	EPA SW 846 (Soil and Wastewater) Methods
E	EPA Methods
SM	Standard Methods
LN	Linear
BR	Branched



Analytical Laboratory Report

Method Summary

Method	Version
ASTMD7979-19M	ASTM Method D7979 - 19 Modified (Isotopic Dilution)

Parameter Summary

Parameter	Synonym	Cas #
PFBA	Perfluorobutanoic Acid	375-22-4
PFPeA	Perfluoropentanoic Acid	2706-90-3
4:2 FTSA	4:2 Fluorotelomer Sulfonic Acid	757124-72-4
PFHxA	Perfluorohexanoic Acid	307-24-4
PFBS	Perfluorobutane sulfonic Acid	375-73-5
PFHpA	Perfluoroheptanoic Acid	375-85-9
PFPeS	Perfluoropentane Sulfonic Acid	2706-91-4
6:2 FTSA	6:2 Fluorotelomer Sulfonic Acid	27619-97-2
PFOA	Perfluorooctanoic Acid	335-67-1
PFHxS	Perfluorohexane Sulfonic Acid	355-46-4
PFHxS-LN	Perfluorohexane Sulfonic Acid - LN	355-46-4-LN
PFHxS-BR	Perfluorohexane Sulfonic Acid - BR	355-46-4-BR
PFNA	Perfluorononanoic Acid	375-95-1
8:2 FTSA	8:2 Fluorotelomer Sulfonic Acid	39108-34-4
PFHpS	Perfluoroheptane Sulfonic Acid	375-92-8
PFDA	Perfluorodecanoic Acid	335-76-2
N-MeFOSAA	N-methyl perfluorooctanesulfonamidoacetic acid	2355-31-9
EtFOSAA	N-Ethyl Perfluorooctane Sulfonamidoacetic Acid	2991-50-6
PFOS	Perfluorooctane Sulfonic Acid	1763-23-1
PFOS-LN	Perfluorooctane Sulfonic Acid - LN	1763-23-1-LN
PFOS-BR	Perfluorooctane Sulfonic Acid - BR	1763-23-1-BR
PFUnDA	Perfluoroundecanoic Acid	2058-94-8
PFNS	Perfluorononane Sulfonic Acid	68259-12-1
PFDODA	Perfluorododecanoic Acid	307-55-1
PFDS	Perfluorodecane Sulfonic Acid	335-77-3
PFTTrDA	Perfluorotridecanoic Acid	72629-94-8
FOSA	Perfluorooctane Sulfonamide	754-91-6
PFTeDA	Perfluorotetradecanoic Acid	376-06-7
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanone1-sulfonic acid	756426-58-1
ADONA	4,8-dioxa-3H-perfluorononanoic acid	919005-14-4
HFPO-DA	Hexafluoropropylene oxide dimer	13252-13-6
FHpPA (7:3 FTCA)	3-Perfluoroheptyl propanoic acid	812-70-4
FPePA (5:3 FTCA)	3-Perfluoropentyl propanoic acid	914637-49-3
FPrPA (3:3 FTCA)	3-Perfluoropropyl propanoic acid	356-02-5
NFDHA	Nonafluoro-3,6-dioxaheptanoic acid	151772-58-6
PFEESA	Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7
PFMBA	Perfluoro-4-methoxybutanoic acid	863090-89-5
PFMPA	Perfluoro-3-methoxypropanoic acid	377-73-1
NMeFOSAM	N-Methylperfluorooctanesulfonamide	31506-32-8
NMeFOSE	N-Methylperfluorooctanesulfonamidoethanol	24448-09-7
NEtFOSAM	N-Ethylperfluorooctanesulfonamide	4151-50-2
NEtFOSE	N-Ethylperfluorooctanesulfonamidoethanol	1691-99-2
PFDoS	Perfluorododecanesulfonic acid	79780-39-5



Analytical Laboratory Report

Sample Summary (3 samples)

Sample ID	Sample Tag	Matrix	Collected Date/Time
S51876.01	013A2023_t1h	Wastewater	08/01/23 15:40
S51876.02	013A2023_t4h	Wastewater	08/02/23 14:44
S51876.03	013A2023_t8h	Wastewater	08/04/23 16:44



Analytical Laboratory Report

Lab Sample ID: S51876.01

Sample Tag: 013A2023_t1h

Collected Date/Time: 08/01/2023 15:40

Matrix: Wastewater

COC Reference: 164240

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep#)	7.050/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/24/23 23:41, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	9,000	5,000		ng/L	1000	375-22-4	Y1
PFPeA*	4,300	2,000		ng/L	1000	2706-90-3	Y1
4:2 FTSA*	Not detected	1,000		ng/L	1000	757124-72-4	Y1
PFHxA*	5,300	1,000		ng/L	1000	307-24-4	Y1
PFBS*	Not detected	1,000		ng/L	1000	375-73-5	Y1
PFHpA*	74,000	1,000		ng/L	1000	375-85-9	Y1
PFPeS*	7,500	1,000		ng/L	1000	2706-91-4	Y1
6:2 FTSA*	Not detected	1,000		ng/L	1000	27619-97-2	Y1
PFOA*	1,200,000	1,000		ng/L	1000	335-67-1	Y1
PFHxS*	120,000	1,000		ng/L	1000	355-46-4	Y1
PFHxS-LN*	100,000	1,000		ng/L	1000	355-46-4-LN	Y1
PFHxS-BR*	14,000	1,000		ng/L	1000	355-46-4-BR	Y1
PFNA*	7,300	1,000		ng/L	1000	375-95-1	Y1
8:2 FTSA*	Not detected	1,000		ng/L	1000	39108-34-4	Y1
PFHpS*	34,000	1,000		ng/L	1000	375-92-8	Y1
PFDA*	5,700	1,000		ng/L	1000	335-76-2	Y1
N-MeFOSAA*	Not detected	1,000		ng/L	1000	2355-31-9	Y1
EtFOSAA*	Not detected	2,000		ng/L	1000	2991-50-6	Y1
PFOS*	2,400,000	1,000		ng/L	1000	1763-23-1	Y1
PFOS-LN*	1,500,000	1,000		ng/L	1000	1763-23-1-LN	Y1
PFOS-BR*	880,000	1,000		ng/L	1000	1763-23-1-BR	Y1
PFUnDA*	Not detected	1,000		ng/L	1000	2058-94-8	Y1
PFNS*	Not detected	1,000		ng/L	1000	68259-12-1	Y1
PFDODA*	Not detected	1,000		ng/L	1000	307-55-1	Y1
PFDS*	Not detected	1,000		ng/L	1000	335-77-3	Y1
PFTTrDA*	Not detected	1,000		ng/L	1000	72629-94-8	Y1
FOSA*	Not detected	1,000		ng/L	1000	754-91-6	Y1
PFTeDA*	Not detected	2,000		ng/L	1000	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	1,000		ng/L	1000	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	1,000		ng/L	1000	756426-58-1	Y1
ADONA*	Not detected	1,000		ng/L	1000	919005-14-4	Y1
HFPO-DA*	Not detected	1,000		ng/L	1000	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	2,000		ng/L	1000	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	2,000		ng/L	1000	914637-49-3	Y1
FPrPA (3:3 FTCA)*	Not detected	2,000		ng/L	1000	356-02-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51876.01 (continued)
Sample Tag: 013A2023_t1h

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/24/23 23:41, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
NFDHA*	Not detected	1,000		ng/L	1000	151772-58-6	Y1
PFEESA*	Not detected	1,000		ng/L	1000	113507-82-7	Y1
PFMBA*	Not detected	1,000		ng/L	1000	863090-89-5	Y1
PFMPA*	Not detected	1,000		ng/L	1000	377-73-1	Y1
NMeFOSAM*	Not detected	1,000		ng/L	1000	31506-32-8	Y1
NMeFOSE*	Not detected	2,000		ng/L	1000	24448-09-7	Y1
NEtFOSAM*	Not detected	1,000		ng/L	1000	4151-50-2	Y1
NEtFOSE*	Not detected	2,000		ng/L	1000	1691-99-2	Y1
PFDoS*	Not detected	3,000		ng/L	1000	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51876.02

Sample Tag: 013A2023_t4h

Collected Date/Time: 08/02/2023 14:44

Matrix: Wastewater

COC Reference: 164240

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep 1)	7.100/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:01, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	14,000	500		ng/L	100	375-22-4	Y1
PFPeA*	5,900	200		ng/L	100	2706-90-3	Y1
4:2 FTSA*	Not detected	100		ng/L	100	757124-72-4	Y1
PFHxA*	6,000	100		ng/L	100	307-24-4	Y1
PFBS*	200	100		ng/L	100	375-73-5	Y1
PFHpA*	41,000	100		ng/L	100	375-85-9	Y1
PFPeS*	4,700	100		ng/L	100	2706-91-4	Y1
6:2 FTSA*	Not detected	100		ng/L	100	27619-97-2	Y1
PFOA*	120,000	100		ng/L	100	335-67-1	Y1
PFHxS*	20,000	100		ng/L	100	355-46-4	Y1
PFHxS-LN*	19,000	100		ng/L	100	355-46-4-LN	Y1
PFHxS-BR*	800	100		ng/L	100	355-46-4-BR	Y1
PFNA*	180	100		ng/L	100	375-95-1	Y1
8:2 FTSA*	Not detected	100		ng/L	100	39108-34-4	Y1
PFHpS*	3,500	100		ng/L	100	375-92-8	Y1
PFDA*	Not detected	100		ng/L	100	335-76-2	Y1
N-MeFOSAA*	Not detected	100		ng/L	100	2355-31-9	Y1
EtFOSAA*	Not detected	200		ng/L	100	2991-50-6	Y1
PFOS*	140,000	100		ng/L	100	1763-23-1	Y1
PFOS-LN*	120,000	100		ng/L	100	1763-23-1-LN	Y1
PFOS-BR*	20,000	100		ng/L	100	1763-23-1-BR	Y1
PFUnDA*	Not detected	100		ng/L	100	2058-94-8	Y1
PFNS*	Not detected	100		ng/L	100	68259-12-1	Y1
PFDODA*	Not detected	100		ng/L	100	307-55-1	Y1
PFDS*	Not detected	100		ng/L	100	335-77-3	Y1
PFTTrDA*	Not detected	100		ng/L	100	72629-94-8	Y1
FOSA*	Not detected	100		ng/L	100	754-91-6	Y1
PFTeDA*	Not detected	200		ng/L	100	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	100		ng/L	100	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	100		ng/L	100	756426-58-1	Y1
ADONA*	Not detected	100		ng/L	100	919005-14-4	Y1
HFPO-DA*	Not detected	100		ng/L	100	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	200		ng/L	100	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	200		ng/L	100	914637-49-3	Y1
FPrPA (3:3 FTCA)*	Not detected	200		ng/L	100	356-02-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51876.02 (continued)

Sample Tag: 013A2023_t4h

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:01, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
NFDHA*	Not detected	100		ng/L	100	151772-58-6	Y1
PFEESA*	Not detected	100		ng/L	100	113507-82-7	Y1
PFMBA*	Not detected	100		ng/L	100	863090-89-5	Y1
PFMPA*	150	100		ng/L	100	377-73-1	Y1
NMeFOSAM*	Not detected	100		ng/L	100	31506-32-8	Y1
NMeFOSE*	Not detected	200		ng/L	100	24448-09-7	Y1
NEtFOSAM*	Not detected	100		ng/L	100	4151-50-2	Y1
NEtFOSE*	Not detected	200		ng/L	100	1691-99-2	Y1
PFDoS*	Not detected	300		ng/L	100	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis



Analytical Laboratory Report

Lab Sample ID: S51876.03

Sample Tag: 013A2023_t8h

Collected Date/Time: 08/04/2023 16:44

Matrix: Wastewater

COC Reference: 164240

Sample Containers

#	Type	Preservative(s)	Refrigerated?	Arrival Temp. (C)	Thermometer #
1	15ml Centrifuge Tube	None	Yes	8.4	IR

Extraction / Prep.

Parameter	Result	Method	Run Date	Analyst	Flags
Initial wt. (g) / Final wt. (g) / Volume (ml)*	7.050/7/10	ASTMD7979-19M	08/08/23 08:30	AB	
Initial wt. (g) / Final wt. (g) / Volume (ml) (Rep#)	7.000/7.000/10	ASTMD7979-19M	08/24/23 09:00	AB	

Organics

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:20, Analyst: KCV

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
PFBA*	16,000	50		ng/L	10	375-22-4	Y1
PFPeA*	6,200	20		ng/L	10	2706-90-3	Y1
4:2 FTSA*	Not detected	10		ng/L	10	757124-72-4	IY1
PFHxA*	5,100	10		ng/L	10	307-24-4	Y1
PFBS*	130	10		ng/L	10	375-73-5	Y1
PFHpA*	8,600	10		ng/L	10	375-85-9	Y1
PFPeS*	820	10		ng/L	10	2706-91-4	Y1
6:2 FTSA*	Not detected	10		ng/L	10	27619-97-2	Y1
PFOA*	3,800	10		ng/L	10	335-67-1	Y1
PFHxS*	1,200	10		ng/L	10	355-46-4	Y1
PFHxS-LN*	1,100	10		ng/L	10	355-46-4-LN	Y1
PFHxS-BR*	22	10		ng/L	10	355-46-4-BR	Y1
PFNA*	12	10		ng/L	10	375-95-1	Y1
8:2 FTSA*	Not detected	10		ng/L	10	39108-34-4	Y1
PFHpS*	180	10		ng/L	10	375-92-8	Y1
PFDA*	Not detected	10		ng/L	10	335-76-2	Y1
N-MeFOSAA*	Not detected	10		ng/L	10	2355-31-9	Y1
EtFOSAA*	Not detected	20		ng/L	10	2991-50-6	Y1
PFOS*	9,700	10		ng/L	10	1763-23-1	Y1
PFOS-LN*	8,200	10		ng/L	10	1763-23-1-LN	Y1
PFOS-BR*	1,500	10		ng/L	10	1763-23-1-BR	Y1
PFUnDA*	Not detected	10		ng/L	10	2058-94-8	Y1
PFNS*	Not detected	10		ng/L	10	68259-12-1	Y1
PFDODA*	Not detected	10		ng/L	10	307-55-1	Y1
PFDS*	Not detected	10		ng/L	10	335-77-3	Y1
PFTTrDA*	Not detected	10		ng/L	10	72629-94-8	Y1
FOSA*	Not detected	10		ng/L	10	754-91-6	Y1
PFTeDA*	Not detected	20		ng/L	10	376-06-7	Y1
11Cl-PF3OUdS*	Not detected	10		ng/L	10	763051-92-9	Y1
9Cl-PF3ONS*	Not detected	10		ng/L	10	756426-58-1	Y1
ADONA*	Not detected	10		ng/L	10	919005-14-4	Y1
HFPO-DA*	48	10		ng/L	10	13252-13-6	Y1
FHpPA (7:3 FTCA)*	Not detected	20		ng/L	10	812-70-4	Y1
FPePA (5:3 FTCA)*	Not detected	20		ng/L	10	914637-49-3	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis

I-Matrix interference with internal standard



Analytical Laboratory Report

Lab Sample ID: S51876.03 (continued)

Sample Tag: 013A2023_t8h

40 PFAs, Method: ASTMD7979-19M, Run Date: 08/25/23 00:20, Analyst: KCV (continued)

Parameter	Result	RL	MDL	Units	Dilution	CAS#	Flags
FPrPA (3:3 FTCA)*	150	20		ng/L	10	356-02-5	Y1
NFDHA*	Not detected	10		ng/L	10	151772-58-6	Y1
PFEESA*	Not detected	10		ng/L	10	113507-82-7	Y1
PFMBA*	29	10		ng/L	10	863090-89-5	Y1
PFMPA*	270	10		ng/L	10	377-73-1	Y1
NMeFOSAM*	Not detected	10		ng/L	10	31506-32-8	Y1
NMeFOSE*	Not detected	20		ng/L	10	24448-09-7	Y1
NEtFOSAM*	Not detected	10		ng/L	10	4151-50-2	Y1
NEtFOSE*	Not detected	20		ng/L	10	1691-99-2	Y1
PFDoS*	Not detected	30		ng/L	10	79780-39-5	Y1

Y-Elevated reporting limit due to high target concentration 1-Bottles overfilled, subsample taken for analysis

Merit Laboratories Login Checklist

Lab Set ID:S51876

Client:ENSPIRED (Enspired Solutions)

Project: Monitoring

Submitted:08/07/2023 11:50 Login User: BJB

Attention: Suzanne Witt

Address: Enspired Solutions
4942 Dawn Avenue, Suite 104
East Lansing, MI 48823

Phone: 937-470-9461

FAX:

Email: suzanne.witt@enspiredsolutions.com

Selection	Description	Note
Sample Receiving		
01.	☐ Yes ☒ No ☐ N/A	Samples are received at 4C +/- 2C Thermometer # IR 8.4
02.	☒ Yes ☐ No ☐ N/A	Received on ice/ cooling process begun
03.	☐ Yes ☒ No ☐ N/A	Samples shipped
04.	☐ Yes ☒ No ☐ N/A	Samples left in 24 hr. drop box
05.	☐ Yes ☐ No ☒ N/A	Are there custody seals/tape or is the drop box locked
Chain of Custody		
06.	☒ Yes ☐ No ☐ N/A	COC adequately filled out
07.	☒ Yes ☐ No ☐ N/A	COC signed and relinquished to the lab
08.	☒ Yes ☐ No ☐ N/A	Sample tag on bottles match COC
09.	☐ Yes ☒ No ☐ N/A	Subcontracting needed? Subcontacted to:
Preservation		
10.	☒ Yes ☐ No ☐ N/A	Do sample have correct chemical preservation
11.	☐ Yes ☐ No ☒ N/A	Completed pH checks on preserved samples? (no VOAs)
12.	☐ Yes ☒ No ☐ N/A	Did any samples need to be preserved in the lab?
Bottle Conditions		
13.	☒ Yes ☐ No ☐ N/A	All bottles intact
14.	☒ Yes ☐ No ☐ N/A	Appropriate analytical bottles are used
15.	☒ Yes ☐ No ☐ N/A	Merit bottles used
16.	☒ Yes ☐ No ☐ N/A	Sufficient sample volume received Tubes were overfilled.
17.	☐ Yes ☒ No ☐ N/A	Samples require laboratory filtration
18.	☒ Yes ☐ No ☐ N/A	Samples submitted within holding time
19.	☐ Yes ☐ No ☒ N/A	Do water VOC or TOX bottles contain headspace

Corrective action for all exceptions is to call the client and to notify the project manager.

Client Review By: _____ Date: _____

APPENDIX B – TF/AOF ANALYTICAL PROCEDURES, RESULTS, AND QA/QC PROCEDURES

ANALYTICAL REPORT

PREPARED FOR

Attn: Suzanne Witt
Enspired Solutions
9047 West Scenic Lake Dr
Laingsburg, Michigan 48848

Generated 8/24/2023 4:49:29 PM

JOB DESCRIPTION

PFAS PRD Destruction Technology

JOB NUMBER

320-103385-1

Eurofins Sacramento

Job Notes

This report may not be reproduced except in full, and with written approval from the laboratory. The results relate only to the samples tested. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

The test results in this report relate only to the samples as received by the laboratory and will meet all requirements of the methodology, with any exceptions noted. This report shall not be reproduced except in full, without the express written approval of the laboratory. All questions should be directed to the Eurofins Environment Testing Northern California, LLC Project Manager.

Authorization



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Authorized for release by
Laura Turpen, Project Manager I
Laura.Turpen@et.eurofinsus.com
(916)374-4414

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Definitions/Glossary

Client: Enspired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
□	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Job ID: 320-103385-1

Laboratory: Eurofins Sacramento

Narrative

Job Narrative
320-103385-1

Comments

No additional comments.

Receipt

The samples were received on 8/8/2023 10:20 AM. Unless otherwise noted below, the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 2.0° C.

LCMS

Method ELLE SOP: Reporting limits were raised for the following samples due to interference from the sample matrix. 013A2023_t0 (320-103385-1), 013A2023_t2h (320-103385-2) and 013A2023_t54 (320-103385-3)

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Organic Prep

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Detection Summary

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Client Sample ID: 013A2023_t0

Lab Sample ID: 320-103385-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Adsorbable Organic Fluorine (AOF)	5400		400		ug/L	1		ELLE SOP	Total/NA
Total Fluorine (TF)	5200		200		ug/L	1		ELLE SOP	Total/NA

Client Sample ID: 013A2023_t2h

Lab Sample ID: 320-103385-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Adsorbable Organic Fluorine (AOF)	1600		400		ug/L	1		ELLE SOP	Total/NA
Total Fluorine (TF)	4100		200		ug/L	1		ELLE SOP	Total/NA

Client Sample ID: 013A2023_t54

Lab Sample ID: 320-103385-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Adsorbable Organic Fluorine (AOF)	450		400		ug/L	1		ELLE SOP	Total/NA
Total Fluorine (TF)	6600		200		ug/L	1		ELLE SOP	Total/NA

This Detection Summary does not include radiochemical test results.

Eurofins Sacramento

Client Sample Results

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Client Sample ID: 013A2023_t0

Lab Sample ID: 320-103385-1

Date Collected: 08/01/23 14:40

Matrix: Water

Date Received: 08/08/23 10:20

Method: ELLE - Lancaster ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	5400		400		ug/L		08/17/23 11:11	08/18/23 17:12	1
Total Fluorine (TF)	5200		200		ug/L		08/16/23 09:08	08/16/23 13:33	1

Client Sample ID: 013A2023_t2h

Lab Sample ID: 320-103385-2

Date Collected: 08/01/23 16:40

Matrix: Water

Date Received: 08/08/23 10:20

Method: ELLE - Lancaster ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	1600		400		ug/L		08/17/23 11:11	08/18/23 17:45	1
Total Fluorine (TF)	4100		200		ug/L		08/16/23 09:08	08/16/23 14:08	1

Client Sample ID: 013A2023_t54

Lab Sample ID: 320-103385-3

Date Collected: 08/01/23 17:30

Matrix: Water

Date Received: 08/08/23 10:20

Method: ELLE - Lancaster ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	450		400		ug/L		08/17/23 11:11	08/18/23 18:18	1
Total Fluorine (TF)	6600		200		ug/L		08/16/23 09:08	08/16/23 14:44	1

QC Sample Results

Client: Enspired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Method: ELLE SOP - Total or Organic Fluorine by Combustion Ion Chromatography

Lab Sample ID: MB 410-408819/1-A

Matrix: Water

Analysis Batch: 409484

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 408819

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Fluorine (TF)	ND		200		ug/L		08/16/23 09:08	08/16/23 11:47	1

Lab Sample ID: LCS 410-408819/2-A

Matrix: Water

Analysis Batch: 409484

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 408819

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Total Fluorine (TF)	5070	5380		ug/L		106	50 - 150

Lab Sample ID: LCSD 410-408819/3-A

Matrix: Water

Analysis Batch: 409484

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 408819

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Fluorine (TF)	5070	5370		ug/L		106	50 - 150	0	20

Lab Sample ID: MB 410-409465/1-A

Matrix: Water

Analysis Batch: 410610

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 409465

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Adsorbable Organic Fluorine (AOF)	ND		2.0		ug/L		08/17/23 11:11	08/20/23 16:49	1

Lab Sample ID: LCS 410-409465/2-A

Matrix: Water

Analysis Batch: 410610

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 409465

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Adsorbable Organic Fluorine (AOF)	20.3	21.5		ug/L		106	50 - 150

Lab Sample ID: LCSD 410-409465/3-A

Matrix: Water

Analysis Batch: 410610

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 409465

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Adsorbable Organic Fluorine (AOF)	20.3	21.2		ug/L		105	50 - 150	1	20

Eurofins Sacramento

QC Association Summary

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

LCMS

Prep Batch: 408819

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
320-103385-1	013A2023_t0	Total/NA	Water	CIC Prep	
320-103385-2	013A2023_t2h	Total/NA	Water	CIC Prep	
320-103385-3	013A2023_t54	Total/NA	Water	CIC Prep	
MB 410-408819/1-A	Method Blank	Total/NA	Water	CIC Prep	
LCS 410-408819/2-A	Lab Control Sample	Total/NA	Water	CIC Prep	
LCSD 410-408819/3-A	Lab Control Sample Dup	Total/NA	Water	CIC Prep	

Prep Batch: 409465

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
320-103385-1	013A2023_t0	Total/NA	Water	NONE	
320-103385-2	013A2023_t2h	Total/NA	Water	NONE	
320-103385-3	013A2023_t54	Total/NA	Water	NONE	
MB 410-409465/1-A	Method Blank	Total/NA	Water	NONE	
LCS 410-409465/2-A	Lab Control Sample	Total/NA	Water	NONE	
LCSD 410-409465/3-A	Lab Control Sample Dup	Total/NA	Water	NONE	

Analysis Batch: 409484

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
320-103385-1	013A2023_t0	Total/NA	Water	ELLE SOP	408819
320-103385-2	013A2023_t2h	Total/NA	Water	ELLE SOP	408819
320-103385-3	013A2023_t54	Total/NA	Water	ELLE SOP	408819
MB 410-408819/1-A	Method Blank	Total/NA	Water	ELLE SOP	408819
LCS 410-408819/2-A	Lab Control Sample	Total/NA	Water	ELLE SOP	408819
LCSD 410-408819/3-A	Lab Control Sample Dup	Total/NA	Water	ELLE SOP	408819

Analysis Batch: 410610

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
320-103385-1	013A2023_t0	Total/NA	Water	ELLE SOP	409465
320-103385-2	013A2023_t2h	Total/NA	Water	ELLE SOP	409465
320-103385-3	013A2023_t54	Total/NA	Water	ELLE SOP	409465
MB 410-409465/1-A	Method Blank	Total/NA	Water	ELLE SOP	409465
LCS 410-409465/2-A	Lab Control Sample	Total/NA	Water	ELLE SOP	409465
LCSD 410-409465/3-A	Lab Control Sample Dup	Total/NA	Water	ELLE SOP	409465

Lab Chronicle

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Client Sample ID: 013A2023_t0

Lab Sample ID: 320-103385-1

Date Collected: 08/01/23 14:40

Matrix: Water

Date Received: 08/08/23 10:20

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	CIC Prep			0.2 g	0.2 mL	408819	08/16/23 09:08	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			409484	08/16/23 13:33	F9DU	ELLE
Total/NA	Prep	NONE			0.5 mL	0.2 mL	409465	08/17/23 11:11	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			410610	08/18/23 17:12	F9DU	ELLE

Client Sample ID: 013A2023_t2h

Lab Sample ID: 320-103385-2

Date Collected: 08/01/23 16:40

Matrix: Water

Date Received: 08/08/23 10:20

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	CIC Prep			0.2 g	0.2 mL	408819	08/16/23 09:08	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			409484	08/16/23 14:08	F9DU	ELLE
Total/NA	Prep	NONE			0.5 mL	0.2 mL	409465	08/17/23 11:11	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			410610	08/18/23 17:45	F9DU	ELLE

Client Sample ID: 013A2023_t54

Lab Sample ID: 320-103385-3

Date Collected: 08/01/23 17:30

Matrix: Water

Date Received: 08/08/23 10:20

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	CIC Prep			0.2 g	0.2 mL	408819	08/16/23 09:08	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			409484	08/16/23 14:44	F9DU	ELLE
Total/NA	Prep	NONE			0.5 mL	0.2 mL	409465	08/17/23 11:11	QLP7	ELLE
Total/NA	Analysis	ELLE SOP		1			410610	08/18/23 18:18	F9DU	ELLE

Laboratory References:

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Accreditation/Certification Summary

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
A2LA	Dept. of Defense ELAP	0001.01	11-30-24
A2LA	ISO/IEC 17025	0001.01	11-30-24
Alabama	State	43200	01-31-24
Alaska	State	PA00009	06-30-24
Alaska (UST)	State	17-027	02-28-24
Arizona	State	AZ0780	03-12-24
Arkansas DEQ	State	88-00660	08-09-24
California	State	2792	11-30-23
Colorado	State	PA00009	06-30-24
Connecticut	State	PH-0746	06-30-25
DE Haz. Subst. Cleanup Act (HSCA)	State	019-006 (PA cert)	01-31-24
Delaware (DW)	State	N/A	01-31-24
Florida	NELAP	E87997	06-30-24
Georgia (DW)	State	C048	01-31-24
Hawaii	State	N/A	01-31-24
Illinois	NELAP	200027	01-31-24
Iowa	State	361	03-01-24
Kansas	NELAP	E-10151	10-31-23
Kentucky (DW)	State	KY90088	12-31-23
Kentucky (UST)	State	0001.01	11-30-24
Kentucky (WW)	State	KY90088	12-31-23
Louisiana (All)	NELAP	02055	06-30-24
Maine	State	2019012	03-12-25
Maryland	State	100	06-30-24
Massachusetts	State	M-PA009	06-30-24
Michigan	State	9930	01-31-24
Minnesota	NELAP	042-999-487	12-31-23
Mississippi	State	023	01-31-24
Missouri	State	450	01-31-25
Montana (DW)	State	0098	01-01-24
Nebraska	State	NE-OS-32-17	01-31-24
New Hampshire	NELAP	2730	01-10-24
New Jersey	NELAP	PA011	06-30-24
New York	NELAP	10670	04-01-24
North Carolina (DW)	State	42705	07-31-24
North Carolina (WW/SW)	State	521	12-31-23
North Dakota	State	R-205	01-31-24
Oklahoma	NELAP	9804	08-31-23
Oregon	NELAP	PA200001	09-11-23
PALA	Canada	1978	09-16-24
Pennsylvania	NELAP	36-00037	01-31-24
Rhode Island	State	LAO00338	12-31-23
South Carolina	State	89002	01-31-24
Tennessee	State	02838	01-31-24
Texas	NELAP	T104704194-23-46	08-31-23
USDA	US Federal Programs	525-22-298-19481	10-25-25
Vermont	State	VT - 36037	10-28-23
Virginia	NELAP	460182	06-14-25
Washington	State	C457	04-11-24
West Virginia (DW)	State	9906 C	12-31-23

Eurofins Sacramento

Accreditation/Certification Summary

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC (Continued)

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
West Virginia DEP	State	055	07-31-24
Wyoming	State	8TMS-L	01-31-24
Wyoming (UST)	A2LA	0001.01	11-30-24

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Method Summary

Client: Enspired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Method	Method Description	Protocol	Laboratory
ELLE SOP	Total or Organic Fluorine by Combustion Ion Chromatography	ELLE - Lancaster	ELLE
CIC Prep	Preparation, Fluorine	ELLE - Lancaster	ELLE
NONE	Preparation, Fluorine	ELLE - Lancaster	ELLE

Protocol References:

ELLE - Lancaster = Eurofins Lancaster, Facility Standard Operating Procedure.

Laboratory References:

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Sample Summary

Client: Ensired Solutions
Project/Site: PFAS PRD Destruction Technology

Job ID: 320-103385-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
320-103385-1	013A2023_t0	Water	08/01/23 14:40	08/08/23 10:20
320-103385-2	013A2023_t2h	Water	08/01/23 16:40	08/08/23 10:20
320-103385-3	013A2023_t54	Water	08/01/23 17:30	08/08/23 10:20

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TAL-8210

[illegible]



Environment Testing

Sacramento Sample Receiving Notes

Tracking #: 772970684307/588155969693

Job: _____

SO / PO / FO / SAT / 2-Day / Ground / UPS / CDO / Courier
GSL / OnTrac / Goldstreak / USPS / Other _____

Use this form to record Sample Custody Seal, Cooler Custody Seal, Temperature & corrected Temperature & other observations.
File in the job folder with the COC

Therm. ID: L04 Corr. Factor: (+/-) NA °C

Ice _____ Wet _____ Gel _____ Other _____

Cooler Custody Seal: 2100350/2100351

Cooler ID: _____

Temp Observed: 2.0 °C Corrected: 2.0 °C
From: Temp Blank ☐ Sample ☒

Opening/Processing The Shipment	Yes	No	NA
Cooler compromised/tampered with?	☐	☒	☐
Cooler Temperature is acceptable?	☒	☐	☐
Frozen samples show signs of thaw?	☐	☐	☒

Initials: DM Date: 08/08/23

Unpacking/Labeling The Samples	Yes	No	NA
Containers are not broken or leaking?	☒	☐	☐
Samples compromised/tampered with?	☐	☒	☐
COC is complete w/o discrepancies	☒	☐	☐
Sample custody seal?	☐	☒	☐
Sample containers have legible labels?	☒	☐	☐
Sample date/times are provided?	☒	☐	☐
Appropriate containers are used?	☒	☐	☐
Sample bottles are completely filled?	☒	☐	☐
Sample preservatives verified?	☐	☐	☒
Is the Field Sampler's name on COC?	☐	☒	☐
Samples w/o discrepancies?	☒	☐	☒
Zero headspace?*	☐	☐	☒
Alkalinity has no headspace?	☐	☐	☒
Perchlorate has headspace? (Methods 314, 331, 6850)	☐	☐	☒
Multiphasic samples are not present?	☒	☐	☐

*Containers requiring zero headspace have no headspace, or bubble < 6 mm (1/4")

Initials: DM Date: 08/08/23

Notes: _____

Trizma Lot #(s): _____

Ammonium

Acetate Lot #(s): _____

Login Completion	Yes	No	NA
Receipt Temperature on COC?	☒	☐	☐
NCM Filed?	☐	☐	☒
Samples received within hold time?	☒	☐	☐
Log Release checked in TALS?	☒	☐	☐

Initials: SO Date: 8/8/23

14A

Login Sample Receipt Checklist

Client: Enspired Solutions

Job Number: 320-103385-1

Login Number: 103385

List Source: Eurofins Sacramento

List Number: 1

Creator: Oropeza, Salvador

Question	Answer	Comment
Radioactivity wasn't checked or is $\leq$ background as measured by a survey meter.	True	REFER TO SSRN
The cooler's custody seal, if present, is intact.	N/A	
Sample custody seals, if present, are intact.	N/A	
The cooler or samples do not appear to have been compromised or tampered with.	N/A	
Samples were received on ice.	N/A	
Cooler Temperature is acceptable.	N/A	
Cooler Temperature is recorded.	N/A	
COC is present.	N/A	
COC is filled out in ink and legible.	N/A	
COC is filled out with all pertinent information.	N/A	
Is the Field Sampler's name present on COC?	N/A	
There are no discrepancies between the containers received and the COC.	N/A	
Samples are received within Holding Time (excluding tests with immediate HTs)	N/A	
Sample containers have legible labels.	N/A	
Containers are not broken or leaking.	N/A	
Sample collection date/times are provided.	N/A	
Appropriate sample containers are used.	N/A	
Sample bottles are completely filled.	N/A	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	N/A	
Containers requiring zero headspace have no headspace or bubble is $<6\text{mm}$ (1/4").	N/A	
Multiphasic samples are not present.	N/A	
Samples do not require splitting or compositing.	N/A	
Residual Chlorine Checked.	N/A	

Login Sample Receipt Checklist

Client: Enspired Solutions

Job Number: 320-103385-1

Login Number: 103385

List Source: Eurofins Lancaster Laboratories Environment Testing, LLC

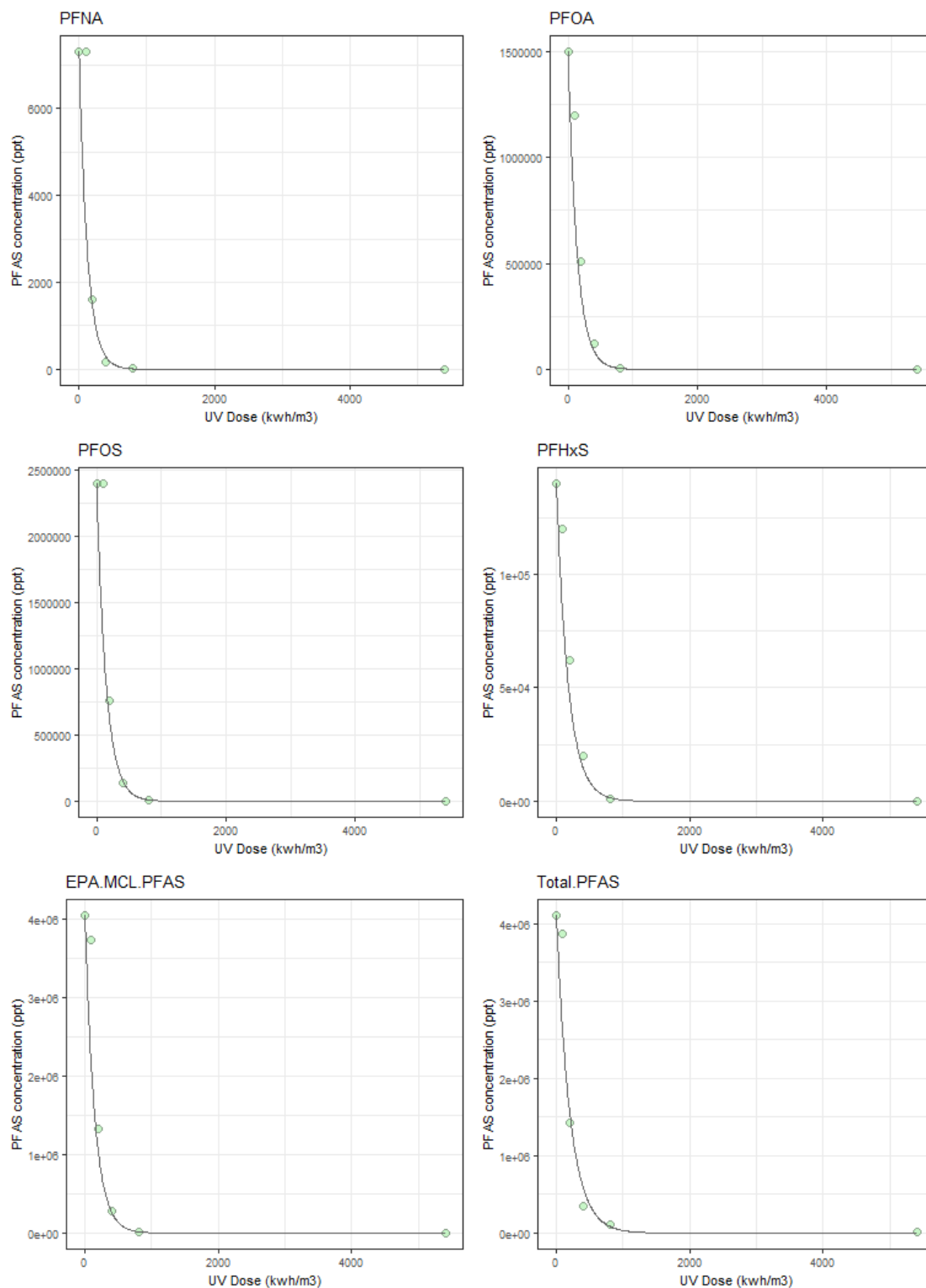
List Number: 2

List Creation: 08/10/23 02:17 PM

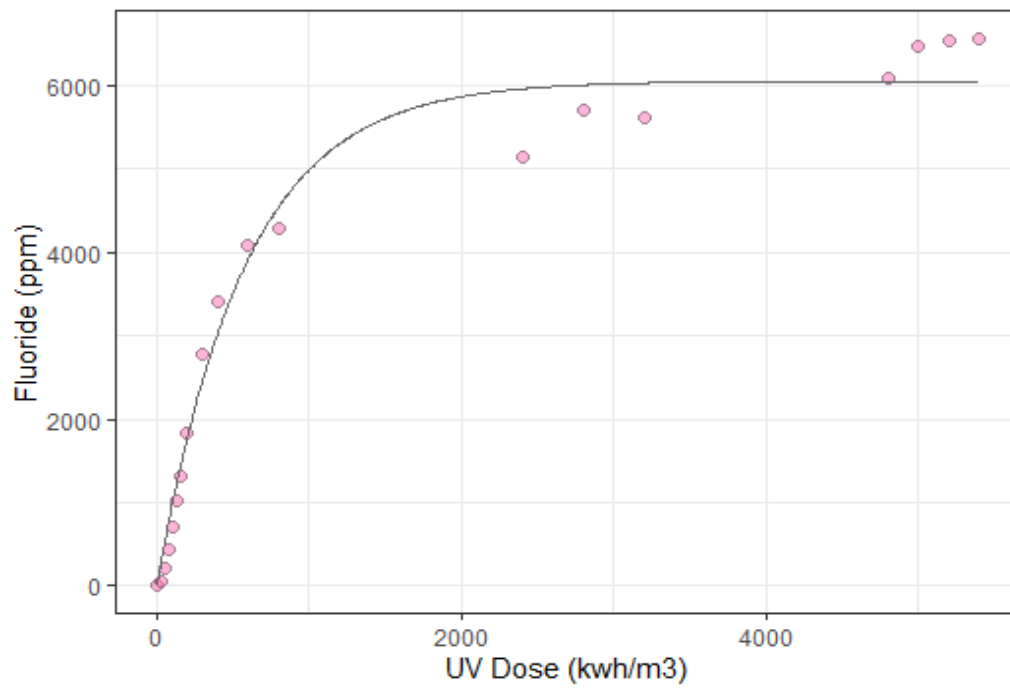
Creator: Arroyo, Haley

Question	Answer	Comment
The cooler's custody seal is intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable ($\leq 6^{\circ}\text{C}$, not frozen).	True	
Cooler Temperature is recorded.	True	
WV: Container Temperature is acceptable ($\leq 6^{\circ}\text{C}$, not frozen).	N/A	
WV: Container Temperature is recorded.	N/A	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
There are no discrepancies between the containers received and the COC.	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
There is sufficient vol. for all requested analyses.	True	
Is the Field Sampler's name present on COC?	False	Received project as a subcontract.
Sample custody seals are intact.	N/A	
VOA sample vials do not have headspace $> 6\text{mm}$ in diameter (none, if from WV)?	N/A	

APPENDIX C – PFAS AND FLUORIDE DATA MODEL FITTING



Model fitting of decreases in individual and groups of PFAS compounds during PRD treatment.



Model fitting of fluoride release (measured by ISE) during PRD treatment.

APPENDIX D – TREATMENT COST DRIVERS

Category	Cost Element	Data Tracked During the Demonstration	Costs
CAPEX	PFASigator Equipment	Unit: \$ per unit for the chosen PFASigator model Influent flow rate, water quality, applied pre-concentration technologies determine the number of units needed.	Equipment purchase from Enspired Solutions
	Reagent & material cost	Subscription: \$ per unit for the chosen PFASigator model.	Enspired Solutions provides monthly subscription for reagent & material usage (delivered to site) and end-user IP license
OPEX	End-user IP license	Subscription: \$ per unit for the chosen PFASigator model.	
	Operational Labor	PFASigator equipment is 100% automatic. Real-time operational process data is fed into a cloud-based database for user to view remotely. Monthly check might be needed for this equipment operation.	Minimum labor required
	Health and Safety Cost	PFASigator equipment is operated under atmospheric temperature and pressure.	No additional health and safety cost other than industrial standard
	Disposal Cost	PFAS destruction occurs on site; no waste disposal is anticipated with the process.	Minimum waste disposal cost if paired with proper concentration technology
	Discharge compliance sampling and analysis	PFAS destruction is assessed via real-time fluoride monitoring on PFASigator equipment, which is fed on a cloud-based database. However, discharge compliance sampling and analysis might be still needed per permit requirements.	Dependent on site permits
	Energy Cost	Unit: \$ per unit for the chosen PFASigator model per day. The same data requirements as determining the number of PFASigator units.	Electricity charge
	Equipment Maintenance Cost	PFASigator equipment utilizes commercial available UV reactors and monitoring meters applied in water treatment industry.	No additional maintenance cost other than industrial standard

Attachment G6: Enspired Solutions Final Report Addendum No. 1



ENSPIRED
SOLUTIONS™

FINAL REPORT ADDENDUM NO. 1

SWIFT Contract number: 230420

Photoactivated Reductive Defluorination PFAS Destruction in
Groundwater Concentrate

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ACRONYMS

Acronym	Definition
CAPEX	Capital expenditure
EEO	Electrical energy per order
ES	Enspired Solutions™
EPA	U.S. Environmental Protection Agency
[F-]max	maximum fluoride ion concentration that can be produced from complete defluorination
ft	feet
gal	gallons
GPD	Gallons per day
GPM	Gallons per minute
h	hour
HFPO-DA	Hexafluoropropylene oxide dimer acid
ISE	Ion-selective electrode
k	PRD rate constant
kW	Kilowatt
kWh	Kilowatt-hour
L	Liters
LC-MS/MS	Liquid chromatography with tandem mass spectrometry
m ³	Cubic meter
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
mL	Milliliter
N/A	Not applicable
OPEX	Operating expenditure
PFAS	Per and polyfluoroalkyl substances
PFBS	Perfluorobutanesulfonic acid
PFHxS	Perfluorohexanesulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
ppb	parts-per-billion
ppt	parts-per-trillion
PRD	Photoactivated reductive defluorination
SAFF	Surface active foam fractionation
UV	Ultraviolet light

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EXECUTIVE SUMMARY

Introduction and Objectives

In October 2023, Ensplied Solutions™ (ES) submitted the Final Report to the State of Minnesota for our project Photoactivated Reductive Defluorination PFAS Destruction in Groundwater Concentrate. In that document, we summarized how we conducted bench-scale testing on small sample aliquots of surface active foam fractionation (SAFF) concentrate generated from surface water from a State of Minnesota site and achieved the project objectives to 1) demonstrate the efficacy of using photo-activated reductive defluorination (PRD) for the destruction of per- and polyfluoroalkyl substances (PFAS) in the SAFF concentrate, and 2) provide a site-specific cost projection for full-scale technology implementation. Since that submittal, ES has continued working diligently to scale up and refine our PFAS destruction technology. As such, we conducted a commercial-scale pilot test of our equipment, the PFASigator™, in November 2023 and conducted numerous additional treatability tests on multiple liquid matrices. Technology advances made since October 2023 have allowed us to extend our understanding of efficient field-scale PFASigator implementation. These advances allow us to save energy use and cost while effectively treating PFAS using PRD in combination with foam fractionation. Our up-to-date results show that the extent of PFAS destruction and energy use required for field implementation are less than originally estimated in the Final Report. A revised site-specific cost projection for full-scale implementation of PFAS destruction using PRD has been prepared and is presented in this Addendum No. 1 to the Final Report.

Discussion of Destruction Efficiencies

As illustrated in the Final Report, PRD is capable of destroying greater than 99% of PFAS in water. In addition, PRD energy efficiency can be optimized by destroying the majority of PFAS at high concentrations, where the ratio of PFAS mass destroyed per ultra-violet light (UV) dose is high, and returning small amounts of PFAS to the SAFF for re-concentration in a recirculating process flow.

In the Final Report, energy requirements and cost for PFAS destruction at the State of Minnesota site were calculated to achieve post-treatment (i.e. PFASigator effluent) PFAS concentrations that were two to three orders of magnitude (99-99.9%) lower than in the SAFF concentrate. However, technology advances since October 2023, including repeated results from a field pilot test, provide evidence that lower destruction percentages, i.e. post-treatment PFAS concentrations that are one order of magnitude (90%) lower than in the SAFF concentrate, are sufficient for effective PFAS destruction, while still meeting discharge limits, when PFASigator is deployed with foam fractionation in a recirculating process flow. Due to these advances, energy consumption and treatment cost projections for this site have been updated based on a more efficient PFASigator implementation scenario than those used in the Final Report. For this re-evaluation, post-treatment PFAS concentrations are set at 90% lower than in the SAFF concentrate, which is considered a conservative value to ensure field implementation success.

Energy Consumption

Consistent with the Final Report, energy consumption rates are based on actual results from benchtop testing PRD on SAFF concentrate from the project site. However, overall energy use, and therefore cost, is lower due to the lower destruction percentages targeted in the re-evaluation.

Revised Treatment Cost Projection

In this updated cost projection, for SAFF-concentrated groundwater and surface water, the PFAS destruction cost was re-estimated within a range of \$1.63 per gallon (/gal) to \$4.88/gal, depending on the

site-specific remediation objective. This field-proven application scenario is a 50% to 70% cost reduction compared to the initial projection that was proposed in the Final Report. A range of remediation targets were evaluated, including treating all U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) PFAS [perfluorononanoic acid (PFNA), perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorohexanesulfonic acid (PFHxS), perfluorobutanesulfonic acid (PFBS), hexafluoropropylene oxide dimer acid (HFPO-DA)]; (low-end cost), treating all 40 PFAS compounds analyzed in this study (mid-range cost), and treating all known and unknown PFAS compounds and precursors (high-end cost). For an assumed PFASigator influent flow rate of 100 gallons per day (GPD), the energy usage for PFAS destruction ranged from 156 kilowatt (kW)/day to 468 kW/day, at an estimated cost of approximately \$30-\$89/day.

Commercial-scale Equipment Readiness

In November 2023, ES successfully launched a pilot demonstration of our groundbreaking PFAS destruction technology, the PFASigator, combined with foam fractionation to treat PFAS-contaminated groundwater. Results of this project demonstrate the ability to destroy PFAS in contaminated groundwater at commercial scale using the PFASigator, eliminate the need for off-site PFAS disposal, and meet site-specific PFAS discharge criteria. This field pilot also provided repeated evidence that PFAS destruction percentages less than two-to-three orders of magnitude are sufficient for effective PFAS destruction while still meeting discharge limits.

Specific results from the demonstration include:

1. Transformed high-volume, low-PFAS groundwater into destruction-ready concentrate. Approximately 50,000 gallons of groundwater were treated. The foam fractionation unit successfully concentrated PFAS from the source groundwater. PFOS concentrations increased from approximately 1,500 parts per trillion (ppt) in the source groundwater to 600,000 ppt in the foam concentrate.
2. Efficiently destroyed PFAS on site. PFOS destruction extents in test batches ranged from 87.2% to 99.7%. Total PFAS destruction extents ranged from 85.2% to 96.2%.
3. Recirculating process flow achieved discharge limit and zero off-site PFAS disposal. PFASigator effluent was re-cycled back to the foam fractionation unit and by blending PFASigator discharge with the source groundwater, steady-state operation was achieved between foam fractionation and PFAS destruction while maintaining < 4 ppt PFOS in the full system effluent. This closed-circuit concentration and destruction loop eliminated the need for off-site PFAS disposal.
4. Real-time fluoride monitoring confirms PFAS destruction. As PFAS destruction occurs and carbon-fluorine bonds are broken in PRD, fluorine is released into solution as inorganic fluoride ions. From start to end of the PFAS destruction batch, over 96% of the decrease in organic fluorine is accounted for by the observed increase in fluoride ions. The excellent fluorine mass balance indicates 1) the utility of using fluoride ion as a proxy for extent of PFAS destruction and 2) the PRD reaction defluorinates PFAS with little loss of PFAS to other pathways such as physical adsorption, conversion into toxic byproducts, etc.

1 INTRODUCTION

Enspired Solutions™ (ES) is submitting this Addendum No. 1 to the Final Report to provide an updated site-specific cost projection for destruction of per- and polyfluoroalkyl substances (PFAS) using photo-activated reductive defluorination (PRD) at the State of Minnesota surface water site.

In October 2023, ES submitted the Final Report to the State of Minnesota for our project Photoactivated Reductive Defluorination PFAS Destruction in Groundwater Concentrate. In that document, we summarized how we conducted bench-scale testing on small sample aliquots of surface active foam fractionation (SAFF) concentrate generated from surface water from a State of Minnesota site and achieved the project objectives to 1) demonstrate the efficacy of using PRD for the destruction of PFAS in the SAFF concentrate, and 2) provide a site-specific cost projection for full-scale technology implementation. Since that submittal, ES has continued working diligently to scale up and refine our PFAS destruction technology. As such, we launched a commercial-scale pilot test of our equipment, the PFASigator™, in November 2023 and conducted numerous additional treatability tests on multiple liquid matrices. Technology advances made since October 2023 have allowed us to advance our understanding of practical implementation of the PFASigator at field-scale, and therefore the necessary energy use and cost, to effectively treat PFAS using PRD in combination with foam fractionation. With proven field pilot success and advanced process understanding, the extent of PFAS destruction and energy required in field implementation can be much less than originally estimated in the Final Report. A revised site-specific cost projection for full-scale implementation of PFAS destruction using PRD has been prepared and is presented in this Addendum.

2 DISCUSSION OF DESTRUCTION EFFICIENCIES

As illustrated in the Final Report, Section 4.1, PRD is capable of destroying greater than 99% of PFAS in water. In addition, as discussed in the Final Report, Section 4.4.1, PRD energy efficiency can be optimized by destroying the majority of PFAS at high concentrations, where the ratio of PFAS mass destroyed per UV dose is high, and returning small amounts of PFAS to the SAFF for re-concentration in a recirculating process flow (**Figure A1-2-1**).

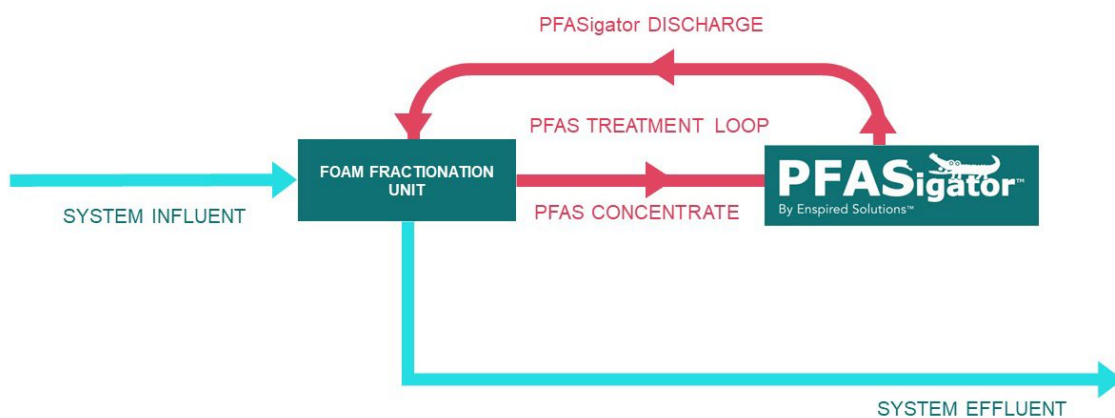


Figure A1-2-1 — Recirculating process flow for PFAS treatment using foam fractionation for PFAS separation and concentration and the PFASigator for PFAS destruction by PRD.

In the Final Report, energy requirements and cost for PFAS destruction at the State of Minnesota site were calculated to achieve post-treatment (i.e. PFASigator effluent) PFAS concentrations that were two to three orders of magnitude (99-99.9%) lower than in the SAFF concentrate. However, technology advances since October 2023 provide evidence that lower destruction percentages, i.e. post-treatment PFAS concentrations that are one order of magnitude (90%) lower than in the SAFF concentrate, are sufficient for effective PFAS destruction in a recirculating process flow.

Results from the recent commercial-scale pilot test of our technology provided repeated evidence that lower destruction percentages are sufficient for effective PFAS destruction while still meeting discharge limits. During the pilot test, the PFASigator was paired with foam fractionation in a recirculating process flow to treat PFAS in contaminated groundwater for one month. Multiple PFAS destruction batches were run over the duration of the test, each batch achieving less than 99% PFAS destruction (85-96%). As these batches were released from the PFASigator and recycled to the foam fractionator for re-processing, concentrations of perfluorooctanesulfonic acid (PFOS) in system discharge (i.e. foam fractionation raffinate) were consistently < 4 parts per trillion (ppt) and met the site-specific discharge limit of < 28 ppt (**Figure A1-2-2**).

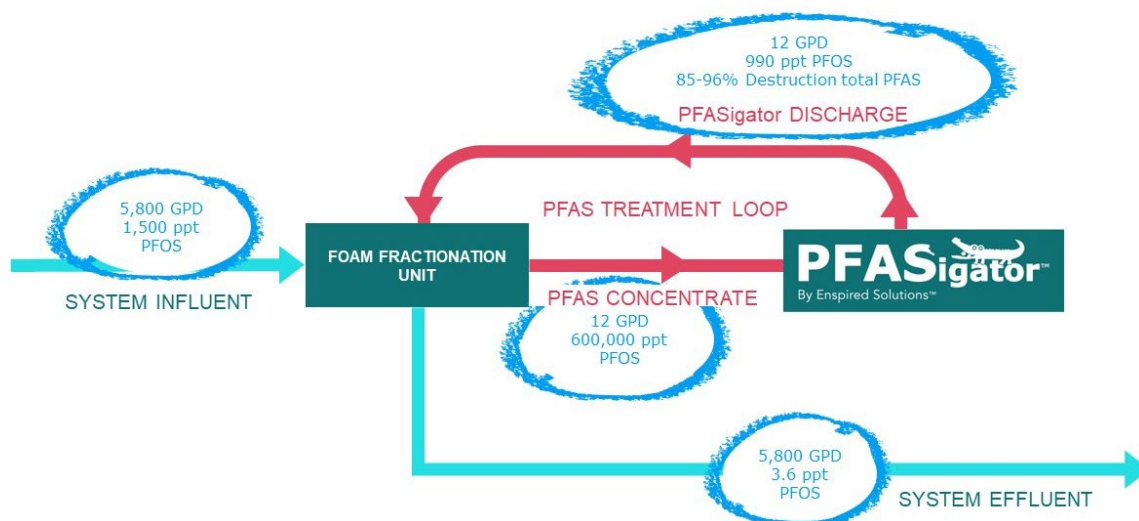


Figure A1-2-2 — Recirculating process flow and performance metrics for ES's pilot test, November 2023, for PFAS treatment using foam fractionation for PFAS separation and concentration and the PFASigator for PFAS destruction by PRD. PFOS concentrations are a batch example; total PFAS percent destruction is range for all batches.

Updated energy consumption and treatment cost projections provided in the following sections are based on more efficient PFASigator operation than those used in the Final Report. For this re-evaluation, post-treatment PFAS concentrations are set at 90% lower than in the SAFF concentrate, which is considered a sufficient value to ensure a successful field implementation.

3 ENERGY CONSUMPTION AND REVISED TREATMENT COST PROJECTIONS

3.1 ENERGY CONSUMPTION

Energy consumption rates are based on actual results from benchtop testing PRD on SAFF concentrate from the project site and remain the same as in the original evaluation presented in the Final Report. The discussion of those calculated rates is re-presented here for clarity.

To determine energy consumption rates, PFAS concentrations, as determined by liquid chromatography with tandem mass spectrometry (LC-MS/MS) analysis, were plotted as a function of UV dose to generate best-fit curves. Then, those modeled curves were used to calculate the electrical energy per order of magnitude PFAS destruction (EEO) for different remediation targets. EEO values were calculated for individual and groups of PFAS compounds. An EEO value was also calculated using a modeled curve fit to the measured fluoride release data and represents energy usage for total PFAS destruction, including both known and unknown fluoroalkyl chemicals in the matrix. The inorganic fluoride ion measurement *via* ion selective electrode (ISE) along the reaction is a much less expensive alternative than laboratory analysis of individual PFAS compounds and precursors. Using the ISE, more data points can be collected in real-time for a quick assessment of energy demand needed for the PRD reaction.

Plots of PFAS concentrations as a function of ultraviolet light (UV) dose and fluoride measurement data for the benchtop tests were fitted to models written in programming language R, and the results are re-presented below in **Table A1-3-1**. Individual fitted curves are included in **Appendix C of the Final Report**. Please note that the UV doses used in model fitting were direct electricity usages recorded from the lamp systems. Therefore, the EEOs calculated from the test data were direct indicators of the electrical demand to destruct PFAS in SAFF-concentrated groundwater using a commercial UV system.

Table A1-3-1. Model fitting for benchtop test data

PFAS Degradation Model Fitting			
Analyte	k (m³/kWh)	p-value	EEO (kWh/m³-order)
PFNA	8.1E-03	9.0E-05 ****	280
PFOA	7.1E-03	5.9E-05 ****	320
PFOS	6.8E-03	6.6E-05 ****	340
PFHxS	5.6E-03	9.2E-05 ****	410
EPA MCL PFAS ^a	6.8E-03	4.8E-05 ****	340
Total PFAS ^b	4.8E-03	2.3E-04 *	480
Fluoride Production Model Fitting			
Analyte	[F⁻]_{max} (ppb)	p-value ([F⁻]_{max})	EEO (kWh/m³-order)
Fluoride Ion	6,060	3.0E-19 ****	1,300
	k (m³/kWh)	p-value (k)	
	1.7E-03	3.8E-11 ****	

* p-value ≤ 0.05

**** p-value ≤ 0.0001

^aEPA MCL PFAS = PFNA, PFOA, PFOS, PFHxS, PFBS, HFPO-DA

^bTotal PFAS = Sum of 40 measured compounds

[F⁻]_{max} = maximum fluoride ion concentration that can be produced from complete defluorination

k = rate constant

3.2 TREATMENT COST PROJECTIONS

Treatment cost projections have been modified from the original Final Report to reflect the technology advances made since October 2023 when the original Final Report was submitted. In the Final Report, cost for PFAS destruction at the State of Minnesota site were calculated to achieve post-treatment (i.e. PFASigator effluent) PFAS concentrations that were two to three orders of magnitude (99-99.9%) lower than in the SAFF concentrate. However, per previous discussion, one order of magnitude (90%) PFAS destruction in PFASigator is considered sufficient to ensure performance success for a recirculating system paired with foam fractionation. This lower destruction percentage requires less energy to achieve and, therefore, is less costly.

Developing cost estimates for PFAS treatment by PRD are highly dependent on PFASigator influent flow rate, PFASigator influent PFAS concentration, and target PFASigator effluent PFAS concentration (or order of magnitude destruction targets). For this revised estimate, we made the following assumptions to provide a range of site-specific cost estimate scenarios that illustrate the capability of PRD to destroy PFAS:

- SAFF concentrate (i.e. PFASigator influent) flow rate is 100 gallons per day (GPD)
- SAFF concentrate (i.e. PFASigator influent) PFAS concentrations are those in the sample provided
- Post treatment (i.e. PFASigator effluent) concentration objective for multiple targets of individual PFAS and PFAS groups is one order of magnitude (90%) lower than in the SAFF concentrate. This objective was selected as a conservative estimate to ensure that the energy used would be sufficient to ensure performance success.

Note that all cost calculations presented are directly related to the treated volumes of SAFF-concentrate and not raw groundwater.

As shown in **Table A1-3-1**, the EEO value is heavily dependent on the analyte or group of analytes for which it was calculated. For example, the energy consumption for treating all PFAS (known and unknown, as determined by fluoride release measurements, 1,300 kWh/m³-order) is 2.7 to 4.6 times higher than treating specific, measured PFAS compounds or groups of compounds. With this in mind, cost projections were calculated for destruction of a variety of groups of target compounds (Targets 1, 2 and 3 in **Table A1-3-2**). The calculated EEOs were used to estimate the appropriate number of PFASigator systems and energy consumption required to achieve each target. Results are presented in **Table A1-3-2**.

The target scenarios presented in **Table A1-3-2** are listed with increasingly stringent requirements, from Target 1 to Target 3. The targets represent a variety of potential regulatory requirements and cleanup objectives as the PFASigator can be tuned to achieve the selected target:

Target 1: EPA MCL PFAS – This scenario provides a cost projection for destroying the sum of all six EPA MCL PFAS by 90%. The model suggests 340 kWh/m³ UV dose will achieve this objective.

Target 2: Total Known PFAS – This scenario provides a cost projection for destroying the sum of all 40 PFAS by 90%. This grouping includes more compounds and more short-chain compounds than Target 1. The model suggests 480 kWh/m³ UV dose will achieve this objective.

Target 3: Total Known PFAS + Unknown Precursors – This scenario provides a cost projection for destroying all 40 PFAS as in Target 2 plus the unknown precursors present in the original sample (as represented by the fluoride release) by 90%. The model suggests 1,300 kWh/m³ UV dose will achieve this objective.

In addition, **Table A1-3-2** presents the capital cost of purchasing a field-ready PFAS destruction system, and the cost of daily operation for field-scale application:

- **Capital Expenditure (CAPEX):** Given that PFASigator is commercial-scale equipment designed and manufactured for field application, the bench-scale testing results are used to estimate the number of PFASigator needed and the associated capital cost of purchase and installation.
- **Operating Expenditure (OPEX):** The estimated operation cost includes itemized costs in energy, chemical reagents, analytical chemistry, safety protection, and labor. The energy, chemical reagents, and materials usage rates are estimated by the quantified reaction rates shown in the previous discussion.

A summary of cost drivers for full-scale implementation of the PFASigator is provided in **Appendix D of the Final Report**.

Table A1-3-2. Cost estimate for groundwater and surface water PFAS destruction scenario

		Target 1: EPA MCL PFAS	Target 2: Total known PFAS	Target 3 Total known PFAS + unknown precursors
Destruction Targets	Remediation Targets	PFNA, PFOA, PFHxA, PFBA, PFOS, PFHxS, PFBS, HFPO-DA	All 40 PFAS analytical compounds	All 40 PFAS analytical compounds + unknown PFAS precursors/ compounds
	Destruction % Targets	90.0%	90.0%	90.0%
	EEO (kWh/m ³ -order) ⁽¹⁾	340	480	1,300
	Destruction Energy Usage (kWh/gal)	1.3	1.8	4.9
Example Site Application Scenarios	PFAS Concentrate Flow Rate	100 GPD		
	\$/gallon ⁽²⁾⁽³⁾⁽⁴⁾	\$1.63	\$1.63	\$4.88
	\$/gallon (CAPEX)	\$0.64	\$0.64	\$1.92
	\$/gallon (OPEX)	\$0.99	\$0.99	\$2.96
	# of PFASigators Needed	1	1	3
	24-hour Total Energy Use (Cost) ⁽⁵⁾	156 kW (\$30)	156 kW (\$30)	468 kW (\$89)

(1) EEO values are from Table A1-3-1.

(2) Cost includes both CAPEX and OPEX. PFASigator lifetime is assumed as 15 years as a robust water treatment equipment. Monthly PFASigator OPEX includes all reagents and delivery to site, and IP sublicense. Routine maintenance, discharge compliance sampling and analysis, and energy costs not included.

(3) Equipment price and monthly subscription price for applied PFASigator model are obtained from Ensplied Solutions.

(4) PFASigator is fully automated such that minimum labor is anticipated to operate it. Real-time end-product fluoride data can be accessed remotely via a web-based data portal.

(5) Based on 2023 residential electric supply rate for Michigan, \$0.19 per KWh.

Under this process scenario for SAFF-concentrated groundwater and surface water, the PFAS destruction cost is within a range of \$1.63/gal to \$4.88/gal. This field-proven application scenario is a 50% - 70% cost reduction compared to the costs previously proposed in the Final Report. Not surprisingly, with more stringent requirements (i.e. more target compounds as in Targets 2 and 3), the PFAS destruction cost increases. For a given SAFF concentrate flow rate of 100 GPD, the energy usage for PFAS destruction ranges from 156 kW/day to 468 kW/day or approximately \$30-\$89/day.

Using PRD technology to destroy concentrated PFAS with foam fractionation in a recirculating process flow as in Targets 1 through 3 of **Table A1-3-2** can be considered optimum conditions for PFASigator and high efficiency PFAS destruction. PRD efficiency is optimized when

concentrations of PFAS in PFASigator influent are high and the ratio of PFAS mass destroyed per UV dose is high, and small amounts of PFAS are discharged back to the SAFF for re-concentration.

To establish site-specific treatment costs for scenarios with PFAS treatment targets greater than one order of magnitude reduction in PFAS, additional testing can be conducted to increase the UV dose beyond the maximum dose tested, 5,400 kWh/m³, then fit a model curve to the new data set to predict energy use to achieve the new target.

4 COMMERCIAL READINESS OF PFASIGATOR



Figure A1-4-1 — PFASigator pilot demonstration, November 2023. Pilot-scale treatment plant including totes of contaminated groundwater (left), the foam fractionation unit (center back, provided and operated by ECT2) and PFASigator (right).

In November 2023, ES launched a pilot demonstration of our groundbreaking PFAS destruction technology, the PFASigator, combined with foam fractionation to treat PFAS-contaminated groundwater (**Figure 4-1**). Results of this project demonstrate the ability to destroy PFAS in contaminated groundwater at commercial scale using the PFASigator, eliminate the need for off-site PFAS disposal, and meet site-specific PFAS discharge criteria.

Specific results from the demonstration include:

1. **Transformed high-volume, low-PFAS groundwater into destruction-ready concentrate.** Approximately 50,000 gallons of groundwater were treated during the pilot project. The foam fractionation unit successfully separated and concentrated PFAS from the source groundwater and produced destruction-ready foam concentrate. During foam fractionation, the PFOS concentration increased from approximately 1,500 ppt in the source groundwater to 600,000 ppt in the foam concentrate that was delivered to the PFASigator.

2. **Efficiently destroyed PFAS on site.** PFAS destruction efficiencies using PFASigator were excellent. After a startup period during which operational conditions were optimized for both the foam fractionation unit and PFASigator, PFOS destruction extents in test batches ranged from 87.2% to 99.7%. Total PFAS destruction extents ranged from 85.2% to 96.2%.
3. **Recirculating process flow achieved discharge limit and zero off-site PFAS disposal.** PFASigator effluent was re-cycled back to the foam fractionation unit at the start of the recirculating PFAS treatment loop. By blending PFASigator discharge with the source groundwater, steady-state operation was achieved between foam fractionation and PFAS destruction while maintaining < 4 ppt PFOS in the full System Effluent. This closed-circuit concentration and destruction loop eliminated the need for off-site PFAS disposal.
4. **Real-time fluoride monitoring confirms PFAS destruction.** As PFAS destruction occurs and carbon-fluorine bonds are broken in PRD, fluorine is released into solution as inorganic fluoride ions. The PFASigator is equipped with a real-time fluoride ISE probe. From start to end of the PFAS destruction batch, over 96% of the decrease in organic fluorine is accounted for by the observed increase in fluoride ions. The excellent fluorine mass balance achieved using PRD indicates 1) the utility of using fluoride ion as a proxy for extent of PFAS destruction and 2) the PRD reaction defluorinates PFAS with little loss of PFAS to other pathways such as physical adsorption, conversion into toxic byproducts, etc.

Attachment G7: Onvector Final Report

Destruction of PFAS in Secondary Foamate derived from Foam Fractionation of Groundwater using a Plasma Vortex Reactor

Executive Summary

Prepared for: Minnesota Pollution Control Agency
SWIFT Contract No. 232225

Report date: April 11, 2024

Prepared by:
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A plasma vortex reactor system fabricated and operated by Onvector LLC was employed to destroy PFAS present in a 5-gallon sample of foam fractionation foamate (from groundwater treatment) obtained from MPCA. The sample was recirculated through the reactor for six hours, which reduced the total PFAS concentration in the groundwater from a starting value of 5,230 µg/L to a terminal value of 26.1 µg/L as measured by EPA Method 1633, a reduction of 99.5%. Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) were reduced from starting values of 1,700 µg/L and 3,200 µg/L respectively to terminal values of 0.29 µg/L and 2.1 µg/L respectively, representing reductions of 99.98% and 99.93% respectively. Plasma energy utilization in this trial as measured by EEO (energy expenditure per order of magnitude of total PFAS reduced) was 3,442 kWh/m³. A double-pass reverse osmosis process was used to further reduce the total PFAS concentration in the plasma-treated foamate to 30 ng/L. PFAS concentrations measured by ASTM Method D8421 generally correlated with the EPA Method 1633 measurements, while total organic fluoride (TOF) measured lower total PFAS concentrations than EPA Method 1633 measurements except for the terminal plasma-treated sample, which had an anomalously high total PFAS concentration based on TOF measurements.

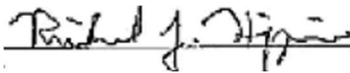
Total costs (capital costs plus operating costs) were calculated for a hypothetical plasma vortex reactor system destroying PFAS in foamate derived from a 1.25 million gallon per day (GPD) foam fractionation groundwater treatment process. Total costs were calculated as \$4.93 per gallon of foamate (or 14¢ per 100 gallons of groundwater), with energy costs representing 62% of the total, or \$3.07 per gallon of foamate.

Destruction of PFAS in Secondary Foamate derived from Foam Fractionation of Groundwater using a Plasma Vortex Reactor

Prepared for: Minnesota Pollution Control Agency
SWIFT Contract No. 232225

Report date: April 11, 2024

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Acronyms

AC	Alternating Current	kWh	Kilowatt-hour
AOP	Advanced Oxidation Process	PFAS	Per- and Poly-fluoroalkyl Substances
ARP	Advanced Reductive Process	PFBA	Perfluorobutanoic acid
ASTM	American Society for Testing and Materials	PFBS	Perfluorobutane sulfonate
CIC	Combustion Ion Chromatography	PFHxA	Perfluorohexanoic acid
EEA	Energy Expenditure Absolute	PFHxS	Perfluorohexane sulfonate
EEM	Energy Expenditure per unit Mass	PFNA	Perfluorononanoic acid
EEO	Energy Expenditure per Order Reduced	PFOA	Perfluorooctanoic acid
EPA	Environmental Protection Agency	PFOS	Perfluorooctane sulfonate
FF	Foam Fractionation	PFPeA	Perfluoropentanoic acid
F-ISE	Fluoride-Ion Specific Electrode	PFPrA	Perfluoropropionoic acid
GPD	Gallons per Day	PV/PVR	Plasma Vortex (Reactor)
GPM	Gallons per Minute	RO	Reverse Osmosis
HV	High Voltage	RVF	Reverse Vortex Flow
HX	Heat Exchanger	SCFM	Standard Cubic Feet per Minute
IC	Ion Chromatography	TOF	Total Organic Fluoride
kW	Kilowatt		

1. Scope of Treatability Study

The objective of this bench-scale treatability study was to evaluate Onvector's Plasma Vortex technology to destroy and mineralize PFAS in a sample of secondary foamate that was produced by foam fractionation of a PFAS-contaminated groundwater sample. Background on Plasma Vortex technology is provided in Appendix A. Specific objectives of the study included the following:

- Measure the trend of PFAS destroyed as a function of process time and of cumulative energy expenditure.
- Characterize the fluid behavior in the plasma vortex system during the destruction process.
- Evaluate the effectiveness of reverse osmosis as a polishing process downstream of the plasma vortex process.
- Summarize relevant observations that are pertinent to scale-up to an on-site pilot or demonstration scale system.

2. Experimental Design

Figure 1 shows a simplified process flow diagram for the Plasma Vortex system (additional detail on this system is provided in Appendix A) used for this study. In this system, aqueous liquid containing PFAS recirculates between a tank and the plasma reactor, where exposure to plasma degrades and ultimately mineralizes PFAS molecules. The system is purged of air at the start of a test and filled with argon, which is the plasma-forming gas.

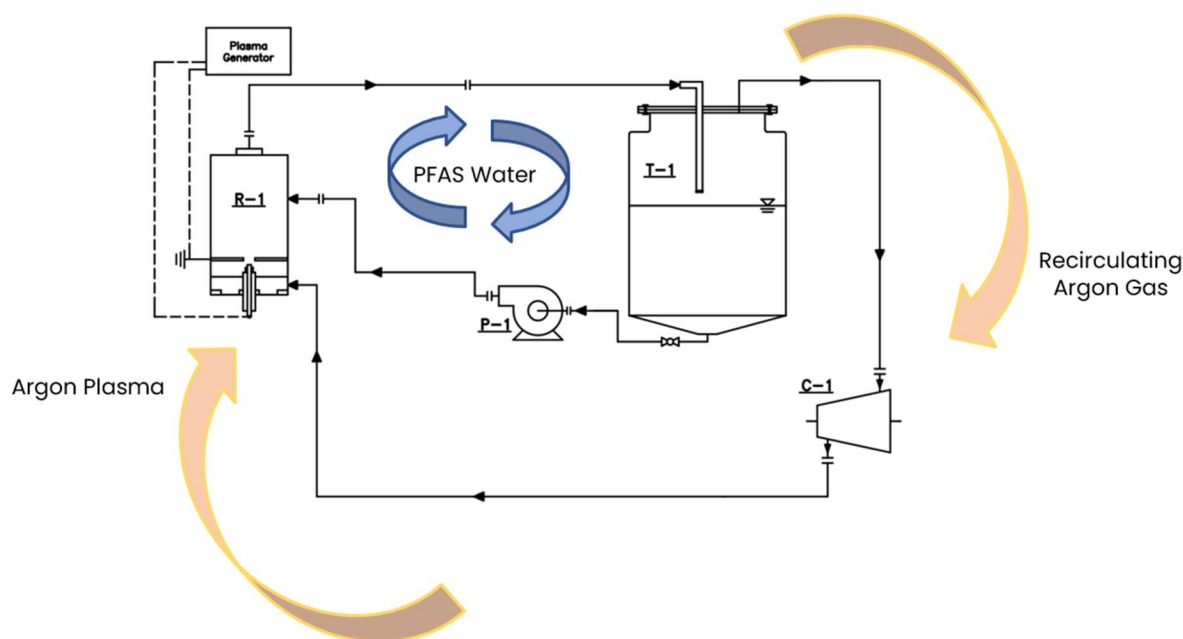


Figure 1. Simplified Process Flow Diagram of Laboratory Plasma Vortex System

Key test parameters in this study are shown in Table 1.

Parameter	Value or Range
Liquid (sample) volume	5 gallons
Recirculating water flow rate	8-10 gallons per minute (GPM)
Gas Composition	Argon
Gas Pressure (Tank)	5 to 11 psia
Recirculating gas flow rate	5-6 SCFM
Plasma power generator and output	25 kW (AC)
Process liquid temperature	55-65°C
Electrode Rod Material	Tungsten

Table 1. Test Parameters for Plasma Destruction Study

This test employed the plasma vortex reactor in “vacuum mode,” where the gas pressure in the tank and reactor was maintained below ambient pressure to reduce the ionization energy of plasma-forming gas per the Paschen curve. During this test, constant plasma power of 25 kW was applied.

Quality control for the testing involved measurement of background PFAS in the system tank prior to the subject test. This total PFAS concentration was < 200 ng/L, which was inconsequential compared to the starting concentration of total PFAS in the groundwater sample of the subject test.

Analytical testing of samples taken from the liquid tank of the system included the following:

- PFAS compound concentrations were measured by EPA Method 1633 (Pace Analytical Services LLC, West Columbia, SC; 40 compounds) and by ASTM Method D8421 (Pace Analytical Services LLC, West Columbia, SC; 44 compounds)
- Total fluorine (by combustion ion chromatography), total inorganic fluorine (by ion chromatography) and total organic fluorine (“TOF”, by difference) were measured by Novem Scientific, Woodbury, MN.
- Dissolved fluoride ion concentrations were measured using a fluoride ion-selective electrode by Onvector.
- pH, electrical conductivity and hydrogen peroxide concentrations were measured by Onvector.

Samples were collected at the start of the test (sample S1) and after every hour of Plasma Vortex operation for six cumulative hours (samples S2 through S7). Due to the large sample volumes required for EPA Method 1633 compared to the available volume of groundwater in the test, only samples S1 and S7 were analyzed by EPA Method 1633 and for total fluorine, total inorganic fluorine and TOF.

Double-pass reverse osmosis (RO) was investigated as a conceptual process option to remove essentially all PFAS compounds from the plasma-treated foamate with recycling of the first-stage RO retentate stream back to the plasma reactor. To evaluate the technical feasibility of this approach, two very small-scale portable seawater RO systems were utilized (SeaWater Pro Watermaker). Each system incorporated a single FilmTec SW30-2514 seawater RO membrane element. Execution of the RO trial involved first filtering most of the plasma-treated groundwater sample through the first RO system, with the permeate from this initial RO “pass” analyzed as sample S9. Subsequently, the permeate from the first RO system was passed through the second RO system, with sampling and analysis of the permeate from the second RO system as sample S9. Only sample S9 was analyzed by EPA Method 1633 and for total fluorine, total inorganic fluorine and TOF.

3. Results

Table 2 lists only the samples taken during the plasma destruction trial that were analyzed by EPA Method 1633 and presents plasma energy expenditure metrics and summarizes PFAS compound group concentrations based on this data. Over six cumulative hours of plasma vortex operation time, the total initial PFAS concentration of the foamate sample was reduced from about 5.2 mg/L to about 26 µg/L, representing a total PFAS destruction level of 99.74%. Specific PFAS compounds regulated by the EPA in drinking water (perfluorooctanoic acid, PFOA, and perfluorooctanesulfonic acid, PFOS) were each destroyed to higher levels of 99.98% and 99.93% respectively. The plasma energy expended per order of magnitude of total PFAS reduction (EEO) was calculated as 3,442 kWh/m³, with absolute plasma energy expenditure (EEA) of 7,925 kWh/m³. Use of double-pass RO to further treat the plasma-treated foamate reduced the total PFAS concentration in the foamate to 30 ng/L, with PFOA and PFOS concentrations reduced to 1.3 and 22 ng/L respectively.

Table 3 lists the non-PFAS analytical data collected during the testing, which were collected after every cumulative hour of plasma treatment of the foamate sample. The measured levels of hydrogen peroxide (H₂O₂) generation were indicative of significant formation of oxidative hydroxyl radicals by the plasma (although these are incapable of mineralizing PFAS to fluoride and decompose rapidly to form oxygen and water). The pH of the treated foamate was quite stable for the first three hours of plasma treatment, then dropped significantly for the latter three hours. For the first three hours of treatment, the pH trend may have been due to reactions of plasma-generated hydrogen radicals and ions with soluble constituents of the foamate that were not analyzed in this trial, while during the final three hours of the trial, plasma-generated hydrogen radicals were converted to hydrogen ions that did not react further with other soluble compounds. Total fluorine concentrations as measured by CIC at the start and end of the plasma treatment were not closely consistent: about 4.9 mg/L of total fluorine was measured at the start whereas about 6.0 mg/L of total fluorine was measured at the end of plasma treatment – at least one of these measurements must be affected by significant experimental error since there is no feasible means for 1.1 mg/L of unmeasured fluorine to be in the system at the start of the experiment. The inorganic fluoride concentration measured by IC at the start of the trial correlated well with the same concentration measured by the less precise F-ISE method, while the inorganic fluoride concentration measured by IC at the end of the trial corresponded with a PFAS mineralization level of between about 5.8 to 7 mg/L, somewhat higher than that measured by PFAS compound measurements (5.2 mg/L), which would be indicative of mineralization of PFAS compounds originally present in the foamate that were not specific analytes of the Method 1633 analysis.

Sample No.	Cumulative Treatment Time	Plasma Cycles	Plasma Energy Expenditure Absolute (EEA) (Cumulative)	Plasma Energy per Mass of PFAS Destroyed (EEM)	Plasma Energy per Order Reduced based on Total PFAS (EEO)	Plasma Power	Cumulative Plasma Energy	PFAS Analytical Results			
								PFOA	PFOS	Total PFAS	Total PFAS Mineralized
	(hours)	(#)	(kWh/m ³)	(kWh/kg)	(kWh/m ³) per order	kW	kWh	(ng/L)	(ng/L)	(ng/L)	(%)
S1	0	0	0	—	—	0.0	0.0	1,700,000	3,200,000	5,230,680.3	0%
S7	6	720	7925	1,524,896	3441.8	25.0	150.0	290	2,100	26,058	99.502%
S9 (RO permeate)								1.3	22	30.07	99.9994%

Table 2. List of Samples taken during Plasma Destruction (and subsequent RO processing) of Foamate; Plasma Energy Expenditure Metrics and Summary of PFAS compound concentrations as taken from EPA Method 1633 analytical data.

Sample #	S1	S2	S3	S4	S5	S6	S7
Sampling Time (Hours):	0	1	2	3	4	5	6
H ₂ O ₂ (mg/L)	0	17	23	35	65	65	65
pH	7.36	7.59	7.11	6.71	5.31	5.13	5.16
Conductivity (mS/cm)	1.3	1.3	1.4	1.4	1.8	2.0	1.9
Total Fluorine (mg/L) by CIC	4.942	NT	NT	NT	NT	NT	6.044
Inorganic F (mg/L) by IC	0.0857	NT	NT	NT	NT	NT	4.546
Fluoride ion by F-ISE (mg/L)	0.1	5	6	6	7	7	7

Table 3. Non-PFAS Analytical Data taken during Plasma Destruction of Foamate (NT = Not tested)

Table 4 provides a list of concentrations for all PFAS compounds that were measured above detection limits by Method 1633, as well as reduction levels due to plasma treatment and due to subsequent double-pass RO processing.

<i>Sample #</i>	S1	S7	S9		
			RO Permeate	Reduction after Plasma Treatment	Reduction after RO
Plasma Destruction Time (Hours):	0	6			
Perfluorotridecanoic acid (PFTrDA)	0	2.7	0		
Perfluorooctanesulfonamide (PFOSA)	0	6.5	0		
Perfluorohexanoic acid (PFHxA)	0	730	0		
Perfluorotetradecanoic acid (PFTeDA)	1.1	4.4	0	-300.00%	100.00%
Perfluorododecanoic acid (PFDoA)	8.2	2.6	0	68.29%	100.00%
Perfluoro-4-methoxybutanoic acid (PFMBA)	11	0	0	100.00%	100.00%
Perfluoro-3-methoxypropanoic acid (PFMPA)	18	23	0	-27.78%	100.00%
3-Perfluoropropyl propanoic acid (3:3FTCA)	30	0	0	100.00%	100.00%
Perfluoroundecanoic acid (PFUnA)	31	3	0	90.97%	100.00%
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	71	0	0	100.00%	100.00%
Hexafluoropropylene oxide dimer acid (HFPO-DA)	220	0	0	100.00%	100.00%
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	310	0	0	100.00%	100.00%
Perfluorobutanesulfonic acid (PFBS)	700	93	0	86.71%	100.00%
Perfluoropentanoic acid (PFPeA)	780	4,500	0	-476.92%	100.00%
3-Perfluoroheptyl propanoic acid (7:3FTCA)	1,500	0	0	100.00%	100.00%
Perfluorobutanoic acid (PFBA)	2,500	18,000	4.2	-620.00%	99.83%
Perfluorodecanoic acid (PFDA)	7,700	20	0	99.74%	100.00%
Perfluorononanoic acid (PFNA)	9,300	21	0.3	99.77%	99.9966%
Perfluoropentanesulfonic acid (PFPeS)	9,500	49	0	99.48%	100.00%
Perfluoroheptanesulfonic acid (PFHpS)	53,000	16	0.3	99.97%	99.9995%
Perfluoroheptanoic acid (PFHpA)	85,000	140	0	99.84%	100.00%
Perfluorohexanesulfonic acid (PFHxS)	160,000	57	1.7	99.96%	99.9989%
Perfluorooctanoic acid (PFOA)	1,700,000	290	1.3	99.98%	99.9999%
Perfluorooctanesulfonic acid (PFOS)	3,200,000	2,100	22	99.93%	99.9993%
Hazard Index:	18,730	8.5	0.2	99.95%	99.9988%
PFOS (ng/L):	3,200,000	2,100	22	99.93%	99.9993%
PFOA (ng/L):	1,700,000	290	1	99.98%	99.9999%
Total PFAS (ng/L):	5,230,680	26,058	29.8	99.50%	99.9994%

Table 4. Individual PFAS Compound Concentrations (ng/L) during Plasma Destruction Trial and after RO Processing (by EPA Method 1633) and Corresponding Reduction Levels

$$\text{Hazard Index} = \left(\frac{[\text{GenX}_{\text{water}}]}{[10 \text{ ppt}]} \right) + \left(\frac{[\text{PFBS}_{\text{water}}]}{[2000 \text{ ppt}]} \right) + \left(\frac{[\text{PFNA}_{\text{water}}]}{[10 \text{ ppt}]} \right) + \left(\frac{[\text{PFHxS}_{\text{water}}]}{[9.0 \text{ ppt}]} \right)$$

Table 4 also provides a calculation of the PFAS National Primary Drinking Water Proposal Hazard Index (“Hazard Index”), which combines the concentrations of four PFAS compounds known to have health effects and where compliance of the Hazard Index for drinking water requires a value of 1.0 or lower. Three short-chain PFAS compounds listed in Table 4 (PFBA, PFPeA and PFHxA) exhibit significantly increased concentrations from the start of the plasma trial to the end of the trial since these are intermediates that

are created during the destruction by plasma of longer-chain PFAS compounds. About 89% of the mass of PFAS compounds present in the treated foamate were comprised of these three short-chain compounds. PFOS and PFOA comprised about 93.7% of the mass of PFAS compounds in the untreated foamate. Reverse osmosis (RO) polishing of the plasma-treated foamate reduced most PFAS compound concentrations below detection limits, with only six PFAS compounds in the RO permeate having concentrations above detection limits and five of those six compounds with concentrations below 5 ng/L. Results from Table 4 are shown in graphical format in Figure 2.

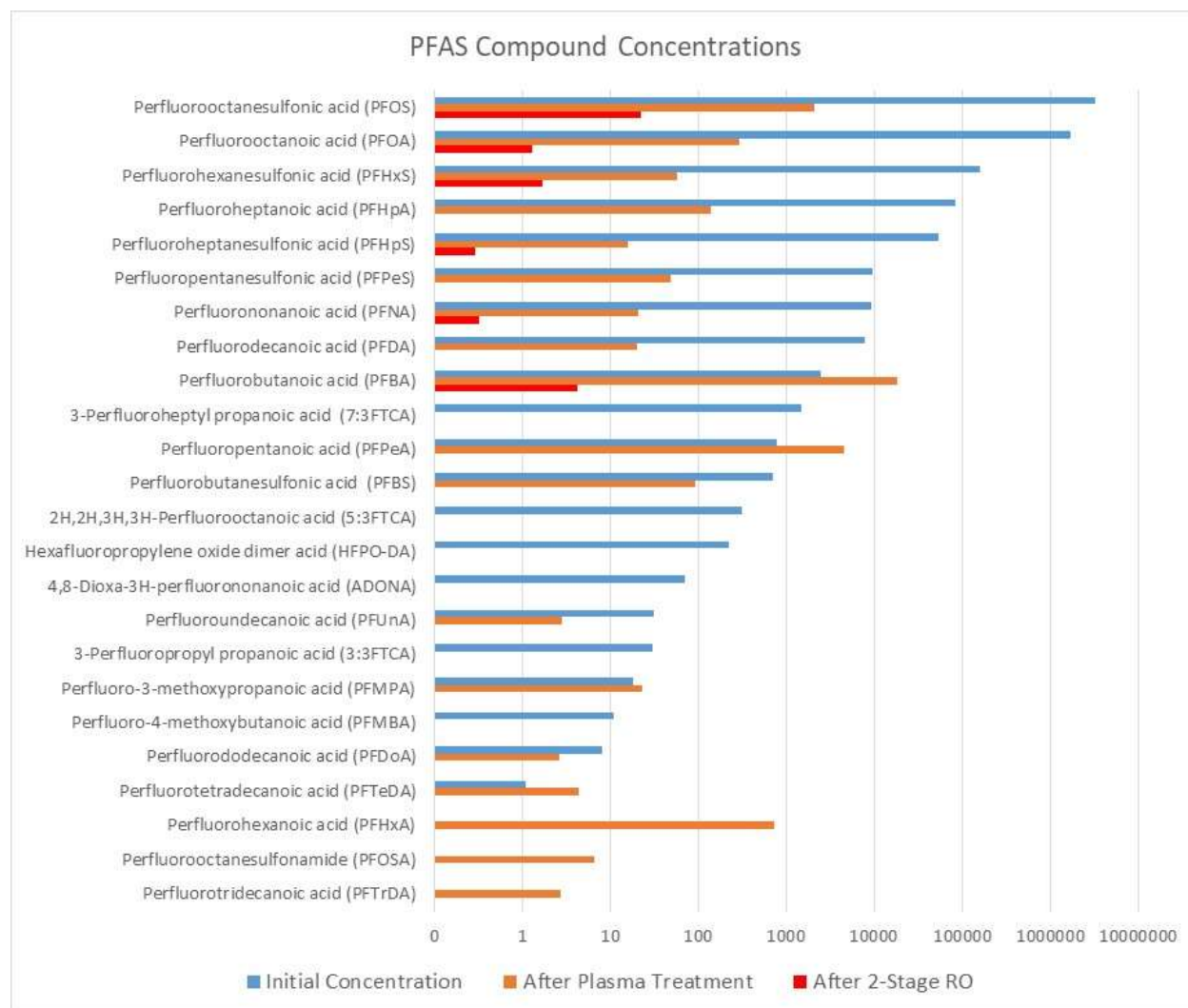


Figure 2. Individual PFAS Compound Concentrations (ng/L) during Plasma Destruction Trial and after RO Processing (by EPA Method 1633)

Foamate samples were also analyzed by ASTM Method D8421 to compare these results with EPA Method 1633 results. Table 5 provides summary total PFAS concentrations comparing the results for the two methods, in addition to showing total organic fluorine (TOF) measurements from the difference of total fluorine (by CIC) and total inorganic fluorine measurements (by IC). These results show that, for the untreated foamate and RO permeate samples, the concentrations measured by the three analysis methods have good correlation. However, for the 6-hour plasma-treated sample, the TOF results gave an

anomalously high total PFAS concentration compared to the other two methods. There is no clear explanation for this TOF result, since as mentioned above, there is no feasible means for about 1.5 mg/L of unmeasured (organic) fluorine to be in the system at the start of the experiment.

Foamate samples treated with plasma were analyzed by ASTM Method D8421 after every hour of treatment to provide trends for individual PFAS compound destruction and for plasma energy expenditure as a function of degree of PFAS destruction. A summary of these results is provided in Table 6. The calculated EEO value at the end of the plasma trial was moderately higher than that based on Method 1633 data. This data shows that the bulk of PFAS destruction occurred during the early part of the trial, as would be expected for a destruction process where mass transport of PFAS into the reactor is the rate-limiting step. Overall PFAS destruction levels were slightly lower than for the Method 1633 data, since higher total PFAS concentrations were measured with Method D8421. The specific reason for this, however, is that Method D8421 unlike Method 1633 measures the concentration of the very short-chain PFAS compound pentafluoropropanoic acid (PFPrA or “C-2”). The complete set of PFAS compound concentrations measured by Method D8421, as shown in Table 7, indicates that PFPrA was about 60% by mass of the total PFAS concentration in the end sample of the trial.

Sample No.	1633	D8421	TOF
	Total PFAS	Total PFAS	Total PFAS
	(ng/L)	(ng/L)	(ng/L)
S1 (Untreated)	5,230,680	4,648,900	4,856,300
S7 (Plasma-treated)	26,058	53,090	1,498,000
S9 (RO Permeate)	30	20	ND

Table 5. Comparison of Total PFAS Concentrations measured by EPA Method 1633, ASTM Method D8421, and Total Organic Fluorine (TOF).

Sample No.	Cumulative Treatment Time	Plasma Cycles	Plasma Energy Expenditure Absolute (EEA) (Cumulative)	Plasma Energy per Mass of PFAS Destroyed (EEM)	Plasma Energy per Order Reduced based on Total PFAS (EEO)	Plasma Power	Plasma energy	Cumulative Plasma Energy	PFAS Analytical Results			
									PFOA	PFOS	Total PFAS	Total PFAS Mineralized
	(hrs)	(#)	(kWh/m ³)	(kWh/kg)	(kWh/m ³) per order	kW	kWh	kWh	(ng/L)	(ng/L)	(ng/L)	(%)
240307-S01	0		0			0.0	0.0	0.0	1,500,000	2,900,000	4,648,900	0.000%
240307-S2	1	120	1,321	386,645	2284.3	25.0	25.0	25.0	330,000	750,000	1,227,800	73.589%
240307-S3	2	240	2,642	630,989	2620.4	25.0	25.0	50.0	87,000	260,000	456,270	90.185%
240307-S4	3	360	3,963	887,050	2783.8	25.0	25.0	75.0	16,000	64,000	175,359	96.228%
240307-S5	4	480	5,283	1,159,673	3052.6	25.0	25.0	100.0	3,200	13,000	86,404	98.141%
240307-S6	5	600	6,604	1,443,012	3569.0	25.0	25.0	125.0	690	4,200	65,599	98.589%
240307-S7	6	720	7,925	1,726,901	4080.2	25.0	25.0	150.0	290	2,000	53,090	98.858%
240307-S8	Permeate: 1st Stage RO								11	11	1,463	99.969%
240307-S9	Permeate: 2nd Stage RO								ND	13	20	99.9996%

Table 6. List of Samples taken during Plasma Destruction (and subsequent RO processing) of Foamate; Plasma Energy Expenditure Metrics and Summary of PFAS compound concentrations as taken from ASTM Method D8421 analytical data.

Table 7. Individual PFAS Compound Concentrations during Plasma Destruction Trial by ASTM Method D8421 (ND = Not Detected)

Sample #	S1	S2	S3	S4	S5	S6	S7	S8	S9
Sampling Time (Hours):	0	1	2	3	4	5	6		
Plasma Energy Expenditure Absolute (EEA), (kW/h/m ³):	0	1,321	2,642	3,963	5,283	6,604	7,925	1st Stage RO Permeate	2nd Stage RO Permeate
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	6,000	3,200	870	ND	ND	ND	11	6.6	6.7
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexafluoropropylene oxide dimer acid (HFPO-DA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
2H-perfluoro-2-decenoic acid (FOUEA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
2H-perfluoro-2-octenoic acid (FHUEA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-methyl perfluorooctanesulfonamide (NMeFOSA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentafluoropropanoic acid (PFPrA)	ND	24,000	33,000	41,000	38,000	35,000	32,000	860	ND
Perfluoro[2-ethoxyethane]sulfonic acid (PFEESA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluoro-3-methoxypropanoic acid (PFMPA)	ND	ND	ND	48	42	30	24	ND	ND
Perfluoro-4-methoxybutanoic acid (PFMBA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorobutanesulfonic acid (PFBS)	ND	ND	420	370	240	150	91	ND	ND
Perfluorobutanoic acid (PFBA)	ND	18,000	24,000	26,000	21,000	18,000	15,000	440	ND
Perfluorodecanesulfonic acid (PFDS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorodecanoic acid (PFDA)	5,100	ND	680	260	ND	31	19	ND	ND
Perfluorododecanesulfonic acid (PFDoS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorododecanoic acid (PFDoA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluoroheptanesulfonic acid (PFHpS)	37,000	9,700	2,400	530	110	25	12	ND	ND
Perfluoroheptanoic acid (PFHpA)	61,000	29,000	13,000	4,800	1,300	370	130	4.1	ND
3-Perfluoroheptyl propanoic acid (7:3FTCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	120,000	38,000	12,000	3,300	670	160	47	1.9	ND
Perfluorohexanoic acid (PFHxA)	ND	9,200	7,500	7,000	2,300	1,300	600	18	ND
Perfluorononanesulfonic acid (PFNS)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorononanoic acid (PFNA)	9,800	2,600	1,000	180	52	37	18	ND	ND
Perfluorooctanesulfonamide (PFOSA)	2,400	ND	ND	41	ND	8.2	3.5	ND	ND
Perfluorooctanesulfonic acid (PFOS)	2,900,000	750,000	260,000	64,000	13,000	4,200	2,000	11	13
Perfluorooctanoic acid (PFOA)	1,500,000	330,000	87,000	16,000	3,200	690	290	11	ND
Perfluoropentanesulfonic acid (PFPeS)	7,600	3,100	1,400	830	290	98	41	ND	ND
Perfluoropentanoic acid (PFPeA)	ND	11,000	13,000	11,000	6,200	5,500	2,800	110	ND
3-Perfluoropropyl propanoic acid (3:3FTCA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorotetradecanoic acid (PFTDA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluorotridecanoic acid (PFTDA)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perfluoroundecanoic acid (PFUnA)	ND	ND	ND	ND	ND	ND	4	ND	ND
Total PFAS (ng/L):	4,648,900	1,227,800	456,270	175,359	86,404	65,599	53,090	1,463	19.7
PFAS Reduction	0.0%	73.589%	90.185%	96.228%	98.141%	98.589%	98.858%	99.969%	99.9996%

4. Implications for Scale-up

Scale-up calculations were performed as follows. The daily generation rate of foamate from a foam fractionation (FF) unit at a groundwater remediation site producing 1,250,000 gallons per day (GPD) of groundwater containing 1.5 µg/L total PFAS was calculated as 359 GPD based on the PFAS concentrations in groundwater and in the foamate used in this test, as shown in Table 8.

Test Process Parameters:		
Groundwater Flow Rate	1,250,000	GPD
Typical PFAS Conc. In Groundwater	1.5	µg/L
Calculated Foamate Flow Rate	359	GPD
Actual PFAS Conc. In Foamate	5,230	µg/L
FF Concentration Factor	3,487	

Table 8. Estimate of Daily Foamate Production Rate from Groundwater Remediation Site

Using the data developed in this laboratory test, for the five-gallon batch size used in the test, a three-hour plasma exposure time was sufficient to destroy about 99% of regulated long-chain PFAS compounds; this is a level for which either the plasma-treated foamate can be re-cycled to the front of the PFAS removal process or the plasma-treated foamate can be treated with double-pass reverse osmosis (RO) to produce nearly PFAS-free water as permeate that can be discharged.

The preferred process parameters for a scaled-up plasma destruction process that would destroy PFAS in 359 GPD of foamate are shown in Table 9. Here, a ten-reactor ("Type 10") plasma vortex destruction system is sized appropriately to treat 360 GPD of foamate at a 90% utilization rate. A 7.2-hour plasma destruction cycle for a 12-gallon batch size at 25 kW is assumed. For this process, the total electrical energy required (for plasma and all other system equipment) is about 7,364 kWh/day, which corresponds to an energy cost of \$3.07 per gallon of foamate at \$0.12 per kWh.

Scale-up Process Parameters:		
Mass of PFAS destroyed daily	7.017	g/day
Estimated cycle time, 12 gallon batch	7.2	hrs.
2 batches per 24 hour day	90.0%	Utilization
Daily destruction capacity	360	GPD
Energy required, daily	7,364	kWh

Table 9. Projected Plasma Destruction Process Parameters based on Lab Test Results

Table 10 provides the total cost of this process when all operating costs are included and the installed cost of the Type 10 system is included with a ten-year depreciation period. The capital costs here do not include the costs of a double-pass reverse osmosis system. Operating cost components include costs for total system electrical energy, operator time, and periodic electrode replacement and maintenance.

Total Cost per annum	\$	648,407
Total Cost per gallon foamate	\$	4.93
Total Cost per gallon groundwater	\$	0.0014

Table 10. Total cost (OpEx + CapEx) for Projected Plasma Destruction Process

Of interest is the fact that about 60% of the total cost is due to energy consumption costs.

Appendices

Appendix A: Background on Plasma Vortex Reactor System

Figure A-1 provides a schematic diagram of Onvector's laboratory Plasma Vortex reactor system for destruction of PFAS in liquid samples. Here, water contaminated with PFAS is loaded and sealed into a tank, leaving some headspace for gas within the tank. The tank headspace and piping of the system can be evacuated and back-filled with an inert gas such as argon. During operation to destroy PFAS, the system is fully sealed. Water is pumped from the tank via the water pump into the plasma reactor (described in more detail below) while gas and PFAS foam are pumped separately into the reactor via action of the vacuum pump. PFAS in the water, foam and gas phases are degraded and destroyed due to exposure to plasma. The water, foam, and gas exit the reactor and are re-circulated to the tank. Multiple cycles of the water volume are passed through the reactor to reduce the PFAS concentration by orders of magnitude, while foam is broken down rapidly and eventually completely disappears from the tank and gas lines. Heat exchangers on the water and gas lines are used to stabilize the temperature of these fluids during the plasma operation, as the action of plasma provides significant heat input into the (closed) system. The gas pressure in the system can vary from as low as about 300 millibars to as high as about 1.5 bar.

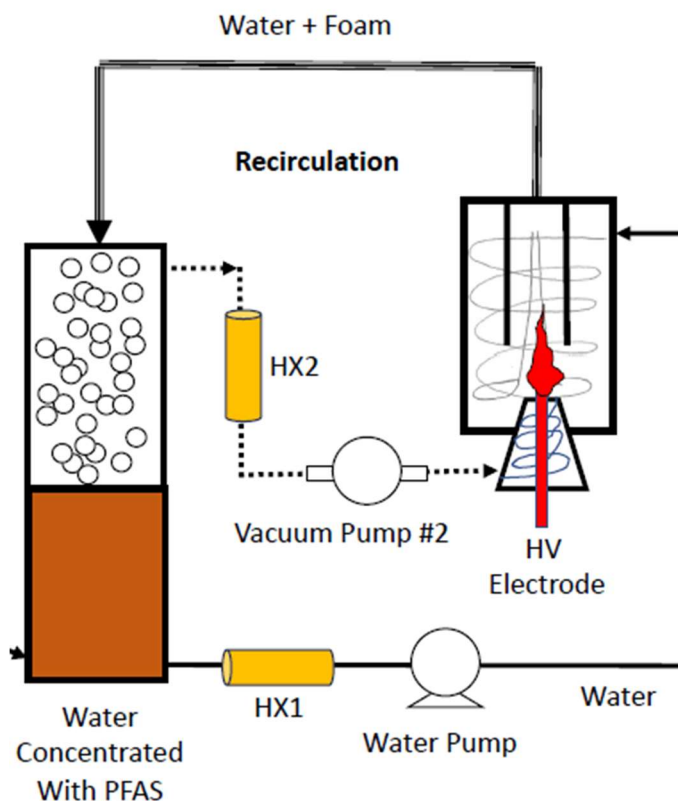


Figure A-1. Schematic Diagram of Onvector's Laboratory Plasma Destruction System (HV = high voltage: HX = heat exchanger)

This system incorporates Onvector's patented plasma vortex reactor, which has the capability to destroy and, ultimately, fully mineralize PFAS compounds. Plasma is ionized gas, considered a fourth state of

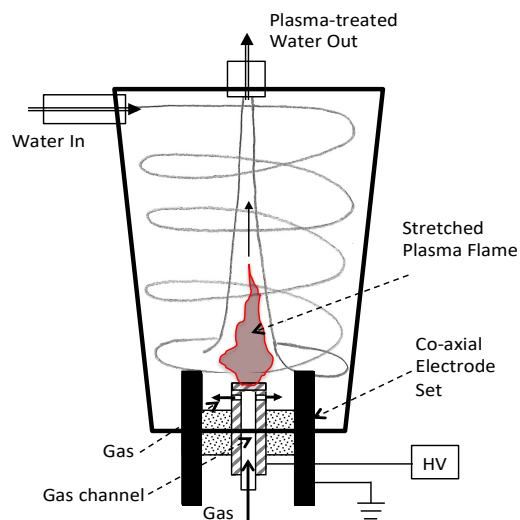


Figure A-2. Block diagram of plasma vortex water treatment reactor. (Not to scale.)

Due to the geometry of gas flow into the plasma reactor, the power electrodes resist erosion since the gas cools them. This reactor also maintains stable plasma discharge regardless of the conductivity of the liquid. Furthermore, the design stretches the plasma arc into the liquid, maximizing the generated reactants' penetration volume and increasing the effective residence time for PFAS compounds within the reaction volume. Compared to competing plasma-based technologies, this reactor design maintains a larger and more reliable plasma "cloud" throughout the treatment process. Furthermore, the plasma-forming gas in this system is fully re-circulated, so there are no gaseous PFAS emissions that escape to the environment. Yet another advantage of this reactor is the capability to maintain stable plasma when foam is present in the gas phase – this feature is enabled by the proprietary AC power supply that is employed to maintain the plasma power level at a closely regulated value.

matter, while plasma-based water treatment is a technology that, using primarily electricity, converts gas and water into a mixture of highly reactive species including $\cdot\text{OH}$, O , $\text{H}\cdot$, $\text{HO}_2\cdot$, $\text{O}_2\cdot^-$, H_2 , O_2 , H_2O_2 , and aqueous, or solvated, electrons (e^-_{aq}). In addition to being classified as an advanced oxidation process (AOP), plasma is one of only a few advanced reductive processes (ARP) for PFAS water treatment due to its capability to generate strong reducing radicals, especially solvated electrons (e^-_{aq}) that are primarily responsible for degradation of PFAS molecules. Plasma has a categorical advantage in destroying PFAS over all other AOP since even strong oxidizing species generated in AOP will not degrade all PFAS compounds (particularly sulfonates/sulfonic acids). A diagram of the plasma vortex reactor is shown in Figure A-2. In this reactor, the gas utilized to form plasma enters the reactor by flowing around and through the power electrode (high voltage - HV), thereby preventing direct contact of water with the electrode and hence avoiding short-circuit quenching. A key innovation in the hydraulic design of this reactor is in the use of reverse vortex flow (RVF), in which the point source plasma arc makes close contact with flowing contaminated water at the bottom of the reactor within a spatial region where the contaminated water switches flow direction. This approach reduces mass transfer constraints, thereby allowing the plasma to efficiently break chemical bonds in contaminant species.

Figure A-3 provides a photo of the laboratory plasma vortex reactor system (the AC power supply is not shown in this photo). The reactor is at the upper left, while the water tank is at right center and the water pump is underneath the reactor. The vacuum pump (not in the photo) is to the left of the water pump.



Figure A-3. Photograph of Onvector's Laboratory Plasma Destruction System (AC Power Supply and Vacuum Pump not shown).

Appendix B: Analytical Data

Appended analytical data from Pace Analytical Laboratories is comprised as follows:

Report ZC12002: EPA Method 1633 data and total fluorine/inorganic fluorine/TOF data

Report ZC12001: ASTM Method D8421 data



Report of Analysis

Onvector

444 Somerville Avenue
Somerville, MA 02143
Attention: Daniel Cho

Project Name: 240307

Project Number: 240307

Lot Number: **ZC12002**

Date Completed: 03/22/2024

03/22/2024 10:55 AM

Approved and released by:

Project Manager II: **Edward Barnett**



The electronic signature above is the equivalent of a handwritten signature.

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PACE ANALYTICAL SERVICES, LLC

SC DHEC No: 32010001

NELAC No: E87653

NC DENR No: 329

NC Field Parameters No: 5639

Case Narrative Onvector Lot Number: ZC12002

This Report of Analysis contains the analytical result(s) for the sample(s) listed on the Sample Summary following this Case Narrative. The sample receiving date is documented in the header information associated with each sample.

All results listed in this report relate only to the samples that are contained within this report. Where sampling is conducted by the client, results relate to the accuracy of the information provided, and as the samples are received.

Sample receipt, sample analysis, and data review have been performed in accordance with the most current approved The NELAC Institute (TNI) standards, the Pace Analytical Services, LLC ("Pace") Laboratory Quality Manual, standard operating procedures (SOPs), and Pace policies. Any exceptions to the TNI standards, the Laboratory Quality Manual, SOPs or policies are qualified on the results page or discussed below.

Pace is a TNI accredited laboratory; however, the following analyses are currently not listed on our TNI scope of accreditation: E. coli and Total coliforms SM 9223 B-2004, Solid Chemical Material: TOC Walkley-Black, Biological Tissue: All, Non-Potable Water: SGT-HEM EPA 1664B, Silica EPA 200.7, Boron, Calcium, Silicon, Strontium EPA 200.8, Bicarbonate, Carbonate, and Hydroxide Alkalinity SM 2320 B-2011, SM 9221 C E-2006 & SM 9222D-2006, Strontium SW-846 6010D, VOC SM 6200 B-2011, Fecal Coliform Colilert-18. If you have any questions regarding this report, please contact the Pace Project Manager listed on the cover page.

PACE ANALYTICAL SERVICES, LLC

SC DHEC No: 32010001

NELAC No: E87653

NC DENR No: 329

NC Field Parameters No: 5639

PFAS

The following sample was diluted due to the nature of the sample matrix: ZC12002-002. The LOQ has been elevated to reflect the dilution. Sample diluted due to dark color

ZC12002-002 (240307-S7) (Run 1) (Analysis Batch 98452) (Prep Batch 98343) 1633 Method List (Refrigerated)

Sample ZC12002-001 required centrifugation prior to extraction, due to excessive solids present in the samples. Centrifugation was performed following the PFAS Aqueous Centrifuge Protocol; samples were spiked with Surrogate (SUR; Extracted Internal Standard/EIS) and shaken vigorously before being poured into a conical bottle and centrifuged. The centrifuged aqueous sample was decanted back into the original sample bottle, off of the condensed solids remaining in the centrifuge bottle. Original sample bottle was rinsed as normal and centrifuge bottle was rinsed with 4mL of 1% amm-MeOH. Centrifuge bottle rinsate was added to the elution. Samples concentrated to 5mL

ZC12002-001 (240307-S1) (Run 1) (Analysis Batch 98393) (Prep Batch 98343) 1633 Method List (Refrigerated)

For samples ZC12002-001 sample matrix prevented full volume from being extracted, precluding method mandated bottle rinse. Elution solvent was aliquoted directly into the reservoir, rinsing the inside. Surrogate recovery may be adversely affected.

ZC12002-001 (240307-S1) (Run 1) (Analysis Batch 98393) (Prep Batch 98343) 1633 Method List (Refrigerated)

Surrogate recovery for the following sample was outside control limits: ZC12002-001. Evidence of matrix interference is present; therefore, re-extraction and/or re-analysis was not performed.

ZC12002-001 (240307-S1) (Run 1) (Analysis Batch 98393) (Prep Batch 98343) 1633 Method List (Refrigerated)

The following sample was diluted due to the nature of the sample matrix: ZC12002-001. The LOQ has been elevated to reflect the dilution. Samples were diluted due to re-extract.

ZC12002-001 (240307-S1) (Run 2) (Analysis Batch 98592) (Prep Batch 98543) 1633 Method List (Refrigerated)

Subcontracted Results

TOF was subcontracted to NOVEM Laboratories for analysis. The results are included after the Pace report of analysis.

PACE ANALYTICAL SERVICES, LLC

Sample Summary

Onvector

Lot Number: ZC12002

Project Name: 240307

Project Number: 240307

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	240307-S1	Aqueous	03/11/2024 1300	03/12/2024
002	240307-S7	Aqueous	03/11/2024 1400	03/12/2024
003	240307-S9	Aqueous	03/11/2024 1420	03/12/2024

(3 samples)

PACE ANALYTICAL SERVICES, LLC

Detection Summary

Onvector

Lot Number: ZC12002

Project Name: 240307

Project Number: 240307

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	240307-S1	Aqueous	ADONA	1633	71	Q	ng/L	7
001	240307-S1	Aqueous	5:3FTCA	1633	310	Q	ng/L	7
001	240307-S1	Aqueous	HFPO-DA	1633	220	Q	ng/L	7
001	240307-S1	Aqueous	PFMPA	1633	18		ng/L	7
001	240307-S1	Aqueous	PFMBA	1633	11		ng/L	7
001	240307-S1	Aqueous	PFBS	1633	700		ng/L	7
001	240307-S1	Aqueous	PFBA	1633	2500	Q	ng/L	7
001	240307-S1	Aqueous	PFDA	1633	7700	J	ng/L	7
001	240307-S1	Aqueous	PFDoA	1633	8.2		ng/L	7
001	240307-S1	Aqueous	PFHpS	1633	53000		ng/L	7
001	240307-S1	Aqueous	PFHpA	1633	85000		ng/L	7
001	240307-S1	Aqueous	7:3FTCA	1633	1500	Q	ng/L	7
001	240307-S1	Aqueous	PFHxS	1633	160000		ng/L	7
001	240307-S1	Aqueous	PFNA	1633	9300	J	ng/L	7
001	240307-S1	Aqueous	PFOS	1633	3200000		ng/L	7
001	240307-S1	Aqueous	PFOA	1633	1700000		ng/L	7
001	240307-S1	Aqueous	PFPeS	1633	9500	J	ng/L	7
001	240307-S1	Aqueous	PFPeA	1633	780		ng/L	7
001	240307-S1	Aqueous	3:3FTCA	1633	30		ng/L	7
001	240307-S1	Aqueous	PFTeDA	1633	1.1	J	ng/L	7
001	240307-S1	Aqueous	PFUnA	1633	31		ng/L	7
002	240307-S7	Aqueous	PFMPA	1633	23		ng/L	9
002	240307-S7	Aqueous	PFBS	1633	93		ng/L	9
002	240307-S7	Aqueous	PFBA	1633	18000		ng/L	9
002	240307-S7	Aqueous	PFDA	1633	20		ng/L	9
002	240307-S7	Aqueous	PFDoA	1633	2.6	J	ng/L	9
002	240307-S7	Aqueous	PFHpS	1633	16		ng/L	9
002	240307-S7	Aqueous	PFHpA	1633	140		ng/L	9
002	240307-S7	Aqueous	PFHxS	1633	57		ng/L	9
002	240307-S7	Aqueous	PFHxA	1633	730		ng/L	9
002	240307-S7	Aqueous	PFNA	1633	21		ng/L	9
002	240307-S7	Aqueous	PFOSA	1633	6.5	J	ng/L	9
002	240307-S7	Aqueous	PFOS	1633	2100		ng/L	9
002	240307-S7	Aqueous	PFOA	1633	290		ng/L	9
002	240307-S7	Aqueous	PFPeS	1633	49		ng/L	9
002	240307-S7	Aqueous	PFPeA	1633	4500		ng/L	9
002	240307-S7	Aqueous	PFTeDA	1633	4.4	J	ng/L	9
002	240307-S7	Aqueous	PFTrDA	1633	2.7	J	ng/L	9
002	240307-S7	Aqueous	PFUnA	1633	2.8	J	ng/L	9
003	240307-S9	Aqueous	PFBA	1633	4.2		ng/L	11
003	240307-S9	Aqueous	PFHpS	1633	0.29	J	ng/L	11
003	240307-S9	Aqueous	PFHxS	1633	1.7		ng/L	11
003	240307-S9	Aqueous	PFHxA	1633	0.26	J	ng/L	11

Detection Summary (Continued)

Lot Number: ZC12002

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
003	240307-S9	Aqueous	PFNA	1633	0.32	J	ng/L	11
003	240307-S9	Aqueous	PFOS	1633	22	S	ng/L	11
003	240307-S9	Aqueous	PFOA	1633	1.3		ng/L	11
(46 detections)								

PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12002-001		
Description: 240307-S1			Matrix: Aqueous		
Date Sampled: 03/11/2024 1300			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	1633	1633	1	03/15/2024 1859	ARC2	03/14/2024 1532	98343
2	1633	1633	1	03/20/2024 2042	ARC2	03/19/2024 1718	98543

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	1633	ND	Q	14	3.1	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	1633	ND	Q	14	2.4	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	1633	71	Q	14	2.4	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	1633	ND		14	2.2	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	1633	ND		14	1.4	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	1633	ND		18	7.3	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	1633	310	Q	90	15	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1633	220	Q	14	3.6	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	1633	ND		10000	1300	ng/L	2
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	1633	ND		10000	2900	ng/L	2
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	1633	ND		100000	6100	ng/L	2
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	1633	ND		10000	2200	ng/L	2
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	1633	ND		10000	2900	ng/L	2
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	1633	ND		100000	6300	ng/L	2
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	1633	ND	Q	7.2	2.1	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEESA)	113507-82-7	1633	ND	Q	7.2	1.3	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	1633	18		7.2	0.66	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	1633	11		7.2	1.4	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1633	700		3.6	0.34	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	1633	2500	Q	14	1.8	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	1633	ND	Q	3.6	0.59	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	1633	7700	J	10000	1400	ng/L	2
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	1633	ND	Q	3.6	0.55	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	1633	8.2		3.6	0.38	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	1633	53000		10000	1900	ng/L	2
Perfluoroheptanoic acid (PFHpA)	375-85-9	1633	85000		10000	2100	ng/L	2
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	1633	1500	Q	90	15	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	1633	160000		10000	1800	ng/L	2
Perfluorohexanoic acid (PFHxA)	307-24-4	1633	ND		10000	1400	ng/L	2
Perfluorononanesulfonic acid (PFNS)	68259-12-1	1633	ND		10000	1500	ng/L	2
Perfluorononanoic acid (PFNA)	375-95-1	1633	9300	J	10000	1000	ng/L	2
Perfluorooctanesulfonamide (PFOSA)	754-91-6	1633	ND		10000	2000	ng/L	2
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	1633	3200000		10000	2500	ng/L	2
Perfluorooctanoic acid (PFOA)	335-67-1	1633	1700000		10000	2100	ng/L	2
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	1633	9500	J	10000	2600	ng/L	2
Perfluoropentanoic acid (PFPeA)	2706-90-3	1633	780		7.2	0.66	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	1633	30		18	2.1	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	1633	1.1	J	3.6	0.97	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	1633	ND		3.6	0.70	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	1633	31		3.6	0.89	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)
106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12002-001
Description: 240307-S1	Matrix: Aqueous
Date Sampled: 03/11/2024 1300	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
13C2-4:2FTS		67	20-150		74	20-150
13C2-6:2FTS		38	20-150		70	20-150
13C2-8:2FTS		27	20-150		70	20-150
13C2-PFDoA		40	20-150		72	20-150
13C2-PFTeDA		43	20-150		73	20-150
13C3-HFPO-DA	N	16	20-150		79	20-150
13C3-PFBS		27	20-150		81	20-150
13C3-PFHxS	N	9.0	20-150		80	20-150
13C4-PFBA	N	19	20-150		78	20-150
13C4-PFHpA	N	16	20-150		74	20-150
13C5-PFHxA	N	19	20-150		78	20-150
13C5-PFPeA		25	20-150		82	20-150
13C6-PFDA	N	17	20-150		82	20-150
13C7-PFUnA		25	20-150		73	20-150
13C8-PFOA	N	19	20-150		78	20-150
13C8-PFOS	N	18	20-150		82	20-150
13C8-PFOSA	N	181	20-150		90	20-150
13C9-PFNA	N	15	20-150		78	20-150
D3-NMeFOSA		127	20-150		67	20-150
D3-NMeFOSAA		71	20-150		78	20-150
D5-NEtFOSA		136	20-150		70	20-150
D5-NEtFOSAA		50	20-150		79	20-150
D7-NMeFOSE		114	20-150		84	20-150
D9-NEtFOSE		116	20-150		82	20-150

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)
106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12002-002		
Description: 240307-S7			Matrix: Aqueous		
Date Sampled: 03/11/2024 1400			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	1633	1633	1	03/18/2024 2048	ARC2	03/14/2024 1532	98343

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	1633	ND		40	8.7	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	56426-58-1	1633	ND		40	6.7	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	1633	ND		40	6.6	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	1633	ND		40	6.1	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	1633	ND		40	4.0	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	1633	ND		50	20	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	1633	ND		250	43	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1633	ND		40	9.9	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	1633	ND		10	1.3	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	1633	ND		10	2.9	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	1633	ND		100	6.1	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	1633	ND		10	2.2	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	1633	ND		10	2.9	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	1633	ND		100	6.3	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	1633	ND		20	5.8	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEESA)	113507-82-7	1633	ND		20	3.6	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	1633	23		20	1.8	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	1633	ND		20	3.9	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1633	93		10	0.94	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	1633	18000		40	5.1	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	1633	ND		10	1.6	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	1633	20		10	1.4	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	1633	ND		10	1.5	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	1633	2.6 J		10	1.1	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	1633	16		10	1.9	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	1633	140		10	2.1	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	1633	ND		250	42	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	1633	57		10	1.8	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	1633	730		10	1.4	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	1633	ND		10	1.5	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	1633	21		10	1.0	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	1633	6.5 J		10	2.0	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	1633	2100		10	2.5	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	1633	290		10	2.1	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	1633	49		10	2.6	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	1633	4500		20	1.8	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	1633	ND		50	6.0	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	1633	4.4 J		10	2.7	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	1633	2.7 J		10	1.9	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	1633	2.8 J		10	2.5	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12002-002
Description: 240307-S7	Matrix: Aqueous
Date Sampled: 03/11/2024 1400	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		62	20-150
13C2-6:2FTS		56	20-150
13C2-8:2FTS		58	20-150
13C2-PFDoA		67	20-150
13C2-PFTeDA		57	20-150
13C3-HFPO-DA		69	20-150
13C3-PFBS		69	20-150
13C3-PFHxS		64	20-150
13C4-PFBA		70	20-150
13C4-PFHpA		69	20-150
13C5-PFHxA		69	20-150
13C5-PFPeA		67	20-150
13C6-PFDA		73	20-150
13C7-PFUnA		68	20-150
13C8-PFOA		73	20-150
13C8-PFOS		65	20-150
13C8-PFOSA		64	20-150
13C9-PFNA		68	20-150
D3-NMeFOSA		51	20-150
D3-NMeFOSAA		68	20-150
D5-NEtFOSA		52	20-150
D5-NEtFOSAA		60	20-150
D7-NMeFOSE		61	20-150
D9-NEtFOSE		56	20-150

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and $\geq$ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12002-003		
Description: 240307-S9			Matrix: Aqueous		
Date Sampled: 03/11/2024 1420			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	1633	1633	1	03/18/2024 2057	ARC2	03/14/2024 1532	98343

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	1633	ND		4.2	0.91	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	56426-58-1	1633	ND		4.2	0.70	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	1633	ND		4.2	0.69	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	1633	ND		4.2	0.63	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	1633	ND		4.2	0.41	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	1633	ND		5.2	2.1	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	1633	ND		26	4.5	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1633	ND		4.2	1.0	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	1633	ND		1.0	0.13	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	1633	ND		1.0	0.30	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	1633	ND		10	0.64	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	1633	ND		1.0	0.22	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	1633	ND		1.0	0.31	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	1633	ND		10	0.66	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	1633	ND		2.1	0.60	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEESA)	113507-82-7	1633	ND		2.1	0.38	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	1633	ND		2.1	0.19	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	1633	ND		2.1	0.40	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	1633	ND		1.0	0.098	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	1633	4.2		4.2	0.53	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	1633	ND		1.0	0.17	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	1633	ND		1.0	0.14	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	1633	ND		1.0	0.16	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	1633	ND		1.0	0.11	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	1633	0.29 J		1.0	0.20	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	1633	ND		1.0	0.22	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	1633	ND		26	4.3	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	1633	1.7		1.0	0.19	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	1633	0.26 J		1.0	0.15	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	1633	ND		1.0	0.15	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	1633	0.32 J		1.0	0.11	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	1633	ND		1.0	0.21	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	1633	22 S		1.0	0.26	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	1633	1.3		1.0	0.22	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	1633	ND		1.0	0.27	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	1633	ND		2.1	0.19	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	1633	ND		5.2	0.62	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	1633	ND		1.0	0.28	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	1633	ND		1.0	0.20	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	1633	ND		1.0	0.26	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12002-003
Description: 240307-S9	Matrix: Aqueous
Date Sampled: 03/11/2024 1420	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		68	20-150
13C2-6:2FTS		74	20-150
13C2-8:2FTS		71	20-150
13C2-PFDoA		84	20-150
13C2-PFTeDA		67	20-150
13C3-HFPO-DA		76	20-150
13C3-PFBS		73	20-150
13C3-PFHxS		71	20-150
13C4-PFBA		76	20-150
13C4-PFHpA		77	20-150
13C5-PFHxA		78	20-150
13C5-PFPeA		75	20-150
13C6-PFDA		78	20-150
13C7-PFUnA		78	20-150
13C8-PFOA		77	20-150
13C8-PFOS		68	20-150
13C8-PFOSA		70	20-150
13C9-PFNA		68	20-150
D3-NMeFOSA		52	20-150
D3-NMeFOSAA		55	20-150
D5-NEtFOSA		50	20-150
D5-NEtFOSAA		70	20-150
D7-NMeFOSE		64	20-150
D9-NEtFOSE		60	20-150

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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QC Summary

PFAS by LC/MS/MS - MB

Sample ID: ZQ98343-001

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
11CI-PF3OUdS	ND		1	4.0	0.87	ng/L	03/15/2024 1746
9CI-PF3ONS	ND		1	4.0	0.67	ng/L	03/15/2024 1746
ADONA	ND		1	4.0	0.66	ng/L	03/15/2024 1746
8:2FTS	ND		1	4.0	0.61	ng/L	03/15/2024 1746
4:2FTS	ND		1	4.0	0.40	ng/L	03/15/2024 1746
6:2FTS	ND		1	5.0	2.0	ng/L	03/15/2024 1746
5:3FTCA	ND		1	25	4.3	ng/L	03/15/2024 1746
HFPO-DA	ND		1	4.0	0.99	ng/L	03/15/2024 1746
NEtFOSA	ND		1	1.0	0.13	ng/L	03/15/2024 1746
NEtFOSAA	ND		1	1.0	0.29	ng/L	03/15/2024 1746
NEtFOSE	ND		1	10	0.61	ng/L	03/15/2024 1746
NMeFOSA	ND		1	1.0	0.22	ng/L	03/15/2024 1746
NMeFOSAA	ND		1	1.0	0.29	ng/L	03/15/2024 1746
NMeFOSE	ND		1	10	0.63	ng/L	03/15/2024 1746
NFDHA	ND		1	2.0	0.58	ng/L	03/15/2024 1746
2-ethoxyethane)sulfonic acid (PFEEESA	ND		1	2.0	0.36	ng/L	03/15/2024 1746
PFMPA	ND		1	2.0	0.18	ng/L	03/15/2024 1746
PFMBA	ND		1	2.0	0.39	ng/L	03/15/2024 1746
PFBS	ND		1	1.0	0.094	ng/L	03/15/2024 1746
PFBA	ND		1	4.0	0.51	ng/L	03/15/2024 1746
PFDS	ND		1	1.0	0.16	ng/L	03/15/2024 1746
PFDA	ND		1	1.0	0.14	ng/L	03/15/2024 1746
PFDoS	ND		1	1.0	0.15	ng/L	03/15/2024 1746
PFDoA	ND		1	1.0	0.11	ng/L	03/15/2024 1746
PFHpS	ND		1	1.0	0.19	ng/L	03/15/2024 1746
PFHpA	ND		1	1.0	0.21	ng/L	03/15/2024 1746
7:3FTCA	ND		1	25	4.2	ng/L	03/15/2024 1746
PFHxS	ND		1	1.0	0.18	ng/L	03/15/2024 1746
PFHxA	ND		1	1.0	0.14	ng/L	03/15/2024 1746
PFNS	ND		1	1.0	0.15	ng/L	03/15/2024 1746
PFNA	ND		1	1.0	0.10	ng/L	03/15/2024 1746
PFOSA	ND		1	1.0	0.20	ng/L	03/15/2024 1746
PFOS	ND		1	1.0	0.25	ng/L	03/15/2024 1746
PFOA	ND		1	1.0	0.21	ng/L	03/15/2024 1746
PFPeS	ND		1	1.0	0.26	ng/L	03/15/2024 1746
PFPeA	ND		1	2.0	0.18	ng/L	03/15/2024 1746
3:3FTCA	ND		1	5.0	0.60	ng/L	03/15/2024 1746
PFTeDA	ND		1	1.0	0.27	ng/L	03/15/2024 1746
PFTTrDA	ND		1	1.0	0.19	ng/L	03/15/2024 1746
PFUnA	ND		1	1.0	0.25	ng/L	03/15/2024 1746

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		78	20-150
13C2-6:2FTS		86	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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QC Data for Lot Number: ZC12002

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PFAS by LC/MS/MS - MB

Sample ID: ZQ98343-001

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Surrogate	Q	% Rec	Acceptance Limit
13C2-8:2FTS		71	20-150
13C2-PFDoA		70	20-150
13C2-PFTeDA		64	20-150
13C3-HFPO-DA		84	20-150
13C3-PFBS		78	20-150
13C3-PFHxS		81	20-150
13C4-PFBA		82	20-150
13C4-PFHpA		77	20-150
13C5-PFHxA		80	20-150
13C5-PFPeA		78	20-150
13C6-PFDA		71	20-150
13C7-PFUnA		71	20-150
13C8-PFOA		89	20-150
13C8-PFOS		88	20-150
13C8-PFOSA		80	20-150
13C9-PFNA		83	20-150
D3-NMeFOSA		59	20-150
D3-NMeFOSAA		92	20-150
D5-NEtFOSA		60	20-150
D5-NEtFOSAA		81	20-150
D7-NMeFOSE		72	20-150
D9-NEtFOSE		70	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

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PFAS by LC/MS/MS - LCS

Sample ID: ZQ98343-002

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Parameter	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
11CI-PF3OUdS	91	89		1	98	40-150	03/18/2024 1935
9CI-PF3ONS	90	98		1	109	40-150	03/18/2024 1935
ADONA	91	90		1	99	40-150	03/18/2024 1935
8:2FTS	92	110		1	115	40-150	03/18/2024 1935
4:2FTS	90	94		1	104	40-150	03/18/2024 1935
6:2FTS	91	110		1	118	40-150	03/18/2024 1935
5:3FTCA	600	550		1	91	40-150	03/18/2024 1935
HFPO-DA	96	92		1	95	40-150	03/18/2024 1935
NEtFOSA	24	28		1	117	40-150	03/18/2024 1935
NEtFOSAA	24	28		1	117	40-150	03/18/2024 1935
NEtFOSE	240	270		1	114	40-150	03/18/2024 1935
NMeFOSA	24	28		1	116	40-150	03/18/2024 1935
NMeFOSAA	24	26		1	109	40-150	03/18/2024 1935
NMeFOSE	240	260		1	109	40-150	03/18/2024 1935
NFDHA	48	45		1	94	40-150	03/18/2024 1935
2-ethoxyethane)sulfonic acid (PFEESA	43	42		1	98	40-150	03/18/2024 1935
PFMPA	48	51		1	106	40-150	03/18/2024 1935
PFMBA	48	44		1	93	40-150	03/18/2024 1935
PFBS	21	23		1	107	40-150	03/18/2024 1935
PFBA	96	100		1	106	40-150	03/18/2024 1935
PFDS	23	24		1	102	40-150	03/18/2024 1935
PFDA	24	26		1	110	40-150	03/18/2024 1935
PFDoS	23	23		1	101	40-150	03/18/2024 1935
PFDoA	24	22		1	94	40-150	03/18/2024 1935
PFHpS	23	26		1	114	40-150	03/18/2024 1935
PFHpA	24	25		1	104	40-150	03/18/2024 1935
7:3FTCA	600	560		1	93	40-150	03/18/2024 1935
PFHxS	22	25		1	113	40-150	03/18/2024 1935
PFHxA	24	23		1	97	40-150	03/18/2024 1935
PFNS	23	26		1	112	40-150	03/18/2024 1935
PFNA	24	23		1	97	40-150	03/18/2024 1935
PFOSA	24	25		1	103	40-150	03/18/2024 1935
PFOS	22	22		1	100	40-150	03/18/2024 1935
PFOA	24	24		1	101	40-150	03/18/2024 1935
PFPeS	23	26		1	116	40-150	03/18/2024 1935
PFPeA	48	50		1	104	40-150	03/18/2024 1935
3:3FTCA	120	120		1	101	40-150	03/18/2024 1935
PFTeDA	24	25		1	106	40-150	03/18/2024 1935
PFTTrDA	24	21		1	87	40-150	03/18/2024 1935
PFUnA	24	25		1	104	40-150	03/18/2024 1935
Surrogate	Q	% Rec	Acceptance Limit				
13C2-4:2FTS		87	20-150				
13C2-6:2FTS		78	20-150				

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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QC Data for Lot Number: ZC12002

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PFAS by LC/MS/MS - LCS

Sample ID: ZQ98343-002

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Surrogate	Q	% Rec	Acceptance Limit
13C2-8:2FTS		74	20-150
13C2-PFDoA		87	20-150
13C2-PFTeDA		75	20-150
13C3-HFPO-DA		81	20-150
13C3-PFBS		85	20-150
13C3-PFHxS		81	20-150
13C4-PFBA		82	20-150
13C4-PFHpA		80	20-150
13C5-PFHxA		84	20-150
13C5-PFPeA		83	20-150
13C6-PFDA		77	20-150
13C7-PFUnA		79	20-150
13C8-PFOA		78	20-150
13C8-PFOS		81	20-150
13C8-PFOSA		83	20-150
13C9-PFNA		80	20-150
D3-NMeFOSA		59	20-150
D3-NMeFOSAA		82	20-150
D5-NEtFOSA		59	20-150
D5-NEtFOSAA		77	20-150
D7-NMeFOSE		77	20-150
D9-NEtFOSE		74	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98343-102

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Parameter	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
11CI-PF3OUdS	7.6	7.2		1	95	40-150	03/18/2024 1944
9CI-PF3ONS	7.5	8.0		1	108	40-150	03/18/2024 1944
ADONA	7.6	7.9		1	104	40-150	03/18/2024 1944
8:2FTS	7.7	6.8		1	89	40-150	03/18/2024 1944
4:2FTS	7.5	7.5		1	100	40-150	03/18/2024 1944
6:2FTS	7.6	8.0		1	106	40-150	03/18/2024 1944
5:3FTCA	50	46		1	92	40-150	03/18/2024 1944
HFPO-DA	8.0	7.9		1	99	40-150	03/18/2024 1944
NEtFOSA	2.0	1.9		1	97	40-150	03/18/2024 1944
NEtFOSAA	2.0	2.1		1	107	40-150	03/18/2024 1944
NEtFOSE	20	22		1	108	40-150	03/18/2024 1944
NMeFOSA	2.0	2.1		1	105	40-150	03/18/2024 1944
NMeFOSAA	2.0	2.0		1	100	40-150	03/18/2024 1944
NMeFOSE	20	21		1	107	40-150	03/18/2024 1944
NFDHA	4.0	4.0		1	100	40-150	03/18/2024 1944
2-ethoxyethane)sulfonic acid (PFEESA	3.6	3.9		1	110	40-150	03/18/2024 1944
PFMPA	4.0	4.2		1	105	40-150	03/18/2024 1944
PFMBA	4.0	3.6		1	90	40-150	03/18/2024 1944
PFBS	1.8	1.7		1	96	40-150	03/18/2024 1944
PFBA	8.0	7.8		1	97	40-150	03/18/2024 1944
PFDS	1.9	1.8		1	93	40-150	03/18/2024 1944
PFDA	2.0	2.0		1	101	40-150	03/18/2024 1944
PFDoS	1.9	1.7		1	85	40-150	03/18/2024 1944
PFDoA	2.0	2.0		1	99	40-150	03/18/2024 1944
PFHpS	1.9	2.0		1	107	40-150	03/18/2024 1944
PFHpA	2.0	1.8		1	90	40-150	03/18/2024 1944
7:3FTCA	50	46		1	92	40-150	03/18/2024 1944
PFHxS	1.8	1.8		1	99	40-150	03/18/2024 1944
PFHxA	2.0	1.8		1	91	40-150	03/18/2024 1944
PFNS	1.9	1.8		1	95	40-150	03/18/2024 1944
PFNA	2.0	1.9		1	96	40-150	03/18/2024 1944
PFOSA	2.0	1.9		1	96	40-150	03/18/2024 1944
PFOS	1.9	1.6		1	88	40-150	03/18/2024 1944
PFOA	2.0	2.3		1	117	40-150	03/18/2024 1944
PFPeS	1.9	2.0		1	106	40-150	03/18/2024 1944
PFPeA	4.0	4.0		1	99	40-150	03/18/2024 1944
3:3FTCA	10	11		1	109	40-150	03/18/2024 1944
PFTeDA	2.0	1.9		1	97	40-150	03/18/2024 1944
PFTTrDA	2.0	2.0		1	100	40-150	03/18/2024 1944
PFUnA	2.0	2.1		1	105	40-150	03/18/2024 1944
Surrogate	Q	% Rec	Acceptance Limit				
13C2-4:2FTS		77	20-150				
13C2-6:2FTS		77	20-150				

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98343-102

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Surrogate	Q	% Rec	Acceptance Limit
13C2-8:2FTS		77	20-150
13C2-PFDoA		76	20-150
13C2-PFTeDA		73	20-150
13C3-HFPO-DA		76	20-150
13C3-PFBS		79	20-150
13C3-PFHxS		75	20-150
13C4-PFBA		76	20-150
13C4-PFHpA		76	20-150
13C5-PFHxA		78	20-150
13C5-PFPeA		79	20-150
13C6-PFDA		89	20-150
13C7-PFUnA		75	20-150
13C8-PFOA		80	20-150
13C8-PFOS		77	20-150
13C8-PFOSA		75	20-150
13C9-PFNA		83	20-150
D3-NMeFOSA		50	20-150
D3-NMeFOSAA		80	20-150
D5-NEtFOSA		54	20-150
D5-NEtFOSAA		71	20-150
D7-NMeFOSE		66	20-150
D9-NEtFOSE		65	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - MS

Sample ID: ZC12002-003MS

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Parameter	Sample Amount (ng/L)	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
11CI-PF3OUdS	ND	93	85		1	91	40-150	03/18/2024 2106
9CI-PF3ONS	ND	93	96		1	104	40-150	03/18/2024 2106
ADONA	ND	93	93		1	100	40-150	03/18/2024 2106
8:2FTS	ND	95	120		1	126	40-150	03/18/2024 2106
4:2FTS	ND	93	96		1	104	40-150	03/18/2024 2106
6:2FTS	ND	94	100		1	108	40-150	03/18/2024 2106
5:3FTCA	ND	620	630		1	101	40-150	03/18/2024 2106
HFPO-DA	ND	99	93		1	94	40-150	03/18/2024 2106
NEtFOSA	ND	25	29		1	115	40-150	03/18/2024 2106
NEtFOSAA	ND	25	22		1	89	40-150	03/18/2024 2106
NEtFOSE	ND	250	270		1	111	40-150	03/18/2024 2106
NMeFOSA	ND	25	28		1	112	40-150	03/18/2024 2106
NMeFOSAA	ND	25	27		1	111	40-150	03/18/2024 2106
NMeFOSE	ND	250	270		1	110	40-150	03/18/2024 2106
NFDHA	ND	49	51		1	102	40-150	03/18/2024 2106
2-ethoxyethane)sulfonic acid (PFEEESA	ND	44	45		1	102	40-150	03/18/2024 2106
PFMPA	ND	49	52		1	105	40-150	03/18/2024 2106
PFMBA	ND	49	48		1	98	40-150	03/18/2024 2106
PFBS	ND	22	29		1	130	40-150	03/18/2024 2106
PFBA	4.2	99	110		1	103	40-150	03/18/2024 2106
PFDS	ND	24	24		1	100	40-150	03/18/2024 2106
PFDA	ND	25	26		1	106	40-150	03/18/2024 2106
PFDoS	ND	24	20		1	83	40-150	03/18/2024 2106
PFDoA	ND	25	25		1	99	40-150	03/18/2024 2106
PFHpS	0.29	24	19		1	78	40-150	03/18/2024 2106
PFHpA	ND	25	26		1	104	40-150	03/18/2024 2106
7:3FTCA	ND	620	640		1	103	40-150	03/18/2024 2106
PFHxS	1.7	23	33		1	140	40-150	03/18/2024 2106
PFHxA	0.26	25	27		1	107	40-150	03/18/2024 2106
PFNS	ND	24	26		1	111	40-150	03/18/2024 2106
PFNA	0.32	25	27		1	107	40-150	03/18/2024 2106
PFOSA	ND	25	26		1	104	40-150	03/18/2024 2106
PFOS	22	23	86	N	1	281	40-150	03/18/2024 2106
PFOA	1.3	25	32		1	124	40-150	03/18/2024 2106
PFPeS	ND	23	23		1	101	40-150	03/18/2024 2106
PFPeA	ND	49	53		1	106	40-150	03/18/2024 2106
3:3FTCA	ND	120	150		1	121	40-150	03/18/2024 2106
PFTeDA	ND	25	27		1	111	40-150	03/18/2024 2106
PFTTrDA	ND	25	23		1	91	40-150	03/18/2024 2106
PFUnA	ND	25	28		1	112	40-150	03/18/2024 2106
Surrogate	Q	% Rec	Acceptance Limit					
13C2-4:2FTS		68	20-150					
13C2-6:2FTS		71	20-150					

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

QC Data for Lot Number: ZC12002

PFAS by LC/MS/MS - MS

Sample ID: ZC12002-003MS

Matrix: Aqueous

Batch: 98343

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/14/2024 1532

Surrogate	Q	% Rec	Acceptance Limit
13C2-8:2FTS		66	20-150
13C2-PFDoA		68	20-150
13C2-PFTeDA		48	20-150
13C3-HFPO-DA		65	20-150
13C3-PFBS		65	20-150
13C3-PFHxS		64	20-150
13C4-PFBA		67	20-150
13C4-PFHpA		66	20-150
13C5-PFHxA		63	20-150
13C5-PFPeA		63	20-150
13C6-PFDA		63	20-150
13C7-PFUnA		70	20-150
13C8-PFOA		66	20-150
13C8-PFOS		65	20-150
13C8-PFOSA		56	20-150
13C9-PFNA		64	20-150
D3-NMeFOSA		42	20-150
D3-NMeFOSAA		42	20-150
D5-NEtFOSA		38	20-150
D5-NEtFOSAA		73	20-150
D7-NMeFOSE		44	20-150
D9-NEtFOSE		33	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

QC Data for Lot Number: ZC12002

PFAS by LC/MS/MS - MB

Sample ID: ZQ98543-001

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
NEtFOSA	ND		1	1.0	0.13	ng/L	03/20/2024 1635
NEtFOSAA	ND		1	1.0	0.29	ng/L	03/20/2024 1635
NEtFOSE	ND		1	10	0.61	ng/L	03/20/2024 1635
NMeFOSA	ND		1	1.0	0.22	ng/L	03/20/2024 1635
NMeFOSAA	ND		1	1.0	0.29	ng/L	03/20/2024 1635
NMeFOSE	ND		1	10	0.63	ng/L	03/20/2024 1635
PFDA	ND		1	1.0	0.14	ng/L	03/20/2024 1635
PFHpS	ND		1	1.0	0.19	ng/L	03/20/2024 1635
PFHpA	ND		1	1.0	0.21	ng/L	03/20/2024 1635
PFHxS	ND		1	1.0	0.18	ng/L	03/20/2024 1635
PFHxA	ND		1	1.0	0.14	ng/L	03/20/2024 1635
PFNS	ND		1	1.0	0.15	ng/L	03/20/2024 1635
PFNA	ND		1	1.0	0.10	ng/L	03/20/2024 1635
PFOSA	ND		1	1.0	0.20	ng/L	03/20/2024 1635
PFOS	ND		1	1.0	0.25	ng/L	03/20/2024 1635
PFOA	ND		1	1.0	0.21	ng/L	03/20/2024 1635
PFPeS	ND		1	1.0	0.26	ng/L	03/20/2024 1635

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		81	20-150
13C2-6:2FTS		74	20-150
13C2-8:2FTS		74	20-150
13C2-PFDaA		79	20-150
13C2-PFTeDA		74	20-150
13C3-HFPO-DA		82	20-150
13C3-PFBS		83	20-150
13C3-PFHxS		91	20-150
13C4-PFBA		81	20-150
13C4-PFHpA		83	20-150
13C5-PFHxA		81	20-150
13C5-PFPeA		85	20-150
13C6-PFDA		87	20-150
13C7-PFUnA		74	20-150
13C8-PFOA		81	20-150
13C8-PFOS		77	20-150
13C8-PFOSA		82	20-150
13C9-PFNA		82	20-150
D3-NMeFOSA		66	20-150
D3-NMeFOSAA		77	20-150
D5-NEtFOSA		69	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - MB

Sample ID: ZQ98543-001

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Surrogate	Q	% Rec	Acceptance Limit
D5-NEtFOSAA		74	20-150
D7-NMeFOSE		80	20-150
D9-NEtFOSE		76	20-150

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

QC Data for Lot Number: ZC12002

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98543-002

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Parameter	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
NEtFOSA	24	25		1	105	40-150	03/20/2024 1644
NEtFOSAA	24	23		1	97	40-150	03/20/2024 1644
NEtFOSE	240	240		1	101	40-150	03/20/2024 1644
NMeFOSA	24	25		1	105	40-150	03/20/2024 1644
NMeFOSAA	24	24		1	99	40-150	03/20/2024 1644
NMeFOSE	240	250		1	104	40-150	03/20/2024 1644
PFDA	24	22		1	91	40-150	03/20/2024 1644
PFHpS	23	21		1	94	40-150	03/20/2024 1644
PFHpA	24	23		1	95	40-150	03/20/2024 1644
PFHxS	22	21		1	98	40-150	03/20/2024 1644
PFHxA	24	21		1	87	40-150	03/20/2024 1644
PFNS	23	21		1	90	40-150	03/20/2024 1644
PFNA	24	22		1	94	40-150	03/20/2024 1644
PFOSA	24	22		1	90	40-150	03/20/2024 1644
PFOS	22	21		1	96	40-150	03/20/2024 1644
PFOA	24	23		1	96	40-150	03/20/2024 1644
PFPeS	23	23		1	102	40-150	03/20/2024 1644
Surrogate	Q	% Rec	Acceptance Limit				
13C2-4:2FTS		92	20-150				
13C2-6:2FTS		98	20-150				
13C2-8:2FTS		79	20-150				
13C2-PFDaA		85	20-150				
13C2-PFTeDA		81	20-150				
13C3-HFPO-DA		89	20-150				
13C3-PFBS		95	20-150				
13C3-PFHxS		94	20-150				
13C4-PFBA		91	20-150				
13C4-PFHpA		91	20-150				
13C5-PFHxA		95	20-150				
13C5-PFPeA		92	20-150				
13C6-PFDA		90	20-150				
13C7-PFUnA		84	20-150				
13C8-PFOA		86	20-150				
13C8-PFOS		88	20-150				
13C8-PFOSA		92	20-150				
13C9-PFNA		87	20-150				
D3-NMeFOSA		71	20-150				
D3-NMeFOSAA		84	20-150				
D5-NEtFOSA		74	20-150				

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98543-002

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Surrogate	Q	% Rec	Acceptance Limit
D5-NEtFOSAA		76	20-150
D7-NMeFOSE		87	20-150
D9-NEtFOSE		84	20-150

LOQ = Limit of Quantitation

DL = Detection Limit

ND = Not detected at or above the DL

J = Estimated result < LOQ and $\geq$ DL

* = RSD is out of criteria

N = Recovery is out of criteria

P = The RPD between two GC columns exceeds 40%

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

QC Data for Lot Number: ZC12002

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98543-102

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Parameter	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
NEtFOSA	2.0	1.7		1	87	40-150	03/20/2024 1654
NEtFOSAA	2.0	1.8		1	90	40-150	03/20/2024 1654
NEtFOSE	20	18		1	91	40-150	03/20/2024 1654
NMeFOSA	2.0	1.8		1	89	40-150	03/20/2024 1654
NMeFOSAA	2.0	1.8		1	92	40-150	03/20/2024 1654
NMeFOSE	20	17		1	86	40-150	03/20/2024 1654
PFDA	2.0	1.8		1	92	40-150	03/20/2024 1654
PFHpS	1.9	2.2		1	116	40-150	03/20/2024 1654
PFHpA	2.0	1.9		1	94	40-150	03/20/2024 1654
PFHxS	1.8	1.6		1	85	40-150	03/20/2024 1654
PFHxA	2.0	1.8		1	92	40-150	03/20/2024 1654
PFNS	1.9	1.9		1	101	40-150	03/20/2024 1654
PFNA	2.0	2.1		1	104	40-150	03/20/2024 1654
PFOSA	2.0	1.8		1	92	40-150	03/20/2024 1654
PFOS	1.9	1.9		1	102	40-150	03/20/2024 1654
PFOA	2.0	1.7		1	85	40-150	03/20/2024 1654
PFPeS	1.9	1.8		1	96	40-150	03/20/2024 1654
Surrogate	Q	% Rec	Acceptance Limit				
13C2-4:2FTS		71	20-150				
13C2-6:2FTS		72	20-150				
13C2-8:2FTS		62	20-150				
13C2-PFDaA		91	20-150				
13C2-PFTeDA		78	20-150				
13C3-HFPO-DA		88	20-150				
13C3-PFBS		77	20-150				
13C3-PFHxS		77	20-150				
13C4-PFBA		89	20-150				
13C4-PFHpA		89	20-150				
13C5-PFHxA		86	20-150				
13C5-PFPeA		92	20-150				
13C6-PFDA		93	20-150				
13C7-PFUnA		90	20-150				
13C8-PFOA		97	20-150				
13C8-PFOS		76	20-150				
13C8-PFOSA		82	20-150				
13C9-PFNA		87	20-150				
D3-NMeFOSA		68	20-150				
D3-NMeFOSAA		78	20-150				
D5-NEtFOSA		72	20-150				

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12002

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98543-102

Matrix: Aqueous

Batch: 98543

Prep Method: 1633

Analytical Method: 1633

Prep Date: 03/19/2024 1718

Surrogate	Q	% Rec	Acceptance Limit
D5-NEtFOSAA		72	20-150
D7-NMeFOSE		83	20-150
D9-NEtFOSE		80	20-150

LOQ = Limit of Quantitation

DL = Detection Limit

ND = Not detected at or above the DL

J = Estimated result < LOQ and $\geq$ DL

* = RSD is out of criteria

N = Recovery is out of criteria

P = The RPD between two GC columns exceeds 40%

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

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QC Data for Lot Number: ZC12002

Chain of Custody and Miscellaneous Documents

Pace Analytical Services, LLC.
106 Vantage Point Drive
West Columbia, South Carolina 29172
Telephone No. (803) 791-8700 Fax No. (803) 791-9111
www.pacelabs.com

**Trace Analytical[®] Chain of Custody
Record**

[illegible]

PACE ANALYTICAL SERVICES, LLC

DC# Title: ENV-FRM-WCOL-0286 v02_Samples Receipt Checklist (SRC)

Effective Date: 8/2/2022

Sample Receipt Checklist (SRC)

Client: Onvector

Cooler Inspected by/date: MSL 3/12/24

Lot #: ZC12002

Means of receipt: ☐ Pace ☒ Client ☒ UPS ☐ FedEx ☐ Other:	
☒ Yes ☐ No	1. Were custody seals present on the cooler?
☐ Yes ☒ No ☐ NA	2. If custody seals were present, were they intact and unbroken?
pH Strip ID: <u>NA</u>	Chlorine Strip ID: <u>NA</u>
Original temperature upon receipt / Derived (Corrected) temperature upon receipt	
1.1 / 1.1 °C <u>NA</u> / <u>NA</u> °C <u>NA</u> / <u>NA</u> °C <u>NA</u> / <u>NA</u> °C	
Method: ☒ Temperature Blank ☐ Against Bottles IR Gun ID: <u>8</u> IR Gun Correction Factor: <u>0</u> °C	
Method of coolant: ☒ Wet Ice ☐ Ice Packs ☐ Dry Ice ☐ None	
☒ Yes ☐ No ☐ NA	3. Were all coolers received at or below 6.0°C? If no, was Project Manager notified? PM was Notified by: phone / email / face-to-face (circle one).
☒ Yes ☐ No ☐ NA	4. Is the commercial courier's packing slip attached to this form?
☒ Yes ☐ No	5. Were proper custody procedures (relinquished/received) followed?
☒ Yes ☐ No	6. Were sample IDs listed on the COC and all sample containers?
☐ Yes ☒ No	7. Was collection date & time listed on the COC and all sample containers?
☐ Yes ☒ No	8. Did all container label information (ID, date, time) agree with the COC?
☒ Yes ☐ No	9. Were tests to be performed listed on the COC?
☒ Yes ☐ No	10. Did all samples arrive in the proper containers for each test and/or in good condition (unbroken, lids on, etc.)?
☒ Yes ☐ No	11. Was adequate sample volume available?
☒ Yes ☐ No	12. Were all samples received within ½ the holding time or 48 hours, whichever comes first?
☒ Yes ☐ No	13. Were all samples containers accounted for? (No missing/excess)
☐ Yes ☐ No ☒ NA	14. Were VOA, 8015C and RSK-175 samples free of bubbles > "pea-size" (¼" or 6mm in diameter) in any of the VOA vials?
☐ Yes ☐ No ☒ NA	15. Were all DRO/metals/nutrient samples received at a pH of < 2?
☐ Yes ☐ No ☒ NA	16. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?
☐ Yes ☐ No ☒ NA	17. Were all applicable NH ₃ /TKN/cyanide/phenol/625.1/608.3 (< 0.5mg/L) samples free of residual chlorine?
☐ Yes ☒ No ☐ NA	18. Was the quote number listed on the container label? If yes, Quote #

Sample Preservation (Must be completed for any sample(s) incorrectly preserved or with headspace.)

Sample(s) NA were received incorrectly preserved and were adjusted accordingly in sample receiving with NA mL of circle one: H₂SO₄, HNO₃, HCl, NaOH using SR # NA.

Time of preservation NA. If more than one preservative is needed, please note in the comments below.

Sample(s) NA were received with bubbles > 6 mm in diameter.

Samples(s) NA were received with TRC > 0.5 mg/L (If #19 is no) and were adjusted accordingly in sample receiving with sodium thiosulfate (Na₂S₂O₃) with Unique ID: NA.

Comments: NO TITRALS ON ANY CONTAINERS

only rec'd 1-500mL PEAS container for 240307-S1

Customer: Pace WC
Customer Job ID: 240307

Sample Test Result

Novem Job ID: Novem24-038-001
Report Date: 2024-03-15

Sample Information

Customer Sample ID: 240307-S1

Novem Sample ID: Novem24-038-001

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	4942.0	ppb (µg/L)
Inorganic Fluoride	IC	IF	85.7	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	4856.3	ppb (µg/L)

TOF LOQ (20% of IF) = 17 ppb

Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 5 ppb to 500 ppb, RL for IF = 5 ppb F or dilution factor * 5

Calibration standards for TF = 20 ppb to 1000 ppb. RL for TF = 20 ppb or dilution factor * 20

Dilution Factor = 10



2357 Ventura Dr Suite 110
Woodbury MN 55125
info@novemscientific.com

Reviewed by: Andrew Christianson

Customer: Pace WC
Customer Job ID: 240307

Sample Test Result

Novem Job ID: Novem24-038-002
Report Date: 2024-03-15

Sample Information

Customer Sample ID: 240307-S7

Novem Sample ID: Novem24-038-002

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	6044.3	ppb (µg/L)
Inorganic Fluoride	IC	IF	4546.3	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	1498.0	ppb (µg/L)

TOF LOQ (20% of IF) = 909 ppb

Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 5 ppb to 500 ppb, RL for IF = 5 ppb F or dilution factor * 5

Calibration standards for TF = 20 ppb to 1000 ppb. RL for TF = 20 ppb or dilution factor * 20

Dilution Factor = 10



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Woodbury MN 55125
info@novemscientific.com

A handwritten signature in black ink, appearing to read "Andrew Christianson".

Reviewed by: Andrew Christianson

Customer: Pace WC
Customer Job ID: 240307

Sample Test Result

Novem Job ID: Novem24-038-003
Report Date: 2024-03-15

Sample Information

Customer Sample ID: 240307-S9

Novem Sample ID: Novem24-038-003

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	775.3	ppb (µg/L)
Inorganic Fluoride	IC	IF		ppb (µg/L)
TOF = TF - IF	Calculation	TOF	invalid	ppb (µg/L)

Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 5 ppb to 500 ppb, RL for IF = 5 ppb F or dilution factor * 5

Calibration standards for TF = 20 ppb to 1000 ppb. RL for TF = 20 ppb or dilution factor * 20

Dilution Factor = 10



2357 Ventura Dr Suite 110
Woodbury MN 55125
info@novemscientific.com

Reviewed by: Andrew Christianson

Customer: NA
Customer Job ID: NA

Quality Control Result

Novem Job ID: CCV
Report Date: 2024-03-15

Sample Information

Continue Calibration Verification (CCV):
Novem Sample ID: 100 ppb IF + 300 ppb TOF =400 ppb TF
Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	C4F9SO3K + NaF	430.0	ppb (µg/L)
Inorganic Fluoride	IC	NaF	97.5	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	332.6	ppb (µg/L)

Calibration standards for Inorganic Fluoride (IF) = 5 ppb to 500 ppb. RL for IF = 5 ppb

Calibration standard for Total Fluorine (TF) = 20 ppb to 1000 ppb. RL for TF = 20 ppb

Total Organic Fluorine (TOF) = Total Fluorine (TF) - Inorganic Fluoride (IF)



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Woodbury MN 55125
info@novemscientific.com

A handwritten signature in black ink, appearing to read "Andrew Christianson".

Reviewed by: Andrew Christianson

Customer: NA
Customer Job ID: NA

Quality Control Result

Novem Job ID: CCV
Report Date: 2024-03-15

Sample Information

Continue Calibration Verification (CCV):
Novem Sample ID: 100 ppb IF + 300 ppb TOF =400 ppb TF
Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	C4F9SO3K + NaF	382.2	ppb (µg/L)
Inorganic Fluoride	IC	NaF	95.0	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	287.2	ppb (µg/L)

Calibration standards for Inorganic Fluoride (IF) = 5 ppb to 500 ppb. RL for IF = 5 ppb

Calibration standard for Total Fluorine (TF) = 20 ppb to 1000 ppb. RL for TF = 20 ppb

Total Organic Fluorine (TOF) = Total Fluorine (TF) - Inorganic Fluoride (IF)



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A handwritten signature in black ink, appearing to read "Andrew Christianson".

Reviewed by: Andrew Christianson



106 Vantage Point Drive

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www.pacelabs.com

Number

[illegible]

**Pace Analytical Services, LLC - South Carolina****Subcontract Shipping Record****Section 1: To be filled out by the PM**

Date: 3/12/2024 Project Manager: Eddie Barnett
Lot Number: ZC12002
Subcontract Lab: NOVEM Scientific
Address: 2357 Venture Drive Suite 110
Woodbury, MN 55125
Phone Number: _____
Test(s): TOF
No. Samples: 3
Turnaround Time: 10-day TAT
Shipping Method: FedEx Priority Overnight Select from drop-down menu
Special Instructions: _____
Report Level: Level 2
EDD: Standard Excel

Section 2: To be filled out by Sample Receiving

SR Custodian Initials: _____
Date: _____
COC Number: _____

Tracking Numbers: _____

(attach Subcontract COC if applicable)



Report of Analysis

Onvector

444 Somerville Avenue
Somerville, MA 02143
Attention: Daniel Cho

Project Name: 240307

Project Number: 240307

Lot Number: **ZC12001**

Date Completed: 03/19/2024

03/19/2024 1:11 PM

Approved and released by:

Project Manager II: **Edward Barnett**



The electronic signature above is the equivalent of a handwritten signature.

This report shall not be reproduced, except in its entirety, without the written approval of Pace Analytical Services, LLC.

PACE ANALYTICAL SERVICES, LLC

SC DHEC No: 32010001

NELAC No: E87653

NC DENR No: 329

NC Field Parameters No: 5639

Case Narrative Onvector Lot Number: ZC12001

This Report of Analysis contains the analytical result(s) for the sample(s) listed on the Sample Summary following this Case Narrative. The sample receiving date is documented in the header information associated with each sample.

All results listed in this report relate only to the samples that are contained within this report. Where sampling is conducted by the client, results relate to the accuracy of the information provided, and as the samples are received.

Sample receipt, sample analysis, and data review have been performed in accordance with the most current approved The NELAC Institute (TNI) standards, the Pace Analytical Services, LLC ("Pace") Laboratory Quality Manual, standard operating procedures (SOPs), and Pace policies. Any exceptions to the TNI standards, the Laboratory Quality Manual, SOPs or policies are qualified on the results page or discussed below.

Pace is a TNI accredited laboratory; however, the following analyses are currently not listed on our TNI scope of accreditation: E. coli and Total coliforms SM 9223 B-2004, Solid Chemical Material: TOC Walkley-Black, Biological Tissue: All, Non-Potable Water: SGT-HEM EPA 1664B, Silica EPA 200.7, Boron, Calcium, Silicon, Strontium EPA 200.8, Bicarbonate, Carbonate, and Hydroxide Alkalinity SM 2320 B-2011, SM 9221 C E-2006 & SM 9222D-2006, Strontium SW-846 6010D, VOC SM 6200 B-2011, Fecal Coliform Colilert-18. If you have any questions regarding this report, please contact the Pace Project Manager listed on the cover page.

PFAS

The method reporting limit check (MRL) exceeded acceptance criteria for the following analyte: 6:2 FTS. This analyte was biased high and was detected less than ½ the LOQ in the samples affected: ZC12001-008, ZC12001-009.

ZC12001-008 (240307-S8) (Run 1) (Analysis Batch 98419) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-009 (240307-S9) (Run 1) (Analysis Batch 98419) (Prep Batch 98235) PFAS by Direct Aqueous Injection

Surrogate recovery (NMeFOSE) in the ICV for the following samples was outside the upper control limit: ZC12001-008, ZC12001-009. The samples did not contain any target analytes; therefore, re-extraction and/or re-analysis was not performed.

ZC12001-008 (240307-S8) (Run 1) (Analysis Batch 98419) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-009 (240307-S9) (Run 1) (Analysis Batch 98419) (Prep Batch 98235) PFAS by Direct Aqueous Injection

Surrogate recovery (NMeFOSE) in the ICV for the following samples was outside the upper control limit: ZC12001-001, ZC12001-002, ZC12001-003, ZC12001-006. The samples did not contain any target analytes; therefore, re-extraction and/or re-analysis was not performed.

PACE ANALYTICAL SERVICES, LLC

SC DHEC No: 32010001

NELAC No: E87653

NC DENR No: 329

NC Field Parameters No: 5639

ZC12001-001 (240307-S1) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-002 (240307-S2) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-003 (240307-S3) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-006 (240307-S6) (Run 2) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

The method reporting limit check (MRL) exceeded acceptance criteria for the following analyte: 6:2 FTS. The analyte was biased high and was detected less than ½ the LOQ in the samples affected: ZC12001-001, ZC12001-002, ZC12001-003. The method reporting limit check (MRL) exceeded acceptance criteria for the following analyte: 6:2 FTS. The analyte was biased high and was non-detect in the samples affected: ZC12001-006.

ZC12001-001 (240307-S1) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-002 (240307-S2) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-003 (240307-S3) (Run 1) (Analysis Batch 98397) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-006 (240307-S6) (Run 1) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

Surrogate recovery (NMeFOSE) in the ICV for the following samples was outside the upper control limit: ZC12001-004, ZC12001-005, ZC12001-007. The samples did not contain any target analytes; therefore, re-extraction and/or re-analysis was not performed.

ZC12001-004 (240307-S4) (Run 1) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-005 (240307-S5) (Run 1) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-007 (240307-S7) (Run 2) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

The method reporting limit check (MRL) exceeded acceptance criteria for the following analyte: 6:2 FTS. The analyte was biased high and was non-detect in the samples affected: ZC12001-004, ZC12001-005.

ZC12001-004 (240307-S4) (Run 1) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-005 (240307-S5) (Run 1) (Analysis Batch 98366) (Prep Batch 98235) PFAS by Direct Aqueous Injection

ZC12001-007 6:2 FTS recovered greater than 1/2 the LOQ in the MRL

ZC12001-007 (240307-S7) (Run 1) (Analysis Batch 98428) (Prep Batch 98235) PFAS by Direct Aqueous Injection

PACE ANALYTICAL SERVICES, LLC

Sample Summary

Onvector

Lot Number: ZC12001

Project Name: 240307

Project Number: 240307

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	240307-S1	Aqueous	03/11/2024 1300	03/12/2024
002	240307-S2	Aqueous	03/11/2024 1310	03/12/2024
003	240307-S3	Aqueous	03/11/2024 1320	03/12/2024
004	240307-S4	Aqueous	03/11/2024 1330	03/12/2024
005	240307-S5	Aqueous	03/11/2024 1340	03/12/2024
006	240307-S6	Aqueous	03/11/2024 1350	03/12/2024
007	240307-S7	Aqueous	03/11/2024 1400	03/12/2024
008	240307-S8	Aqueous	03/11/2024 1410	03/12/2024
009	240307-S9	Aqueous	03/11/2024 1420	03/12/2024

(9 samples)

PACE ANALYTICAL SERVICES, LLC

Detection Summary

Onvector

Lot Number: ZC12001

Project Name: 240307

Project Number: 240307

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	240307-S1	Aqueous	6:2FTS	D8421-ID	6000	BJ	ng/L	8
001	240307-S1	Aqueous	PFDA	D8421-ID	5100	J	ng/L	8
001	240307-S1	Aqueous	PFHpS	D8421-ID	37000		ng/L	8
001	240307-S1	Aqueous	PFHpA	D8421-ID	61000		ng/L	8
001	240307-S1	Aqueous	PFHxS	D8421-ID	120000		ng/L	8
001	240307-S1	Aqueous	PFNA	D8421-ID	9800	J	ng/L	8
001	240307-S1	Aqueous	PFOSA	D8421-ID	2400	J	ng/L	8
001	240307-S1	Aqueous	PFOS	D8421-ID	2900000		ng/L	8
001	240307-S1	Aqueous	PFOA	D8421-ID	1500000		ng/L	8
001	240307-S1	Aqueous	PFPeS	D8421-ID	7600	J	ng/L	8
002	240307-S2	Aqueous	6:2FTS	D8421-ID	3200	BJ	ng/L	10
002	240307-S2	Aqueous	PFPrA	D8421-ID	24000	J	ng/L	10
002	240307-S2	Aqueous	PFBA	D8421-ID	18000	J	ng/L	10
002	240307-S2	Aqueous	PFHpS	D8421-ID	9700		ng/L	10
002	240307-S2	Aqueous	PFHpA	D8421-ID	29000		ng/L	10
002	240307-S2	Aqueous	PFHxS	D8421-ID	38000		ng/L	10
002	240307-S2	Aqueous	PFHxA	D8421-ID	9200		ng/L	10
002	240307-S2	Aqueous	PFNA	D8421-ID	2600	J	ng/L	10
002	240307-S2	Aqueous	PFOS	D8421-ID	750000		ng/L	10
002	240307-S2	Aqueous	PFOA	D8421-ID	330000		ng/L	10
002	240307-S2	Aqueous	PFPeS	D8421-ID	3100	J	ng/L	10
002	240307-S2	Aqueous	PFPeA	D8421-ID	11000	J	ng/L	10
003	240307-S3	Aqueous	6:2FTS	D8421-ID	870	BJ	ng/L	12
003	240307-S3	Aqueous	PFPrA	D8421-ID	33000		ng/L	12
003	240307-S3	Aqueous	PFBS	D8421-ID	420	J	ng/L	12
003	240307-S3	Aqueous	PFBA	D8421-ID	24000		ng/L	12
003	240307-S3	Aqueous	PFDA	D8421-ID	680	J	ng/L	12
003	240307-S3	Aqueous	PFHpS	D8421-ID	2400		ng/L	12
003	240307-S3	Aqueous	PFHpA	D8421-ID	13000		ng/L	12
003	240307-S3	Aqueous	PFHxS	D8421-ID	12000		ng/L	12
003	240307-S3	Aqueous	PFHxA	D8421-ID	7500		ng/L	12
003	240307-S3	Aqueous	PFNA	D8421-ID	1000		ng/L	12
003	240307-S3	Aqueous	PFOS	D8421-ID	260000		ng/L	12
003	240307-S3	Aqueous	PFOA	D8421-ID	87000		ng/L	12
003	240307-S3	Aqueous	PFPeS	D8421-ID	1400		ng/L	12
003	240307-S3	Aqueous	PFPeA	D8421-ID	13000		ng/L	12
004	240307-S4	Aqueous	PFPrA	D8421-ID	41000		ng/L	14
004	240307-S4	Aqueous	PFMPA	D8421-ID	48	J	ng/L	14
004	240307-S4	Aqueous	PFBS	D8421-ID	370		ng/L	14
004	240307-S4	Aqueous	PFBA	D8421-ID	26000		ng/L	14
004	240307-S4	Aqueous	PFDA	D8421-ID	260		ng/L	14
004	240307-S4	Aqueous	PFHpS	D8421-ID	530		ng/L	14
004	240307-S4	Aqueous	PFHpA	D8421-ID	4800		ng/L	14

Detection Summary (Continued)

Lot Number: ZC12001

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
004	240307-S4	Aqueous	PFHxS	D8421-ID	3300		ng/L	14
004	240307-S4	Aqueous	PFHxA	D8421-ID	7000		ng/L	14
004	240307-S4	Aqueous	PFNA	D8421-ID	180	J	ng/L	14
004	240307-S4	Aqueous	PFOSA	D8421-ID	41	J	ng/L	14
004	240307-S4	Aqueous	PFOS	D8421-ID	64000		ng/L	14
004	240307-S4	Aqueous	PFOA	D8421-ID	16000		ng/L	14
004	240307-S4	Aqueous	PFPeS	D8421-ID	830		ng/L	14
004	240307-S4	Aqueous	PFPeA	D8421-ID	11000		ng/L	14
005	240307-S5	Aqueous	PFPrA	D8421-ID	38000		ng/L	16
005	240307-S5	Aqueous	PFMPA	D8421-ID	42	J	ng/L	16
005	240307-S5	Aqueous	PFBS	D8421-ID	240		ng/L	16
005	240307-S5	Aqueous	PFBA	D8421-ID	21000		ng/L	16
005	240307-S5	Aqueous	PFHpS	D8421-ID	110	J	ng/L	16
005	240307-S5	Aqueous	PFHpA	D8421-ID	1300		ng/L	16
005	240307-S5	Aqueous	PFHxS	D8421-ID	670		ng/L	16
005	240307-S5	Aqueous	PFHxA	D8421-ID	2300		ng/L	16
005	240307-S5	Aqueous	PFNA	D8421-ID	52	J	ng/L	16
005	240307-S5	Aqueous	PFOS	D8421-ID	13000		ng/L	16
005	240307-S5	Aqueous	PFOA	D8421-ID	3200		ng/L	16
005	240307-S5	Aqueous	PFPeS	D8421-ID	290		ng/L	16
005	240307-S5	Aqueous	PFPeA	D8421-ID	6200		ng/L	16
006	240307-S6	Aqueous	PFPrA	D8421-ID	35000		ng/L	18
006	240307-S6	Aqueous	PFMPA	D8421-ID	30	J	ng/L	18
006	240307-S6	Aqueous	PFBS	D8421-ID	150		ng/L	18
006	240307-S6	Aqueous	PFBA	D8421-ID	18000		ng/L	18
006	240307-S6	Aqueous	PFDA	D8421-ID	31	J	ng/L	18
006	240307-S6	Aqueous	PFHpS	D8421-ID	25	J	ng/L	18
006	240307-S6	Aqueous	PFHpA	D8421-ID	370		ng/L	18
006	240307-S6	Aqueous	PFHxS	D8421-ID	160		ng/L	18
006	240307-S6	Aqueous	PFHxA	D8421-ID	1300		ng/L	18
006	240307-S6	Aqueous	PFNA	D8421-ID	37	J	ng/L	18
006	240307-S6	Aqueous	PFOSA	D8421-ID	8.2	J	ng/L	18
006	240307-S6	Aqueous	PFOS	D8421-ID	4200		ng/L	18
006	240307-S6	Aqueous	PFOA	D8421-ID	690		ng/L	18
006	240307-S6	Aqueous	PFPeS	D8421-ID	98		ng/L	18
006	240307-S6	Aqueous	PFPeA	D8421-ID	5500		ng/L	18
007	240307-S7	Aqueous	6:2FTS	D8421-ID	11	BJ	ng/L	20
007	240307-S7	Aqueous	PFPrA	D8421-ID	32000		ng/L	20
007	240307-S7	Aqueous	PFMPA	D8421-ID	24	J	ng/L	20
007	240307-S7	Aqueous	PFBS	D8421-ID	91		ng/L	20
007	240307-S7	Aqueous	PFBA	D8421-ID	15000		ng/L	20
007	240307-S7	Aqueous	PFDA	D8421-ID	19		ng/L	20
007	240307-S7	Aqueous	PFHpS	D8421-ID	12		ng/L	20
007	240307-S7	Aqueous	PFHpA	D8421-ID	130		ng/L	20
007	240307-S7	Aqueous	PFHxS	D8421-ID	47		ng/L	20
007	240307-S7	Aqueous	PFHxA	D8421-ID	600		ng/L	20
007	240307-S7	Aqueous	PFNA	D8421-ID	18		ng/L	20
007	240307-S7	Aqueous	PFOSA	D8421-ID	3.5	J	ng/L	20

Detection Summary (Continued)

Lot Number: ZC12001

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
007	240307-S7	Aqueous	PFOS	D8421-ID	2000		ng/L	20
007	240307-S7	Aqueous	PFOA	D8421-ID	290		ng/L	20
007	240307-S7	Aqueous	PFPeS	D8421-ID	41		ng/L	20
007	240307-S7	Aqueous	PFPeA	D8421-ID	2800		ng/L	20
007	240307-S7	Aqueous	PFOA	D8421-ID	3.7	J	ng/L	21
008	240307-S8	Aqueous	6:2FTS	D8421-ID	6.6	BJ	ng/L	22
008	240307-S8	Aqueous	PFPrA	D8421-ID	860		ng/L	22
008	240307-S8	Aqueous	PFBA	D8421-ID	440		ng/L	22
008	240307-S8	Aqueous	PFHpA	D8421-ID	4.1	J	ng/L	22
008	240307-S8	Aqueous	PFHxS	D8421-ID	1.9	J	ng/L	22
008	240307-S8	Aqueous	PFHxA	D8421-ID	18		ng/L	22
008	240307-S8	Aqueous	PFOS	D8421-ID	11		ng/L	22
008	240307-S8	Aqueous	PFOA	D8421-ID	11		ng/L	22
008	240307-S8	Aqueous	PFPeA	D8421-ID	110		ng/L	22
009	240307-S9	Aqueous	6:2FTS	D8421-ID	6.7	BJ	ng/L	24
009	240307-S9	Aqueous	PFOS	D8421-ID	13		ng/L	24
(107 detections)								

PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-001				
Description: 240307-S1			Matrix: Aqueous				
Date Sampled: 03/11/2024 1300			Project Name: 240307				
Date Received: 03/12/2024			Project Number: 240307				

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	1000	03/15/2024 1318	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		10000	3100	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		10000	1900	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		10000	1800	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		10000	5400	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		10000	2000	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	6000	BJ	21000	4600	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		41000	5100	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		10000	2500	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		10000	3300	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		10000	4800	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		10000	3100	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		10000	2700	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		10000	3600	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		10000	2700	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		10000	2200	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		10000	2800	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		10000	4700	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		10000	1900	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	ND		210000	35000	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		10000	1000	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	ND		10000	1500	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		10000	2100	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	ND		10000	3600	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	ND		52000	8600	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		10000	2700	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	5100	J	10000	2300	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		52000	52000	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		10000	2100	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	37000		10000	1700	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	61000		10000	3300	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		41000	2800	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	120000		10000	1700	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	ND		10000	1500	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		10000	2000	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	9800	J	10000	2300	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	2400	J	10000	1700	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	2900000		10000	1700	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	1500000		10000	4200	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	7600	J	10000	3000	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	ND		52000	15000	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		41000	5200	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		52000	52000	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		10000	6000	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		10000	1500	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-001
Description: 240307-S1	Matrix: Aqueous
Date Sampled: 03/11/2024 1300	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		114	70-130
13C2-6:2FTS		125	70-130
13C2-8:2FTS		119	70-130
13C2-PFDoA		123	70-130
13C2-PFTeDA		167	10-200
13C3-HFPO-DA		110	70-130
13C3-PFBS		112	70-130
13C3-PFHxS		116	70-130
13C4-PFBA		115	70-130
13C4-PFHpA		114	70-130
13C5-PFHxA		107	70-130
13C5-PFPeA		112	70-130
13C6-PFDA		112	70-130
13C7-PFUnA		120	70-130
13C8-PFOA		108	70-130
13C8-PFOS		113	70-130
13C8-PFOSA		110	70-130
13C9-PFNA		113	70-130
D3-NMeFOSA		120	70-130
D3-NMeFOSAA		118	70-130
D5-NEtFOSA		124	70-130
D5-NEtFOSAA		118	70-130
D7-NMeFOSE		108	70-130
D9-NEtFOSE		112	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-002		
Description: 240307-S2			Matrix: Aqueous		
Date Sampled: 03/11/2024 1310			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	500	03/15/2024 1334	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		5100	1500	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		5100	920	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		5100	870	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND	Q	5100	2700	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND	Q	5100	970	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	3200	BJ	10000	2300	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		21000	2500	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		5100	1200	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		5100	1600	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		5100	2400	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		5100	1500	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND	Q	5100	1300	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND	Q	5100	1800	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		5100	1300	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		5100	1100	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND	Q	5100	1400	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		5100	2300	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		5100	920	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	24000	J	100000	17000	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		5100	510	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	ND		5100	720	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		5100	1000	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	ND		5100	1800	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	18000	J	26000	4300	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		5100	1300	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	ND		5100	1100	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		26000	26000	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND	Q	5100	1000	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	9700		5100	820	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	29000		5100	1600	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		21000	1400	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	38000		5100	820	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	9200		5100	720	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		5100	970	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	2600	J	5100	1100	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	ND		5100	820	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	750000		5100	820	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	330000		5100	2100	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	3100	J	5100	1500	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	11000	J	26000	7200	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		21000	2600	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		26000	26000	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND	Q	5100	3000	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		5100	720	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-002
Description: 240307-S2	Matrix: Aqueous
Date Sampled: 03/11/2024 1310	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS	N	133	70-130
13C2-6:2FTS		128	70-130
13C2-8:2FTS	N	134	70-130
13C2-PFDoA	N	132	70-130
13C2-PFTeDA		178	10-200
13C3-HFPO-DA		115	70-130
13C3-PFBS		122	70-130
13C3-PFHxS		125	70-130
13C4-PFBA		123	70-130
13C4-PFHpA		123	70-130
13C5-PFHxA		128	70-130
13C5-PFPeA		120	70-130
13C6-PFDA		128	70-130
13C7-PFUnA		128	70-130
13C8-PFOA		117	70-130
13C8-PFOS		124	70-130
13C8-PFOSA		123	70-130
13C9-PFNA		128	70-130
D3-NMeFOSA		122	70-130
D3-NMeFOSAA	N	135	70-130
D5-NEtFOSA	N	132	70-130
D5-NEtFOSAA	N	135	70-130
D7-NMeFOSE		117	70-130
D9-NEtFOSE		118	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-003				
Description: 240307-S3			Matrix: Aqueous				
Date Sampled: 03/11/2024 1320			Project Name: 240307				
Date Received: 03/12/2024			Project Number: 240307				

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	100	03/15/2024 1350	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		1000	310	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		1000	180	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		1000	170	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		1000	530	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		1000	190	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	870 BJ		2000	450	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		4100	500	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		1000	250	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		1000	330	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		1000	470	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		1000	310	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		1000	270	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		1000	360	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		1000	270	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		1000	210	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		1000	280	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		1000	460	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		1000	180	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	33000		20000	3500	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		1000	100	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	ND		1000	140	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		1000	200	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	420 J		1000	360	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	24000		5100	850	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		1000	270	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	680 J		1000	220	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		5100	5100	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		1000	200	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	2400		1000	160	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	13000		1000	330	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		4100	280	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	12000		1000	160	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	7500		1000	140	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		1000	190	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	1000		1000	220	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	ND		1000	160	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	260000		1000	160	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	87000		1000	420	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	1400		1000	300	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	13000		5100	1400	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		4100	510	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		5100	5100	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		1000	590	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		1000	140	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-003
Description: 240307-S3	Matrix: Aqueous
Date Sampled: 03/11/2024 1320	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		115	70-130
13C2-6:2FTS		122	70-130
13C2-8:2FTS		126	70-130
13C2-PFDoA		127	70-130
13C2-PFTeDA		173	10-200
13C3-HFPO-DA		113	70-130
13C3-PFBS		119	70-130
13C3-PFHxS		119	70-130
13C4-PFBA		114	70-130
13C4-PFHpA		114	70-130
13C5-PFHxA		123	70-130
13C5-PFPeA		103	70-130
13C6-PFDA		120	70-130
13C7-PFUnA		122	70-130
13C8-PFOA		112	70-130
13C8-PFOS		115	70-130
13C8-PFOSA		116	70-130
13C9-PFNA		121	70-130
D3-NMeFOSA		120	70-130
D3-NMeFOSAA		128	70-130
D5-NEtFOSA		122	70-130
D5-NEtFOSAA		124	70-130
D7-NMeFOSE		113	70-130
D9-NEtFOSE		116	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-004		
Description: 240307-S4			Matrix: Aqueous		
Date Sampled: 03/11/2024 1330			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	20	03/14/2024 1218	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		200	61	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	56426-58-1	D8421-ID	ND		200	37	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		200	35	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		200	110	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		200	39	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	ND		410	89	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		810	100	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		200	49	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		200	65	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		200	94	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		200	61	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		200	53	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		200	71	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		200	53	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		200	43	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		200	55	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		200	91	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		200	37	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	41000		4100	690	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEESA)	113507-82-7	D8421-ID	ND		200	20	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	48 J		200	28	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		200	41	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	370		200	71	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	26000		1000	170	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		200	53	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	260		200	45	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		1000	1000	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		200	41	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	530		200	33	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	4800		200	65	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		810	55	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	3300		200	33	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	7000		200	28	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		200	39	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	180 J		200	45	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	41 J		200	33	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	64000		200	33	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	16000		200	83	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	830		200	59	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	11000		1000	280	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		810	100	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		1000	1000	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		200	120	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		200	28	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-004
Description: 240307-S4	Matrix: Aqueous
Date Sampled: 03/11/2024 1330	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		96	70-130
13C2-6:2FTS		97	70-130
13C2-8:2FTS		115	70-130
13C2-PFDoA		106	70-130
13C2-PFTeDA		104	10-200
13C3-HFPO-DA		110	70-130
13C3-PFBS		91	70-130
13C3-PFHxS		103	70-130
13C4-PFBA		83	70-130
13C4-PFHpA		106	70-130
13C5-PFHxA		82	70-130
13C5-PFPeA		92	70-130
13C6-PFDA		100	70-130
13C7-PFUnA		81	70-130
13C8-PFOA		104	70-130
13C8-PFOS		98	70-130
13C8-PFOSA		112	70-130
13C9-PFNA		109	70-130
D3-NMeFOSA		95	70-130
D3-NMeFOSAA		98	70-130
D5-NEtFOSA		109	70-130
D5-NEtFOSAA		91	70-130
D7-NMeFOSE		115	70-130
D9-NEtFOSE		104	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-005		
Description: 240307-S5			Matrix: Aqueous		
Date Sampled: 03/11/2024 1340			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	20	03/14/2024 1202	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		200	61	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	56426-58-1	D8421-ID	ND		200	37	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		200	35	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		200	110	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		200	39	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	ND		410	90	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		810	100	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		200	49	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		200	65	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		200	94	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		200	61	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		200	53	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		200	71	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		200	53	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		200	43	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		200	55	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		200	92	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		200	37	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	38000		4100	690	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEESA)	113507-82-7	D8421-ID	ND		200	20	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	42 J		200	29	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		200	41	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	240		200	71	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	21000		1000	170	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		200	53	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	ND		200	45	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		1000	1000	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		200	41	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	110 J		200	33	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	1300		200	65	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		810	55	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	670		200	33	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	2300		200	29	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		200	39	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	52 J		200	45	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	ND		200	33	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	13000		200	33	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	3200		200	84	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	290		200	59	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	6200		1000	290	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		810	100	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		1000	1000	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		200	120	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		200	29	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-005
Description: 240307-S5	Matrix: Aqueous
Date Sampled: 03/11/2024 1340	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		87	70-130
13C2-6:2FTS		114	70-130
13C2-8:2FTS		98	70-130
13C2-PFDoA		101	70-130
13C2-PFTeDA		91	10-200
13C3-HFPO-DA		114	70-130
13C3-PFBS		96	70-130
13C3-PFHxS		107	70-130
13C4-PFBA		84	70-130
13C4-PFHpA		108	70-130
13C5-PFHxA		116	70-130
13C5-PFPeA		110	70-130
13C6-PFDA		96	70-130
13C7-PFUnA		100	70-130
13C8-PFOA		94	70-130
13C8-PFOS		103	70-130
13C8-PFOSA		109	70-130
13C9-PFNA		111	70-130
D3-NMeFOSA		106	70-130
D3-NMeFOSAA		100	70-130
D5-NEtFOSA		98	70-130
D5-NEtFOSAA		119	70-130
D7-NMeFOSE		114	70-130
D9-NEtFOSE		98	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and $\geq$ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-006		
Description: 240307-S6			Matrix: Aqueous		
Date Sampled: 03/11/2024 1350			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	10	03/14/2024 1146	JM1	03/13/2024 1148	98235
2	D8421-ID	D8421-ID	5	03/15/2024 1407	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		51	15	ng/L	2
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		51	9.1	ng/L	2
4,8-Dioxo-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		51	8.6	ng/L	2
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		51	26	ng/L	2
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		51	9.7	ng/L	2
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	ND		100	22	ng/L	2
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		200	25	ng/L	2
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		51	12	ng/L	2
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		51	16	ng/L	2
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		51	23	ng/L	2
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		51	15	ng/L	2
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		51	13	ng/L	2
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		51	18	ng/L	2
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		51	13	ng/L	2
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		51	11	ng/L	2
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		51	14	ng/L	2
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		51	23	ng/L	2
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		51	9.1	ng/L	2
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	35000		2000	350	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		51	5.1	ng/L	2
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	30 J		100	14	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		51	10	ng/L	2
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	150		51	18	ng/L	2
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	18000		510	84	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		51	13	ng/L	2
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	31 J		51	11	ng/L	2
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		250	250	ng/L	2
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		51	10	ng/L	2
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	25 J		51	8.1	ng/L	2
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	370		51	16	ng/L	2
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		200	14	ng/L	2
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	160		51	8.1	ng/L	2
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	1300		51	7.1	ng/L	2
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		51	9.7	ng/L	2
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	37 J		51	11	ng/L	2
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	8.2 J		51	8.1	ng/L	2
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	4200		51	8.1	ng/L	2
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	690		51	21	ng/L	2
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	98		51	15	ng/L	2
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	5500		250	71	ng/L	2
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		200	25	ng/L	2
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		250	250	ng/L	2
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		51	29	ng/L	2

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-006		
Description: 240307-S6			Matrix: Aqueous		
Date Sampled: 03/11/2024 1350			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	10	03/14/2024 1146	JM1	03/13/2024 1148	98235
2	D8421-ID	D8421-ID	5	03/15/2024 1407	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		51	7.1	ng/L	2
Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits		
13C2-4:2FTS		78	70-130		86	70-130		
13C2-6:2FTS		106	70-130		86	70-130		
13C2-8:2FTS		122	70-130		90	70-130		
13C2-PFDoA		111	70-130		88	70-130		
13C2-PFTeDA		86	10-200		90	10-200		
13C3-HFPO-DA		108	70-130		85	70-130		
13C3-PFBS		105	70-130		99	70-130		
13C3-PFHxS		106	70-130		105	70-130		
13C4-PFBA		70	70-130	N	61	70-130		
13C4-PFHpA		109	70-130		104	70-130		
13C5-PFHxA		96	70-130		104	70-130		
13C5-PFPeA	N	68	70-130		78	70-130		
13C6-PFDA		100	70-130		99	70-130		
13C7-PFUnA		104	70-130		103	70-130		
13C8-PFOA		93	70-130		100	70-130		
13C8-PFOS		101	70-130		98	70-130		
13C8-PFOSA		107	70-130		96	70-130		
13C9-PFNA		105	70-130		96	70-130		
D3-NMeFOSA		100	70-130		87	70-130		
D3-NMeFOSAA		119	70-130		102	70-130		
D5-NEtFOSA		104	70-130		98	70-130		
D5-NEtFOSAA		91	70-130		91	70-130		
D7-NMeFOSE		106	70-130		93	70-130		
D9-NEtFOSE		100	70-130		93	70-130		

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-007		
Description: 240307-S7			Matrix: Aqueous		
Date Sampled: 03/11/2024 1400			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	1	03/13/2024 1935	JM1	03/13/2024 1148	98235
2	D8421-ID	D8421-ID	10	03/14/2024 1130	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		10	3.1	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		10	1.8	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		10	1.7	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		10	5.3	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		100	19	ng/L	2
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	11 BJ		20	4.5	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		41	5.0	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		10	2.4	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		10	3.3	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		10	4.7	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		10	3.1	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		10	2.7	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		10	3.6	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		10	2.7	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		10	2.1	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		10	2.8	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		10	4.6	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		10	1.8	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	32000		2000	350	ng/L	2
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		10	1.0	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	24 J		100	14	ng/L	2
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		100	20	ng/L	2
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	91		10	3.6	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	15000		510	85	ng/L	2
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		10	2.7	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	19		10	2.2	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		51	51	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		10	2.0	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	12		10	1.6	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	130		10	3.3	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		41	2.8	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	47		10	1.6	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	600		10	1.4	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		10	1.9	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	18		10	2.2	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	3.5 J		10	1.6	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	2000		10	1.6	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	290		10	4.2	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	41		10	3.0	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	2800		510	140	ng/L	2
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		410	51	ng/L	2
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		51	51	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		10	5.9	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-007		
Description: 240307-S7			Matrix: Aqueous		
Date Sampled: 03/11/2024 1400			Project Name: 240307		
Date Received: 03/12/2024			Project Number: 240307		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	1	03/13/2024 1935	JM1	03/13/2024 1148	98235
2	D8421-ID	D8421-ID	10	03/14/2024 1130	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	3.7	J	10	1.4	ng/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
13C2-4:2FTS	N	64	70-130		83	70-130
13C2-6:2FTS		74	70-130		88	70-130
13C2-8:2FTS		76	70-130		100	70-130
13C2-PFDoA		98	70-130		112	70-130
13C2-PFTeDA		93	10-200		93	10-200
13C3-HFPO-DA		90	70-130		113	70-130
13C3-PFBS		81	70-130		99	70-130
13C3-PFHxS		90	70-130		98	70-130
13C4-PFBA	N	50	70-130		70	70-130
13C4-PFHpA		94	70-130		121	70-130
13C5-PFHxA		91	70-130		89	70-130
13C5-PFPeA	N	64	70-130		103	70-130
13C6-PFDA		93	70-130		109	70-130
13C7-PFUnA		94	70-130		102	70-130
13C8-PFOA		90	70-130		108	70-130
13C8-PFOS		86	70-130		99	70-130
13C8-PFOSA		97	70-130		107	70-130
13C9-PFNA		94	70-130		105	70-130
D3-NMeFOSA		90	70-130		117	70-130
D3-NMeFOSAA		90	70-130		109	70-130
D5-NEtFOSA		94	70-130		103	70-130
D5-NEtFOSAA		92	70-130		90	70-130
D7-NMeFOSE		98	70-130		92	70-130
D9-NEtFOSE		99	70-130		92	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-008				
Description: 240307-S8			Matrix: Aqueous				
Date Sampled: 03/11/2024 1410			Project Name: 240307				
Date Received: 03/12/2024			Project Number: 240307				

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	1	03/13/2024 1951	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		10	3.0	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		10	1.8	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		10	1.7	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		10	5.3	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		10	1.9	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	6.6	BJ	20	4.5	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		41	5.0	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		10	2.4	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		10	3.3	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		10	4.7	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		10	3.0	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		10	2.6	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		10	3.6	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		10	2.6	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		10	2.1	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		10	2.7	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		10	4.6	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		10	1.8	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	860		200	35	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEESA)	113507-82-7	D8421-ID	ND		10	1.0	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	ND		10	1.4	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		10	2.0	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	ND		10	3.6	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	440		51	8.4	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		10	2.6	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	ND		10	2.2	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		51	51	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		10	2.0	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	ND		10	1.6	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	4.1	J	10	3.3	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		41	2.7	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	1.9	J	10	1.6	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	18		10	1.4	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		10	1.9	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	ND		10	2.2	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	ND		10	1.6	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	11		10	1.6	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	11		10	4.2	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	ND		10	2.9	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	110		51	14	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		41	5.1	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		51	51	ng/L	1
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	D8421-ID	ND		10	5.9	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		10	1.4	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-008
Description: 240307-S8	Matrix: Aqueous
Date Sampled: 03/11/2024 1410	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		75	70-130
13C2-6:2FTS		88	70-130
13C2-8:2FTS		85	70-130
13C2-PFDoA		105	70-130
13C2-PFTeDA		108	10-200
13C3-HFPO-DA		92	70-130
13C3-PFBS		94	70-130
13C3-PFHxS		94	70-130
13C4-PFBA		97	70-130
13C4-PFHpA		96	70-130
13C5-PFHxA		96	70-130
13C5-PFPeA		98	70-130
13C6-PFDA		105	70-130
13C7-PFUnA		100	70-130
13C8-PFOA		94	70-130
13C8-PFOS		92	70-130
13C8-PFOSA		98	70-130
13C9-PFNA		99	70-130
D3-NMeFOSA		100	70-130
D3-NMeFOSAA		104	70-130
D5-NEtFOSA		100	70-130
D5-NEtFOSAA		99	70-130
D7-NMeFOSE		100	70-130
D9-NEtFOSE		98	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector			Laboratory ID: ZC12001-009				
Description: 240307-S9			Matrix: Aqueous				
Date Sampled: 03/11/2024 1420			Project Name: 240307				
Date Received: 03/12/2024			Project Number: 240307				

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	D8421-ID	D8421-ID	1	03/13/2024 2024	JM1	03/13/2024 1148	98235

Parameter	CAS Number	Analytical Method	Result	Q	LOQ	DL	Units	Run
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3...)	763051-92-9	D8421-ID	ND		10	3.0	ng/L	1
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ON9)	56426-58-1	D8421-ID	ND		10	1.8	ng/L	1
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	D8421-ID	ND		10	1.7	ng/L	1
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	D8421-ID	ND		10	5.3	ng/L	1
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	D8421-ID	ND		10	1.9	ng/L	1
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	D8421-ID	6.7	BJ	20	4.5	ng/L	1
2H,2H,3H,3H-Perfluorooctanoic acid (5:3FTCA)	914637-49-3	D8421-ID	ND		41	5.0	ng/L	1
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	D8421-ID	ND		10	2.4	ng/L	1
2H-perfluoro-2-decenoic acid (FOUEA)	70887-84-2	D8421-ID	ND		10	3.2	ng/L	1
2H-perfluoro-2-octenoic acid (FHUEA)	70887-88-6	D8421-ID	ND		10	4.7	ng/L	1
Lithium Bis(trifluoromethane)sulfonimide (HQ-115)	90076-65-6	D8421-ID	ND		10	3.0	ng/L	1
N-ethyl perfluorooctanesulfonamide (NEtFOSA)	4151-50-2	D8421-ID	ND		10	2.6	ng/L	1
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	D8421-ID	ND		10	3.6	ng/L	1
N-ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	D8421-ID	ND		10	2.6	ng/L	1
N-methyl perfluorooctanesulfonamide (NMeFOSA)	31506-32-8	D8421-ID	ND		10	2.1	ng/L	1
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	D8421-ID	ND		10	2.7	ng/L	1
N-methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	D8421-ID	ND		10	4.6	ng/L	1
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	D8421-ID	ND		10	1.8	ng/L	1
Pentafluoropropanoic acid (PFPrA)	422-64-0	D8421-ID	ND		200	34	ng/L	1
Perfluoro(2-ethoxyethane)sulfonic acid (PFEEA)	113507-82-7	D8421-ID	ND		10	1.0	ng/L	1
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	D8421-ID	ND		10	1.4	ng/L	1
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	D8421-ID	ND		10	2.0	ng/L	1
Perfluorobutanesulfonic acid (PFBS)	375-73-5	D8421-ID	ND		10	3.6	ng/L	1
Perfluorobutanoic acid (PFBA)	375-22-4	D8421-ID	ND		51	8.4	ng/L	1
Perfluorodecanesulfonic acid (PFDS)	335-77-3	D8421-ID	ND		10	2.6	ng/L	1
Perfluorodecanoic acid (PFDA)	335-76-2	D8421-ID	ND		10	2.2	ng/L	1
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	D8421-ID	ND		51	51	ng/L	1
Perfluorododecanoic acid (PFDoA)	307-55-1	D8421-ID	ND		10	2.0	ng/L	1
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	D8421-ID	ND		10	1.6	ng/L	1
Perfluoroheptanoic acid (PFHpA)	375-85-9	D8421-ID	ND		10	3.2	ng/L	1
3-Perfluoroheptyl propanoic acid (7:3FTCA)	812-70-4	D8421-ID	ND		41	2.7	ng/L	1
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	D8421-ID	ND		10	1.6	ng/L	1
Perfluorohexanoic acid (PFHxA)	307-24-4	D8421-ID	ND		10	1.4	ng/L	1
Perfluorononanesulfonic acid (PFNS)	68259-12-1	D8421-ID	ND		10	1.9	ng/L	1
Perfluorononanoic acid (PFNA)	375-95-1	D8421-ID	ND		10	2.2	ng/L	1
Perfluorooctanesulfonamide (PFOSA)	754-91-6	D8421-ID	ND		10	1.6	ng/L	1
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	D8421-ID	13		10	1.6	ng/L	1
Perfluorooctanoic acid (PFOA)	335-67-1	D8421-ID	ND		10	4.2	ng/L	1
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	D8421-ID	ND		10	2.9	ng/L	1
Perfluoropentanoic acid (PFPeA)	2706-90-3	D8421-ID	ND		51	14	ng/L	1
3-Perfluoropropyl propanoic acid (3:3FTCA)	356-02-5	D8421-ID	ND		41	5.1	ng/L	1
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	D8421-ID	ND		51	51	ng/L	1
Perfluorotridecanoic acid (PFTTrDA)	72629-94-8	D8421-ID	ND		10	5.9	ng/L	1
Perfluoroundecanoic acid (PFUnA)	2058-94-8	D8421-ID	ND		10	1.4	ng/L	1

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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PFAS by LC/MS/MS

Client: Onvector	Laboratory ID: ZC12001-009
Description: 240307-S9	Matrix: Aqueous
Date Sampled: 03/11/2024 1420	Project Name: 240307
Date Received: 03/12/2024	Project Number: 240307

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
13C2-4:2FTS		86	70-130
13C2-6:2FTS		87	70-130
13C2-8:2FTS		96	70-130
13C2-PFDoA		97	70-130
13C2-PFTeDA		79	10-200
13C3-HFPO-DA		87	70-130
13C3-PFBS		94	70-130
13C3-PFHxS		97	70-130
13C4-PFBA		101	70-130
13C4-PFHpA		94	70-130
13C5-PFHxA		95	70-130
13C5-PFPeA		103	70-130
13C6-PFDA		99	70-130
13C7-PFUnA		97	70-130
13C8-PFOA		93	70-130
13C8-PFOS		94	70-130
13C8-PFOSA		97	70-130
13C9-PFNA		92	70-130
D3-NMeFOSA		95	70-130
D3-NMeFOSAA		104	70-130
D5-NEtFOSA		99	70-130
D5-NEtFOSAA		111	70-130
D7-NMeFOSE		97	70-130
D9-NEtFOSE		95	70-130

LOQ = Limit of Quantitation	B = Detected in the method blank	E = Quantitation of compound exceeded the calibration range	DL = Detection Limit	Q = Surrogate failure
ND = Not detected at or above the DL	N = Recovery is out of criteria	P = The RPD between two GC columns exceeds 40%	J = Estimated result < LOQ and ≥ DL	L = LCS/LCSD failure
H = Out of holding time	W = Reported on wet weight basis			S = MS/MSD failure

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QC Summary

PFAS by LC/MS/MS - MB

Sample ID: ZQ98235-001

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
11CI-PF3OUdS	ND		1	10	3.0	ng/L	03/13/2024 1654
9CI-PF3ONS	ND		1	10	1.8	ng/L	03/13/2024 1654
ADONA	ND		1	10	1.7	ng/L	03/13/2024 1654
8:2FTS	ND		1	10	5.2	ng/L	03/13/2024 1654
4:2FTS	ND		1	10	1.9	ng/L	03/13/2024 1654
6:2FTS	8.5	J	1	20	4.4	ng/L	03/13/2024 1654
5:3FTCA	ND		1	40	4.9	ng/L	03/13/2024 1654
HFPO-DA	ND		1	10	2.4	ng/L	03/13/2024 1654
FOUEA	ND		1	10	3.2	ng/L	03/13/2024 1654
FHUEA	ND		1	10	4.6	ng/L	03/13/2024 1654
trifluoromethane)sulfonimide (HQ-115	ND		1	10	3.0	ng/L	03/13/2024 1654
NEtFOSA	ND		1	10	2.6	ng/L	03/13/2024 1654
NEtFOSAA	ND		1	10	3.5	ng/L	03/13/2024 1654
NEtFOSE	ND		1	10	2.6	ng/L	03/13/2024 1654
NMeFOSA	ND		1	10	2.1	ng/L	03/13/2024 1654
NMeFOSAA	ND		1	10	2.7	ng/L	03/13/2024 1654
NMeFOSE	ND		1	10	4.5	ng/L	03/13/2024 1654
NFDHA	ND		1	10	1.8	ng/L	03/13/2024 1654
PFPrA	ND		1	200	34	ng/L	03/13/2024 1654
2-ethoxyethane)sulfonic acid (PFEESA	ND		1	10	1.0	ng/L	03/13/2024 1654
PFMPA	ND		1	10	1.4	ng/L	03/13/2024 1654
PFMBA	ND		1	10	2.0	ng/L	03/13/2024 1654
PFBS	ND		1	10	3.5	ng/L	03/13/2024 1654
PFBA	ND		1	50	8.3	ng/L	03/13/2024 1654
PFDS	ND		1	10	2.6	ng/L	03/13/2024 1654
PFDA	ND		1	10	2.2	ng/L	03/13/2024 1654
PFDoS	ND		1	50	50	ng/L	03/13/2024 1654
PFDaA	ND		1	10	2.0	ng/L	03/13/2024 1654
PFHpS	ND		1	10	1.6	ng/L	03/13/2024 1654
PFHpA	ND		1	10	3.2	ng/L	03/13/2024 1654
7:3FTCA	ND		1	40	2.7	ng/L	03/13/2024 1654
PFHxS	ND		1	10	1.6	ng/L	03/13/2024 1654
PFHxA	ND		1	10	1.4	ng/L	03/13/2024 1654
PFNS	ND		1	10	1.9	ng/L	03/13/2024 1654
PFNA	ND		1	10	2.2	ng/L	03/13/2024 1654
PFOSA	ND		1	10	1.6	ng/L	03/13/2024 1654
PFOS	ND		1	10	1.6	ng/L	03/13/2024 1654
PFOA	ND		1	10	4.1	ng/L	03/13/2024 1654
PFPeS	ND		1	10	2.9	ng/L	03/13/2024 1654
PFPeA	ND		1	50	14	ng/L	03/13/2024 1654
3:3FTCA	ND		1	40	5.0	ng/L	03/13/2024 1654
PFTeDA	ND		1	50	50	ng/L	03/13/2024 1654
PFTTrDA	ND		1	10	5.8	ng/L	03/13/2024 1654
PFUnA	ND		1	10	1.4	ng/L	03/13/2024 1654

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

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QC Data for Lot Number: ZC12001

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PFAS by LC/MS/MS - MB

Sample ID: ZQ98235-001

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		98	70-130
13C2-6:2FTS		96	70-130
13C2-8:2FTS		105	70-130
13C2-PFDoA		93	70-130
13C2-PFTeDA		59	10-200
13C3-HFPO-DA		109	70-130
13C3-PFBS		94	70-130
13C3-PFHxS		97	70-130
13C4-PFBA		101	70-130
13C4-PFHpA		98	70-130
13C5-PFHxA		98	70-130
13C5-PFPeA		105	70-130
13C6-PFDA		98	70-130
13C7-PFUnA		95	70-130
13C8-PFOA		93	70-130
13C8-PFOS		98	70-130
13C8-PFOSA		99	70-130
13C9-PFNA		109	70-130
D3-NMeFOSA		116	70-130
D3-NMeFOSAA		112	70-130
D5-NEtFOSA		117	70-130
D5-NEtFOSAA		111	70-130
D7-NMeFOSE		111	70-130
D9-NEtFOSE		116	70-130

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

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PFAS by LC/MS/MS - MB

Sample ID: ZQ98235-101

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Parameter	Result	Q	Dil	LOQ	DL	Units	Analysis Date
11CI-PF3OUdS	ND		1	10	3.0	ng/L	03/13/2024 1711
9CI-PF3ONS	ND		1	10	1.8	ng/L	03/13/2024 1711
ADONA	ND		1	10	1.7	ng/L	03/13/2024 1711
8:2FTS	ND		1	10	5.2	ng/L	03/13/2024 1711
4:2FTS	ND		1	10	1.9	ng/L	03/13/2024 1711
6:2FTS	5.7	J	1	20	4.4	ng/L	03/13/2024 1711
5:3FTCA	ND		1	40	4.9	ng/L	03/13/2024 1711
HFPO-DA	ND		1	10	2.4	ng/L	03/13/2024 1711
FOUEA	ND		1	10	3.2	ng/L	03/13/2024 1711
FHUEA	ND		1	10	4.6	ng/L	03/13/2024 1711
trifluoromethane)sulfonimide (HQ-115	ND		1	10	3.0	ng/L	03/13/2024 1711
NEtFOSA	ND		1	10	2.6	ng/L	03/13/2024 1711
NEtFOSAA	ND		1	10	3.5	ng/L	03/13/2024 1711
NEtFOSE	ND		1	10	2.6	ng/L	03/13/2024 1711
NMeFOSA	ND		1	10	2.1	ng/L	03/13/2024 1711
NMeFOSAA	ND		1	10	2.7	ng/L	03/13/2024 1711
NMeFOSE	ND		1	10	4.5	ng/L	03/13/2024 1711
NFDHA	ND		1	10	1.8	ng/L	03/13/2024 1711
PFPrA	ND		1	200	34	ng/L	03/13/2024 1711
2-ethoxyethane)sulfonic acid (PFEESA	ND		1	10	1.0	ng/L	03/13/2024 1711
PFMPA	ND		1	10	1.4	ng/L	03/13/2024 1711
PFMBA	ND		1	10	2.0	ng/L	03/13/2024 1711
PFBS	ND		1	10	3.5	ng/L	03/13/2024 1711
PFBA	ND		1	50	8.3	ng/L	03/13/2024 1711
PFDS	ND		1	10	2.6	ng/L	03/13/2024 1711
PFDA	ND		1	10	2.2	ng/L	03/13/2024 1711
PFDoS	ND		1	50	50	ng/L	03/13/2024 1711
PFDaA	ND		1	10	2.0	ng/L	03/13/2024 1711
PFHpS	ND		1	10	1.6	ng/L	03/13/2024 1711
PFHpA	ND		1	10	3.2	ng/L	03/13/2024 1711
7:3FTCA	ND		1	40	2.7	ng/L	03/13/2024 1711
PFHxS	ND		1	10	1.6	ng/L	03/13/2024 1711
PFHxA	ND		1	10	1.4	ng/L	03/13/2024 1711
PFNS	ND		1	10	1.9	ng/L	03/13/2024 1711
PFNA	ND		1	10	2.2	ng/L	03/13/2024 1711
PFOSA	ND		1	10	1.6	ng/L	03/13/2024 1711
PFOS	ND		1	10	1.6	ng/L	03/13/2024 1711
PFOA	ND		1	10	4.1	ng/L	03/13/2024 1711
PFPeS	ND		1	10	2.9	ng/L	03/13/2024 1711
PFPeA	ND		1	50	14	ng/L	03/13/2024 1711
3:3FTCA	ND		1	40	5.0	ng/L	03/13/2024 1711
PFTeDA	ND		1	50	50	ng/L	03/13/2024 1711
PFTTrDA	ND		1	10	5.8	ng/L	03/13/2024 1711
PFUnA	ND		1	10	1.4	ng/L	03/13/2024 1711

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - MB

Sample ID: ZQ98235-101

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		98	70-130
13C2-6:2FTS		100	70-130
13C2-8:2FTS		110	70-130
13C2-PFD _o A		113	70-130
13C2-PFTeDA		128	10-200
13C3-HFPO-DA		103	70-130
13C3-PFBS		98	70-130
13C3-PFHxS		102	70-130
13C4-PFBA		109	70-130
13C4-PFH _p A		99	70-130
13C5-PFHxA		100	70-130
13C5-PFPeA		109	70-130
13C6-PFDA		105	70-130
13C7-PFUnA		111	70-130
13C8-PFOA		101	70-130
13C8-PFOS		105	70-130
13C8-PFOSA		106	70-130
13C9-PFNA		106	70-130
D3-NMeFOSA		112	70-130
D3-NMeFOSAA		113	70-130
D5-NEtFOSA		115	70-130
D5-NEtFOSAA		115	70-130
D7-NMeFOSE		110	70-130
D9-NEtFOSE		112	70-130

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98235-002

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Parameter	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
11CI-PF3OUdS	160	130		1	84	70-130	03/13/2024 1743
9CI-PF3ONS	160	150		1	95	70-130	03/13/2024 1743
ADONA	160	140		1	88	70-130	03/13/2024 1743
8:2FTS	160	140		1	88	70-130	03/13/2024 1743
4:2FTS	160	170		1	104	70-130	03/13/2024 1743
6:2FTS	160	160		1	99	70-130	03/13/2024 1743
5:3FTCA	160	150		1	91	70-130	03/13/2024 1743
HFPO-DA	160	150		1	96	70-130	03/13/2024 1743
FOUEA	160	140		1	86	70-130	03/13/2024 1743
FHUEA	160	140		1	90	70-130	03/13/2024 1743
trifluoromethane)sulfonimide (HQ-115	160	140		1	88	70-130	03/13/2024 1743
NEtFOSA	160	150		1	95	70-130	03/13/2024 1743
NEtFOSAA	160	140		1	85	70-130	03/13/2024 1743
NEtFOSE	160	150		1	96	70-130	03/13/2024 1743
NMeFOSA	160	160		1	97	70-130	03/13/2024 1743
NMeFOSAA	160	140		1	88	70-130	03/13/2024 1743
NMeFOSE	160	150		1	96	70-130	03/13/2024 1743
NFDHA	160	150		1	96	70-130	03/13/2024 1743
PFPrA	160	140		1	89	70-130	03/13/2024 1743
2-ethoxyethane)sulfonic acid (PFEESA	160	150		1	92	70-130	03/13/2024 1743
PFMPA	160	150		1	94	70-130	03/13/2024 1743
PFMBA	160	140		1	87	70-130	03/13/2024 1743
PFBS	160	150		1	92	70-130	03/13/2024 1743
PFBA	160	140		1	90	70-130	03/13/2024 1743
PFDS	160	140		1	86	70-130	03/13/2024 1743
PFDA	160	150		1	93	70-130	03/13/2024 1743
PFDoS	160	100		1	65	50-150	03/13/2024 1743
PFDoA	160	150		1	92	70-130	03/13/2024 1743
PFHpS	160	140		1	89	70-130	03/13/2024 1743
PFHpA	160	160		1	97	70-130	03/13/2024 1743
7:3FTCA	160	160		1	97	70-130	03/13/2024 1743
PFHxS	160	140		1	89	70-130	03/13/2024 1743
PFHxA	160	150		1	92	70-130	03/13/2024 1743
PFNS	160	140		1	89	70-130	03/13/2024 1743
PFNA	160	160		1	99	70-130	03/13/2024 1743
PFOSA	160	150		1	92	70-130	03/13/2024 1743
PFOS	160	150		1	92	70-130	03/13/2024 1743
PFOA	160	140		1	89	70-130	03/13/2024 1743
PFPeS	160	150		1	92	70-130	03/13/2024 1743
PFPeA	160	140		1	89	70-130	03/13/2024 1743
3:3FTCA	160	120		1	78	70-130	03/13/2024 1743
PFTeDA	160	150		1	92	50-150	03/13/2024 1743
PFTTrDA	160	140		1	86	70-130	03/13/2024 1743
PFUnA	160	150		1	91	70-130	03/13/2024 1743

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - LCS

Sample ID: ZQ98235-002

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		102	70-130
13C2-6:2FTS		106	70-130
13C2-8:2FTS		106	70-130
13C2-PFDoA		96	70-130
13C2-PFTeDA		70	10-200
13C3-HFPO-DA		96	70-130
13C3-PFBS		101	70-130
13C3-PFHxS		106	70-130
13C4-PFBA		106	70-130
13C4-PFHpA		99	70-130
13C5-PFHxA		99	70-130
13C5-PFPeA		108	70-130
13C6-PFDA		104	70-130
13C7-PFUnA		104	70-130
13C8-PFOA		100	70-130
13C8-PFOS		106	70-130
13C8-PFOSA		104	70-130
13C9-PFNA		107	70-130
D3-NMeFOSA		100	70-130
D3-NMeFOSAA		117	70-130
D5-NEtFOSA		105	70-130
D5-NEtFOSAA		113	70-130
D7-NMeFOSE		101	70-130
D9-NEtFOSE		103	70-130

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - MS

Sample ID: ZC12001-008MS

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Parameter	Sample Amount (ng/L)	Spike Amount (ng/L)	Result (ng/L)	Q	Dil	% Rec	%Rec Limit	Analysis Date
11CI-PF3OUdS	ND	170	160		1	96	70-130	03/13/2024 2008
9CI-PF3ONS	ND	170	160		1	97	70-130	03/13/2024 2008
ADONA	ND	170	170		1	101	70-130	03/13/2024 2008
8:2FTS	ND	170	180		1	108	70-130	03/13/2024 2008
4:2FTS	ND	170	170		1	104	70-130	03/13/2024 2008
6:2FTS	6.6	170	150		1	87	70-130	03/13/2024 2008
5:3FTCA	ND	170	150		1	90	70-130	03/13/2024 2008
HFPO-DA	ND	170	150		1	89	70-130	03/13/2024 2008
FOUEA	ND	170	150		1	89	70-130	03/13/2024 2008
FHUEA	ND	170	150		1	91	70-130	03/13/2024 2008
trifluoromethane)sulfonimide (HQ-115	ND	170	160		1	98	70-130	03/13/2024 2008
NEtFOSA	ND	170	150		1	92	70-130	03/13/2024 2008
NEtFOSAA	ND	170	170		1	100	70-130	03/13/2024 2008
NEtFOSE	ND	170	160		1	97	70-130	03/13/2024 2008
NMeFOSA	ND	170	160		1	96	70-130	03/13/2024 2008
NMeFOSAA	ND	170	150		1	92	70-130	03/13/2024 2008
NMeFOSE	ND	170	160		1	97	70-130	03/13/2024 2008
NFDHA	ND	170	180		1	106	70-130	03/13/2024 2008
PFPrA	860	170	1000		1	90	70-130	03/13/2024 2008
2-ethoxyethane)sulfonic acid (PFEESA	ND	170	160		1	99	70-130	03/13/2024 2008
PFMPA	ND	170	170		1	100	70-130	03/13/2024 2008
PFMBA	ND	170	140		1	86	70-130	03/13/2024 2008
PFBS	ND	170	160		1	97	70-130	03/13/2024 2008
PFBA	440	170	620		1	110	70-130	03/13/2024 2008
PFDS	ND	170	160		1	96	70-130	03/13/2024 2008
PFDA	ND	170	160		1	98	70-130	03/13/2024 2008
PFDoS	ND	170	150		1	89	50-150	03/13/2024 2008
PFDoS	ND	170	170		1	99	70-130	03/13/2024 2008
PFHpS	ND	170	160		1	95	70-130	03/13/2024 2008
PFHpA	4.1	170	170		1	100	70-130	03/13/2024 2008
7:3FTCA	ND	170	150		1	90	70-130	03/13/2024 2008
PFHxS	1.9	170	150		1	92	70-130	03/13/2024 2008
PFHxA	18	170	190		1	104	70-130	03/13/2024 2008
PFNS	ND	170	160		1	97	70-130	03/13/2024 2008
PFNA	ND	170	180		1	107	70-130	03/13/2024 2008
PFOSA	ND	170	160		1	97	70-130	03/13/2024 2008
PFOS	11	170	160		1	91	70-130	03/13/2024 2008
PFOA	11	170	170		1	92	70-130	03/13/2024 2008
PFPeS	ND	170	170		1	102	70-130	03/13/2024 2008
PFPeA	110	170	240		1	76	70-130	03/13/2024 2008
3:3FTCA	ND	170	140		1	82	70-130	03/13/2024 2008
PFTeDA	ND	170	160		1	96	50-150	03/13/2024 2008
PFTTrDA	ND	170	160		1	96	70-130	03/13/2024 2008
PFUnA	ND	170	160		1	94	70-130	03/13/2024 2008

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - MS

Sample ID: ZC12001-008MS

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		81	70-130
13C2-6:2FTS		92	70-130
13C2-8:2FTS		82	70-130
13C2-PFDoA		97	70-130
13C2-PFTeDA		87	10-200
13C3-HFPO-DA		99	70-130
13C3-PFBS		91	70-130
13C3-PFHxS		94	70-130
13C4-PFBA		93	70-130
13C4-PFHpA		90	70-130
13C5-PFHxA		88	70-130
13C5-PFPeA		104	70-130
13C6-PFDA		98	70-130
13C7-PFUnA		99	70-130
13C8-PFOA		91	70-130
13C8-PFOS		97	70-130
13C8-PFOSA		94	70-130
13C9-PFNA		97	70-130
D3-NMeFOSA		92	70-130
D3-NMeFOSAA		105	70-130
D5-NEtFOSA		100	70-130
D5-NEtFOSAA		98	70-130
D7-NMeFOSE		97	70-130
D9-NEtFOSE		98	70-130

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - Duplicate

Sample ID: ZC12001-009DU

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Parameter	Sample Amount (ng/L)	Result (ng/L)	Q	Dil	% RPD	%RPD Limit	Analysis Date
11CI-PF3OUdS	ND	ND		1	0.00	20	03/13/2024 2040
9CI-PF3ONS	ND	ND		1	0.00	20	03/13/2024 2040
ADONA	ND	ND		1	0.00	20	03/13/2024 2040
8:2FTS	ND	ND		1	0.00	20	03/13/2024 2040
4:2FTS	ND	ND		1	0.00	20	03/13/2024 2040
6:2FTS	6.7	7.8	J	1	15	20	03/13/2024 2040
5:3FTCA	ND	ND		1	0.00	20	03/13/2024 2040
HFPO-DA	ND	ND		1	0.00	20	03/13/2024 2040
FOUEA	ND	ND		1	0.00	20	03/13/2024 2040
FHUEA	ND	ND		1	0.00	20	03/13/2024 2040
trifluoromethane)sulfonimide (HQ-115	ND	ND		1	0.00	20	03/13/2024 2040
NEtFOSA	ND	ND		1	0.00	20	03/13/2024 2040
NEtFOSAA	ND	ND		1	0.00	20	03/13/2024 2040
NEtFOSE	ND	ND		1	0.00	20	03/13/2024 2040
NMeFOSA	ND	ND		1	0.00	20	03/13/2024 2040
NMeFOSAA	ND	ND		1	0.00	20	03/13/2024 2040
NMeFOSE	ND	ND		1	0.00	20	03/13/2024 2040
NFDHA	ND	ND		1	0.00	20	03/13/2024 2040
PFPrA	ND	ND		1	0.00	20	03/13/2024 2040
2-ethoxyethane)sulfonic acid (PFEESA	ND	ND		1	0.00	20	03/13/2024 2040
PFMPA	ND	ND		1	0.00	20	03/13/2024 2040
PFMBA	ND	ND		1	0.00	20	03/13/2024 2040
PFBS	ND	ND		1	0.00	20	03/13/2024 2040
PFBA	ND	ND		1	0.00	20	03/13/2024 2040
PFDS	ND	ND		1	0.00	20	03/13/2024 2040
PFDA	ND	ND		1	0.00	20	03/13/2024 2040
PFDoS	ND	ND		1	0.00	20	03/13/2024 2040
PFDoS	ND	ND		1	0.00	20	03/13/2024 2040
PFHpS	ND	ND		1	0.00	20	03/13/2024 2040
PFHpA	ND	ND		1	0.00	20	03/13/2024 2040
7:3FTCA	ND	ND		1	0.00	20	03/13/2024 2040
PFHxS	ND	ND		1	0.00	20	03/13/2024 2040
PFHxA	ND	ND		1	0.00	20	03/13/2024 2040
PFNS	ND	ND		1	0.00	20	03/13/2024 2040
PFNA	ND	ND		1	0.00	20	03/13/2024 2040
PFOSA	ND	ND		1	0.00	20	03/13/2024 2040
PFOS	13	13		1	5.2	20	03/13/2024 2040
PFOA	ND	ND		1	0.00	20	03/13/2024 2040
PFPeS	ND	ND		1	0.00	20	03/13/2024 2040
PFPeA	ND	ND		1	0.00	20	03/13/2024 2040
3:3FTCA	ND	ND		1	0.00	20	03/13/2024 2040
PFTeDA	ND	ND		1	0.00	20	03/13/2024 2040
PFTTrDA	ND	ND		1	0.00	20	03/13/2024 2040
PFUnA	ND	ND		1	0.00	20	03/13/2024 2040

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and ≥ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

PFAS by LC/MS/MS - Duplicate

Sample ID: ZC12001-009DU

Matrix: Aqueous

Batch: 98235

Prep Method: D8421-ID

Analytical Method: D8421-ID

Prep Date: 03/13/2024 1148

Surrogate	Q	% Rec	Acceptance Limit
13C2-4:2FTS		93	70-130
13C2-6:2FTS		91	70-130
13C2-8:2FTS		92	70-130
13C2-PFDoA		88	70-130
13C2-PFTeDA		60	10-200
13C3-HFPO-DA		92	70-130
13C3-PFBS		96	70-130
13C3-PFHxS		94	70-130
13C4-PFBA		101	70-130
13C4-PFHpA		95	70-130
13C5-PFHxA		88	70-130
13C5-PFPeA		101	70-130
13C6-PFDA		90	70-130
13C7-PFUnA		96	70-130
13C8-PFOA		91	70-130
13C8-PFOS		97	70-130
13C8-PFOSA		98	70-130
13C9-PFNA		94	70-130
D3-NMeFOSA		96	70-130
D3-NMeFOSAA		99	70-130
D5-NEtFOSA		97	70-130
D5-NEtFOSAA		108	70-130
D7-NMeFOSE		96	70-130
D9-NEtFOSE		95	70-130

LOQ = Limit of Quantitation

ND = Not detected at or above the DL

N = Recovery is out of criteria

DL = Detection Limit

J = Estimated result < LOQ and $\geq$ DL

P = The RPD between two GC columns exceeds 40%

* = RSD is out of criteria

+ = RPD is out of criteria

Note: Calculations are performed before rounding to avoid round-off errors in calculated results

Pace Analytical Services, LLC (formerly Shealy Environmental Services, Inc.)

QC Data for Lot Number: ZC12001

106 Vantage Point Drive West Columbia, SC 29172 (803) 791-9700 Fax (803) 791-9111 www.pacelabs.com

Chain of Custody and Miscellaneous Documents



Pace Analytical Services, LLC.
 106 Vantage Point Drive
 West Columbia, South Carolina 29172
 Telephone No. (803) 791-9700 Fax No. (803) 791-9111
 www.paceabs.com

Number

Client Onvector LLC Address: 3700 I-95 Drive, Building A City: King of Prussia PA 19406 Project Name: 240307		Report to Contact HYOUNGSUP KIM Sampler's Signature: <i>[Signature]</i> X Printed Name: <i>HYOUNGSUP KIM</i>		F.O. No. 240307		Matrix Aqueous: ☒ Solid: ☒ Non-Aqueous: ☒		No of Containers by Preservative Type H2SO4: ☒ HNO3: ☒ HCl: ☒ NaOH: ☒ 5035 KIL: ☒ Filtered: ☒		Analysis PFAS-D8421		QC No. ZC12001 E782	
Sample ID / Description (Containers for each sample must be combined and one list)		Collection Date(s)		Collection Time (Military)		Matrix		No of Containers by Preservative Type		Analysis		QC No.	
240307-S1		3/11/2024		13:00		G		X		X		X	
240307-S2		3/11/2024		13:10		G		X		X		X	
240307-S3		3/11/2024		13:20		G		X		X		X	
240307-S4		3/11/2024		13:30		G		X		X		X	
240307-S5		3/11/2024		13:40		G		X		X		X	
240307-S6		3/11/2024		13:50		G		X		X		X	
240307-S7		3/11/2024		14:00		G		X		X		X	
240307-S8		3/11/2024		14:10		G		X		X		X	
240307-S9		3/11/2024		14:20		G		X		X		X	
Turn Around Time Required (Prior lab approval required for expedited TAT) ☐ Standard ☒ Rush (Please Specify) 5 biz days		Sample Disposal ☐ Return to Client ☒ Disposal by Lab		Possible Hazard Identification (List any known hazards in the remarks)		QC Requirements		Remarks / Cooler ID. Expedited delivery of test results		QC No.		Page	
1. Relinquished by <i>HYOUNGSUP KIM</i>		Date: 3/11/24 Time: 15:00		1. Received by		Date		Time		☐ Non-hazardous ☐ Flammable ☐ Biohazard ☐ SDS provided ☐ Unknown		Temp. Bank ☐ Y ☐ N	
2. Relinquished by		Date		2. Received by		Date		Time					
3. Relinquished by		Date		3. Received by		Date		Time					
4. Relinquished by <i>URS</i>		Date: 03/12/24 Time: 0930		4. Laboratory Approved by <i>[Signature]</i>		Date: 03/12/24 Time: 0930		Temp. Bank		☐ Y ☐ N			

Note: All samples are retained for four weeks from receipt unless other arrangements are made

PACE ANALYTICAL SERVICES, LLC

DC# Title: ENV-FRM-WCOL-0286 v02_Samples Receipt Checklist (SRC)

Effective Date: 8/2/2022

Sample Receipt Checklist (SRC)

Client: ONVECTOR

Cooler Inspected by/date: BPB 2/3/12/24 Lot #: 2C12001

Means of receipt: ☐ Pace ☐ Client ☒ UPS ☐ FedEx ☐ Other: _____	
☐ Yes ☒ No	1. Were custody seals present on the cooler?
☐ Yes ☒ No ☒ NA	2. If custody seals were present, were they intact and unbroken?
pH Strip ID: <u>NA</u> Chlorine Strip ID: <u>NA</u> Tested by: <u>NA</u>	
Original temperature upon receipt / Derived (Corrected) temperature upon receipt %Solid Snap-Cup ID: <u>NA</u>	
1. / 1. / 1. °C <u>NA</u> / <u>NA</u> °C <u>NA</u> / <u>NA</u> °C <u>NA</u> / <u>NA</u> °C	
Method: ☒ Temperature Blank ☐ Against Bottles IR Gun ID: <u>8</u> IR Gun Correction Factor: <u>0</u> °C	
Method of coolant: ☒ Wet Ice ☐ Ice Packs ☐ Dry Ice ☐ None	
☒ Yes ☐ No ☐ NA	3. Were all coolers received at or below 6.0°C? If no, was Project Manager notified? PM was Notified by: phone / email / face-to-face (circle one).
☒ Yes ☐ No ☐ NA	4. Is the commercial courier's packing slip attached to this form?
☒ Yes ☐ No	5. Were proper custody procedures (relinquished/received) followed?
☒ Yes ☐ No	6. Were sample IDs listed on the COC and all sample containers?
☐ Yes ☒ No	7. Was collection date & time listed on the COC and all sample containers?
☐ Yes ☒ No	8. Did all container label information (ID, date, time) agree with the COC?
☒ Yes ☐ No	9. Were tests to be performed listed on the COC?
☒ Yes ☐ No	10. Did all samples arrive in the proper containers for each test and/or in good condition (unbroken, lids on, etc.)?
☒ Yes ☐ No	11. Was adequate sample volume available?
☒ Yes ☐ No	12. Were all samples received within ½ the holding time or 48 hours, whichever comes first?
☒ Yes ☐ No	13. Were all samples containers accounted for? (No missing/excess)
☐ Yes ☐ No ☒ NA	14. Were VOA, 8015C and RSK-175 samples free of bubbles > "pea-size" (¼" or 6mm in diameter) in any of the VOA vials?
☐ Yes ☐ No ☒ NA	15. Were all DRO/metals/nutrient samples received at a pH of < 2?
☐ Yes ☐ No ☒ NA	16. Were all cyanide samples received at a pH > 12 and sulfide samples received at a pH > 9?
☐ Yes ☐ No ☒ NA	17. Were all applicable NH ₃ /TKN/cyanide/phenol/625.1/608.3 (< 0.5mg/L) samples free of residual chlorine?
☐ Yes ☒ No ☐ NA	18. Was the quote number listed on the container label? If yes, Quote #

Sample Preservation (Must be completed for any sample(s) incorrectly preserved or with headspace.)

Sample(s) NA were received incorrectly preserved and were adjusted accordingly

in sample receiving with NA mL of circle one: H₂SO₄, HNO₃, HCl, NaOH using SR # NA.

Time of preservation NA. If more than one preservative is needed, please note in the comments below.

Sample(s) NA were received with bubbles > 6 mm in diameter.

Samples(s) NA were received with TRC > 0.5 mg/L (If #19 is no) and were adjusted accordingly in sample receiving with sodium thiosulfate (Na₂S₂O₃) with Unique ID: NA.

Comments: NA no times on any containers

Attachment G8: Revive Environmental Final Report



December 28, 2023

Andri Dahlmeier
3M Settlement Technical Workgroup Coordinate
Minnesota Pollution Control Agency (MPCA)
Remediation Division
520 Lafayette Rd N
St Paul, MN 55155

Revive Environmental Technology, LLC ("Revive") is pleased to submit this Final Report to the Minnesota Pollution Control Agency (MPCA) to demonstrate the effectiveness of Revive's PFAS Annihilator® supercritical water oxidation (SCWO) technology in destroying per- and poly-fluoroalkyl substances (PFAS) on the foam fractionation hyper-concentrate produced as part of the MPCA Pilot Study on groundwater and surface water at Tablyn Park in Lake Elmo, Minnesota.

CONCLUSIONS

Bench-scale testing confirmed the successful destruction of significant amounts of PFAS from the hyper-concentrate with the PFAS Annihilator technology. The testing showed that the organic fluorine from the hyper-concentrate influent was transformed to inorganic fluoride in the effluent.

Based on these results, and as well on Revive's experience destroying PFAS at commercial scale in various other waste streams (including landfill leachate, groundwater, industrial wastewater, and aqueous film-forming foams), we are confident in the PFAS Annihilator's capability to achieved complete, permanent and verifiable destruction of this and other similar influet streams being handled by MPCA.

TEST SCOPE

A 5-gallon sample of the hyper-concentrate was provided by MPCA to evaluate the destruction of various PFAS compounds in the hyper-concentrate. Test samples were run through the PFAS Annihilator bench-scale unit for treatability analysis and then sent to PACE labs for EPA method 1633 and Total Organic Flourine Analysis (TOF). The results of the testing were analyzed to determine effectiveness in the removal of PFAS compounds.

TEST RESULTS

Before testing was started, influent from MPCA was sampled (MPCA-01) to understand how much PFAS and TOF was found in solution. The influent was then filtered, and the system was set to heat up. Set points for temperature and pressure were 625°C and 3,500 psi, respectively.

DI water was used during heat up of the system. NaOH was used as the neutralizing agent for the effluent stream.

Once the test was started, MPCA-02 sample was taken as a baseline for the DI water run through the system that was used for warmup and cool down procedures. 30 minutes after feed introduction, sample MPCA-03 was taken from the effluent stream.

The amount of PFAS in the influent sample was higher than expected for the 1633 method. Therefore, the results presented in the analysis packet are preliminary. There will be another extraction completed with results expected by end of day January 13, 2024. There are high levels of PFAS in the influent sample. Particularly, it measured high in perfluorooctanesulfonic acid (6.19 ppm) and perfluorooctanoic acid (2.45 ppm). The broader list of analytes and their detected quantities can be found in Attachment A. The effluent sample, MPCA-03, showed “ND” or not detected for all analytes, indicating that the PFAS compounds were destroyed in the bench scale SCWO system. MPCA-02 showed 1.1 ppt of perfluorooctanesulfonic acid but not detected for all other analytes.

The influent sample measured roughly 4,150 ppb of TOF, while the treated effluent sample measured roughly 289 ppb. These results indicated a 93% reduction in the TOF measurement from influent to effluent. The total fluorine in the influent and effluent samples measured about 4,275 and 4,128 ppb, respectively, suggesting that the organic fluorine in the influent transformed to inorganic fluoride in the effluent stream as a product of the SCWO reaction. The baseline DI water sample measured about 27 ppb of TOF. Full TOF results can be found in Attachment A.

ATTACHMENTS

Attachment A: Analytical Report, including analytical results from PACE (1633 Analysis) and their subcontractor (TOF Analysis).

Please contact Trevor Whitson, Director of Product Portfolio & Marketing, at 817-659-9700 (twhitson@revive-environmental.com) with any questions.

Respectfully submitted,

David Trueba
President and CEO
Revive Environmental Technology, LLC

Attachment A: Analytical Report



January 10, 2024

Taylor Cochran
Revive Environmental
1375 Perry Street
Columbus, OH 43201

RE: Project: MPCA-Revised Report
Pace Project No.: 10678538

Dear Taylor Cochran:

Enclosed are the analytical results for sample(s) received by the laboratory on December 11, 2023. The results relate only to the samples included in this report. Results reported herein conform to the applicable TNI/NELAC Standards and the laboratory's Quality Manual, where applicable, unless otherwise noted in the body of the report.

Some analyses were subcontracted outside of the Pace Network. The test report from the external subcontractor is attached to this report in its entirety.

The test results provided in this final report were generated by each of the following laboratories within the Pace Network:

- Pace Analytical Services - Minneapolis

This report was revised on January 10th 2024, to provide re-run results Pace sample 10678538-001.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Kongmeng Vang
kongmeng.vang@pacelabs.com
612-607-6382
Project Manager

Enclosures



REPORT OF LABORATORY ANALYSIS

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CERTIFICATIONS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Pace Analytical Services, LLC - Minneapolis MN

1700 Elm Street SE, Minneapolis, MN 55414

A2LA Certification #: 2926.01

Alabama Certification #: 40770

Alaska Contaminated Sites Certification #: 17-009

Alaska DW Certification #: MN00064

Arizona Certification #: AZ0014

Arkansas DW Certification #: MN00064

Arkansas WW Certification #: 88-0680

California Certification #: 2929

Colorado Certification #: MN00064

Connecticut Certification #: PH-0256

EPA Region 8 Tribal Water Systems+Wyoming DW
Certification #: via MN 027-053-137

Florida Certification #: E87605

Georgia Certification #: 959

GMP+ Certification #: GMP050884

Hawaii Certification #: MN00064

Idaho Certification #: MN00064

Illinois Certification #: 200011

Indiana Certification #: C-MN-01

Iowa Certification #: 368

Kansas Certification #: E-10167

Kentucky DW Certification #: 90062

Kentucky WW Certification #: 90062

Louisiana DEQ Certification #: AI-03086

Louisiana DW Certification #: MN00064

Maine Certification #: MN00064

Maryland Certification #: 322

Michigan Certification #: 9909

Minnesota Certification #: 027-053-137

Minnesota Dept of Ag Approval: via MN 027-053-137

Minnesota Petrofund Registration #: 1240

Mississippi Certification #: MN00064

Missouri Certification #: 10100

Montana Certification #: CERT0092

Nebraska Certification #: NE-OS-18-06

Nevada Certification #: MN00064

New Hampshire Certification #: 2081

New Jersey Certification #: MN002

New York Certification #: 11647

North Carolina DW Certification #: 27700

North Carolina WW Certification #: 530

North Dakota Certification (A2LA) #: R-036

North Dakota Certification (MN) #: R-036

Ohio DW Certification #: 41244

Ohio VAP Certification (1700) #: CL101

Oklahoma Certification #: 9507

Oregon Primary Certification #: MN300001

Oregon Secondary Certification #: MN200001

Pennsylvania Certification #: 68-00563

Puerto Rico Certification #: MN00064

South Carolina Certification #: 74003001

Tennessee Certification #: TN02818

Texas Certification #: T104704192

Utah Certification #: MN00064

Vermont Certification #: VT-027053137

Virginia Certification #: 460163

Washington Certification #: C486

West Virginia DEP Certification #: 382

West Virginia DW Certification #: 9952 C

Wisconsin Certification #: 999407970

Wyoming UST Certification #: via A2LA 2926.01

USDA Permit #: P330-19-00208

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SAMPLE SUMMARY

Project: MPCA-Revised Report

Pace Project No.: 10678538

Lab ID	Sample ID	Matrix	Date Collected	Date Received
10678538001	MPCA-01	Water	12/01/23 14:26	12/11/23 08:40
10678538002	MPCA-02	Water	12/01/23 14:24	12/11/23 08:40
10678538003	MPCA-03	Water	12/01/23 16:25	12/11/23 08:40

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SAMPLE ANALYTE COUNT

Project: MPCA-Revised Report

Pace Project No.: 10678538

Lab ID	Sample ID	Method	Analysts	Analytes Reported
10678538001	MPCA-01	EPA 1633 DRAFT	NBH, NF1	64
10678538002	MPCA-02	EPA 1633 DRAFT	NBH	64
10678538003	MPCA-03	EPA 1633 DRAFT	NBH	64

PASI-M = Pace Analytical Services - Minneapolis

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-01		Lab ID: 10678538001		Collected: 12/01/23 14:26		Received: 12/11/23 08:40		Matrix: Water	
Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual	
EPA 1633 DRAFT Water		Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis							
11CI-PF3OUdS	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	763051-92-9		
3:3 FTCA	ND	ng/L	12500	1	01/03/24 12:33	01/05/24 10:10	356-02-5		
4:2 FTS	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	757124-72-4		
5:3 FTCA	ND	ng/L	62500	1	01/03/24 12:33	01/05/24 10:10	914637-49-3		
6:2 FTS	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	27619-97-2		
7:3 FTCA	ND	ng/L	62500	1	01/03/24 12:33	01/05/24 10:10	812-70-4		
8:2 FTS	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	39108-34-4		
9CI-PF3ONS	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	756426-58-1		
ADONA	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	919005-14-4		
HFPO-DA	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	13252-13-6		
NEtFOSAA	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	2991-50-6		
NEtFOSA	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	4151-50-2		
NEtFOSE	ND	ng/L	25000	1	01/03/24 12:33	01/05/24 10:10	1691-99-2		
NFDHA	ND	ng/L	5000	1	01/03/24 12:33	01/05/24 10:10	151772-58-6		
NMeFOSAA	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	2355-31-9		
NMeFOSA	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	31506-32-8		
NMeFOSE	ND	ng/L	25000	1	01/03/24 12:33	01/05/24 10:10	24448-09-7		
Perfluorobutanesulfonic acid	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	375-73-5		
Perfluorodecanoic acid	7320	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	335-76-2		
Perfluorohexanoic acid	2830	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	307-24-4		
PFBA	ND	ng/L	10000	1	01/03/24 12:33	01/05/24 10:10	375-22-4		
PFDS	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	335-77-3		
PFDoS	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	79780-39-5		
PFEESA	ND	ng/L	5000	1	01/03/24 12:33	01/05/24 10:10	113507-82-7		
PFHpS	64600	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	375-92-8		
PFMBA	ND	ng/L	5000	1	01/03/24 12:33	01/05/24 10:10	863090-89-5		
PFMPA	ND	ng/L	5000	1	01/03/24 12:33	01/05/24 10:10	377-73-1		
PFNS	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	68259-12-1		
PFOSA	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	754-91-6		
PFPeA	ND	ng/L	5000	1	01/03/24 12:33	01/05/24 10:10	2706-90-3		
PFPeS	8280	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	2706-91-4		
Perfluorododecanoic acid	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	307-55-1		
Perfluoroheptanoic acid	70900	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	375-85-9		
Perfluorohexanesulfonic acid	138000	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	355-46-4		
Perfluorononanoic acid	10200	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	375-95-1		
Perfluorooctanesulfonic acid	3510000	ng/L	25000	10	01/03/24 12:33	01/04/24 20:33	1763-23-1		
Perfluorooctanoic acid	1670000	ng/L	25000	10	01/03/24 12:33	01/04/24 20:33	335-67-1		
Perfluorotetradecanoic acid	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	376-06-7		
Perfluorotridecanoic acid	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	72629-94-8		
Perfluoroundecanoic acid	ND	ng/L	2500	1	01/03/24 12:33	01/05/24 10:10	2058-94-8		
Surrogates									
13C2-PFDoA (S)	76	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			
13C3HFPO-DA (S)	84	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			
13C3-PFBS (S)	86	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	375-73-5		
13C3-PFHxS (S)	82	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	355-46-4		
13C4-PFBA (S)	81	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	375-22-4		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-01		Lab ID: 10678538001		Collected: 12/01/23 14:26		Received: 12/11/23 08:40		Matrix: Water	
Parameters		Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
EPA 1633 DRAFT Water		Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis							
Surrogates									
13C4-PFHpA (S)	76	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	375-85-9		
13C5-PFHxA (S)	81	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	307-24-4		
13C5-PFPeA (S)	86	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	2706-90-3		
13C6-PFDA (S)	83	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	335-76-2		
13C8-PFOA (S)	79	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	335-67-1		
13C8-PFOS (S)	85	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	1763-23-1		
13C8-PFOSA (S)	96	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	754-91-6		
13C9-PFNA (S)	85	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	375-95-1		
d3-MeFOSAA (S)	119	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	2355-31-9		
d3-NMeFOSA (S)	76	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	31506-32-8		
d5-EtFOSAA (S)	92	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	2991-50-6		
d5-NEtFOSA (S)	74	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	4151-50-2		
d7-NMeFOSE (S)	81	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	24448-09-7		
d9-NEtFOSE (S)	78	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	1691-99-2		
13C2-PFTA (S)	71	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			
13C7-PFUDa (S)	78	%.	20-150	1	01/03/24 12:33	01/05/24 10:10	2058-94-8		
13C24:2FTS (S)	85	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			
13C26:2FTS (S)	91	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			
13C28:2FTS (S)	82	%.	20-150	1	01/03/24 12:33	01/05/24 10:10			

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-02		Lab ID: 10678538002		Collected: 12/01/23 14:24		Received: 12/11/23 08:40		Matrix: Water	
Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual	
EPA 1633 DRAFT Water		Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis							
11CI-PF3OUdS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	763051-92-9		
3:3 FTCA	ND	ng/L	5.0	1	12/15/23 13:00	12/19/23 09:55	356-02-5		
4:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	757124-72-4		
5:3 FTCA	ND	ng/L	24.8	1	12/15/23 13:00	12/19/23 09:55	914637-49-3		
6:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	27619-97-2		
7:3 FTCA	ND	ng/L	24.8	1	12/15/23 13:00	12/19/23 09:55	812-70-4		
8:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	39108-34-4		
9CI-PF3ONS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	756426-58-1		
ADONA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	919005-14-4		
HFPO-DA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	13252-13-6		
NEtFOSAA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	2991-50-6		
NEtFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	4151-50-2		
NEtFOSE	ND	ng/L	9.9	1	12/15/23 13:00	12/19/23 09:55	1691-99-2		
NFDHA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 09:55	151772-58-6		
NMeFOSAA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	2355-31-9		
NMeFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	31506-32-8		
NMeFOSE	ND	ng/L	9.9	1	12/15/23 13:00	12/19/23 09:55	24448-09-7		
Perfluorobutanesulfonic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	375-73-5		
Perfluorodecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	335-76-2		
Perfluorohexanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	307-24-4		
PFBA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 09:55	375-22-4		
PFDS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	335-77-3		
PFDoS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	79780-39-5		
PFEESA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 09:55	113507-82-7		
PFHpS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	375-92-8		
PFMBA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 09:55	863090-89-5		
PFMPA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 09:55	377-73-1		
PFNS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	68259-12-1		
PFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	754-91-6		
PFPeA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 09:55	2706-90-3		
PFPeS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	2706-91-4		
Perfluorododecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	307-55-1		
Perfluoroheptanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	375-85-9		
Perfluorohexanesulfonic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	355-46-4		
Perfluorononanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	375-95-1		
Perfluorooctanesulfonic acid	1.1	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	1763-23-1		
Perfluorooctanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	335-67-1		
Perfluorotetradecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	376-06-7		
Perfluorotridecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	72629-94-8		
Perfluoroundecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 09:55	2058-94-8		
Surrogates									
13C2-PFDoA (S)	66	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			
13C3HFPO-DA (S)	74	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			
13C3-PFBS (S)	88	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	375-73-5		
13C3-PFHxS (S)	81	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	355-46-4		
13C4-PFBA (S)	78	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	375-22-4		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-02		Lab ID: 10678538002		Collected: 12/01/23 14:24		Received: 12/11/23 08:40		Matrix: Water	
Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual	
EPA 1633 DRAFT Water	Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis								
Surrogates									
13C4-PFHpA (S)	74	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	375-85-9		
13C5-PFHxA (S)	75	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	307-24-4		
13C5-PFPeA (S)	75	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	2706-90-3		
13C6-PFDA (S)	78	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	335-76-2		
13C8-PFOA (S)	82	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	335-67-1		
13C8-PFOS (S)	80	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	1763-23-1		
13C8-PFOSA (S)	65	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	754-91-6		
13C9-PFNA (S)	76	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	375-95-1		
d3-MeFOSAA (S)	86	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	2355-31-9		
d3-NMeFOSA (S)	50	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	31506-32-8		
d5-EtFOSAA (S)	73	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	2991-50-6		
d5-NEtFOSA (S)	53	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	4151-50-2		
d7-NMeFOSE (S)	66	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	24448-09-7		
d9-NEtFOSE (S)	83	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	1691-99-2		
13C2-PFTA (S)	55	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			
13C7-PFUdA (S)	70	%.	20-150	1	12/15/23 13:00	12/19/23 09:55	2058-94-8		
13C24:2FTS (S)	93	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			
13C26:2FTS (S)	96	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			
13C28:2FTS (S)	82	%.	20-150	1	12/15/23 13:00	12/19/23 09:55			

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-03		Lab ID: 10678538003		Collected: 12/01/23 16:25		Received: 12/11/23 08:40		Matrix: Water	
Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual	
EPA 1633 DRAFT Water		Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis							
11CI-PF3OUdS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	763051-92-9		
3:3 FTCA	ND	ng/L	4.9	1	12/15/23 13:00	12/19/23 10:10	356-02-5		
4:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	757124-72-4		
5:3 FTCA	ND	ng/L	24.7	1	12/15/23 13:00	12/19/23 10:10	914637-49-3		
6:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	27619-97-2		
7:3 FTCA	ND	ng/L	24.7	1	12/15/23 13:00	12/19/23 10:10	812-70-4		
8:2 FTS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	39108-34-4		
9CI-PF3ONS	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	756426-58-1		
ADONA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	919005-14-4		
HFPO-DA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	13252-13-6		
NEtFOSAA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	2991-50-6		
NEtFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	4151-50-2		
NEtFOSE	ND	ng/L	9.9	1	12/15/23 13:00	12/19/23 10:10	1691-99-2		
NFDHA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 10:10	151772-58-6		
NMeFOSAA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	2355-31-9		
NMeFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	31506-32-8		
NMeFOSE	ND	ng/L	9.9	1	12/15/23 13:00	12/19/23 10:10	24448-09-7		
Perfluorobutanesulfonic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	375-73-5		
Perfluorodecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	335-76-2		
Perfluorohexanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	307-24-4		
PFBA	ND	ng/L	4.0	1	12/15/23 13:00	12/19/23 10:10	375-22-4		
PFDS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	335-77-3		
PFDoS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	79780-39-5		
PFEESA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 10:10	113507-82-7		
PFHpS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	375-92-8		
PFMBA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 10:10	863090-89-5		
PFMPA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 10:10	377-73-1		
PFNS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	68259-12-1		
PFOSA	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	754-91-6		
PFPeA	ND	ng/L	2.0	1	12/15/23 13:00	12/19/23 10:10	2706-90-3		
PFPeS	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	2706-91-4		
Perfluorododecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	307-55-1		
Perfluoroheptanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	375-85-9		
Perfluorohexanesulfonic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	355-46-4		
Perfluorononanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	375-95-1		
Perfluorooctanesulfonic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	1763-23-1		
Perfluorooctanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	335-67-1		
Perfluorotetradecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	376-06-7		
Perfluorotridecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	72629-94-8		
Perfluoroundecanoic acid	ND	ng/L	0.99	1	12/15/23 13:00	12/19/23 10:10	2058-94-8		
Surrogates									
13C2-PFDoA (S)	74	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			
13C3HFPO-DA (S)	87	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			
13C3-PFBS (S)	102	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	375-73-5		
13C3-PFHxS (S)	95	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	355-46-4		
13C4-PFBA (S)	89	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	375-22-4		

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: MPCA-Revised Report

Pace Project No.: 10678538

Sample: MPCA-03		Lab ID: 10678538003		Collected: 12/01/23 16:25		Received: 12/11/23 08:40		Matrix: Water	
Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual	
EPA 1633 DRAFT Water	Analytical Method: EPA 1633 DRAFT Preparation Method: EPA 1633 DRAFT Pace Analytical Services - Minneapolis								
Surrogates									
13C4-PFHpA (S)	85	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	375-85-9		
13C5-PFHxA (S)	88	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	307-24-4		
13C5-PFPeA (S)	89	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	2706-90-3		
13C6-PFDA (S)	89	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	335-76-2		
13C8-PFOA (S)	89	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	335-67-1		
13C8-PFOS (S)	87	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	1763-23-1		
13C8-PFOSA (S)	79	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	754-91-6		
13C9-PFNA (S)	87	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	375-95-1		
d3-MeFOSAA (S)	97	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	2355-31-9		
d3-NMeFOSA (S)	50	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	31506-32-8		
d5-EtFOSAA (S)	82	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	2991-50-6		
d5-NEtFOSA (S)	52	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	4151-50-2		
d7-NMeFOSE (S)	70	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	24448-09-7		
d9-NEtFOSE (S)	75	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	1691-99-2		
13C2-PFTA (S)	65	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			
13C7-PFUdA (S)	76	%.	20-150	1	12/15/23 13:00	12/19/23 10:10	2058-94-8		
13C24:2FTS (S)	112	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			
13C26:2FTS (S)	106	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			
13C28:2FTS (S)	98	%.	20-150	1	12/15/23 13:00	12/19/23 10:10			

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

QC Batch: 923396

Analysis Method: EPA 1633 DRAFT

QC Batch Method: EPA 1633 DRAFT

Analysis Description: 1633 W

Laboratory: Pace Analytical Services - Minneapolis

Associated Lab Samples: 10678538002, 10678538003

METHOD BLANK: 4851301

Matrix: Water

Associated Lab Samples: 10678538002, 10678538003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
11CI-PF3OUdS	ng/L	ND	3.9	12/18/23 15:41	
3:3 FTCA	ng/L	ND	4.9	12/18/23 15:41	
4:2 FTS	ng/L	ND	3.9	12/18/23 15:41	
5:3 FTCA	ng/L	ND	24.5	12/18/23 15:41	
6:2 FTS	ng/L	ND	3.9	12/18/23 15:41	
7:3 FTCA	ng/L	ND	24.5	12/18/23 15:41	
8:2 FTS	ng/L	ND	3.9	12/18/23 15:41	
9CI-PF3ONS	ng/L	ND	3.9	12/18/23 15:41	
ADONA	ng/L	ND	3.9	12/18/23 15:41	
HFPO-DA	ng/L	ND	3.9	12/18/23 15:41	
NEtFOSA	ng/L	ND	0.98	12/18/23 15:41	
NEtFOSAA	ng/L	ND	0.98	12/18/23 15:41	
NEtFOSE	ng/L	ND	9.8	12/18/23 15:41	
NFDHA	ng/L	ND	2.0	12/18/23 15:41	
NMeFOSA	ng/L	ND	0.98	12/18/23 15:41	
NMeFOSAA	ng/L	ND	0.98	12/18/23 15:41	
NMeFOSE	ng/L	ND	9.8	12/18/23 15:41	
Perfluorobutanesulfonic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorodecanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorododecanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluoroheptanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorohexanesulfonic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorohexanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorononanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorooctanesulfonic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorooctanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorotetradecanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluorotridecanoic acid	ng/L	ND	0.98	12/18/23 15:41	
Perfluoroundecanoic acid	ng/L	ND	0.98	12/18/23 15:41	
PFBA	ng/L	ND	3.9	12/18/23 15:41	
PFDoS	ng/L	ND	0.98	12/18/23 15:41	
PFDS	ng/L	ND	0.98	12/18/23 15:41	
PFEESA	ng/L	ND	2.0	12/18/23 15:41	
PFHpS	ng/L	ND	0.98	12/18/23 15:41	
PFMBA	ng/L	ND	2.0	12/18/23 15:41	
PFMPA	ng/L	ND	2.0	12/18/23 15:41	
PFNS	ng/L	ND	0.98	12/18/23 15:41	
PFOSA	ng/L	ND	0.98	12/18/23 15:41	
PFPeA	ng/L	ND	2.0	12/18/23 15:41	
PFPeS	ng/L	ND	0.98	12/18/23 15:41	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

METHOD BLANK: 4851301

Matrix: Water

Associated Lab Samples: 10678538002, 10678538003

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
13C2-PFDaA (S)	%	78	20-150	12/18/23 15:41	
13C2-PFTA (S)	%	68	20-150	12/18/23 15:41	
13C24:2FTS (S)	%	107	20-150	12/18/23 15:41	
13C26:2FTS (S)	%	109	20-150	12/18/23 15:41	
13C28:2FTS (S)	%	105	20-150	12/18/23 15:41	
13C3-PFBS (S)	%	89	20-150	12/18/23 15:41	
13C3-PFHxS (S)	%	88	20-150	12/18/23 15:41	
13C3HFPO-DA (S)	%	79	20-150	12/18/23 15:41	
13C4-PFBA (S)	%	84	20-150	12/18/23 15:41	
13C4-PFHpA (S)	%	84	20-150	12/18/23 15:41	
13C5-PFHxA (S)	%	84	20-150	12/18/23 15:41	
13C5-PFPeA (S)	%	88	20-150	12/18/23 15:41	
13C6-PFDA (S)	%	83	20-150	12/18/23 15:41	
13C7-PFUDa (S)	%	81	20-150	12/18/23 15:41	
13C8-PFOA (S)	%	84	20-150	12/18/23 15:41	
13C8-PFOS (S)	%	86	20-150	12/18/23 15:41	
13C8-PFOSA (S)	%	64	20-150	12/18/23 15:41	
13C9-PFNA (S)	%	83	20-150	12/18/23 15:41	
d3-MeFOSAA (S)	%	77	20-150	12/18/23 15:41	
d3-NMeFOSA (S)	%	33	20-150	12/18/23 15:41	
d5-EtFOSAA (S)	%	71	20-150	12/18/23 15:41	
d5-NEtFOSA (S)	%	33	20-150	12/18/23 15:41	
d7-NMeFOSE (S)	%	44	20-150	12/18/23 15:41	
d9-NEtFOSE (S)	%	41	20-150	12/18/23 15:41	

LABORATORY CONTROL SAMPLE & LCSD: 4851302

4851303

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
11Cl-PF3OUdS	ng/L	88.8	87.7	93.5	99	104	40-150	6	30	
3:3 FTCA	ng/L	118	105	104	89	87	40-150	1	30	
4:2 FTS	ng/L	88.2	86.6	87.6	98	98	40-150	1	30	
5:3 FTCA	ng/L	588	543	525	92	88	40-150	3	30	
6:2 FTS	ng/L	89.3	87.8	87.7	98	97	40-150	0	30	
7:3 FTCA	ng/L	588	519	505	88	85	40-150	3	30	
8:2 FTS	ng/L	90.5	92.8	94.1	102	103	40-150	1	30	
9Cl-PF3ONS	ng/L	88.2	92.8	95.1	105	107	40-150	2	30	
ADONA	ng/L	88.8	87.7	88.3	99	98	40-150	1	30	
HFPO-DA	ng/L	94	89.0	91.6	95	96	40-150	3	30	
NEtFOSA	ng/L	23.5	23.8	23.1	101	97	40-150	3	30	
NEtFOSAA	ng/L	23.5	23.6	23.2	101	98	40-150	2	30	
NEtFOSE	ng/L	235	231	230	98	97	40-150	0	30	
NFDHA	ng/L	47	45.2	43.5	96	92	40-150	4	30	
NMeFOSA	ng/L	23.5	23.0	22.8	98	96	40-150	1	30	
NMeFOSAA	ng/L	23.5	22.2	22.0	94	92	40-150	1	30	

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE & LCSD: 4851302			4851303							
Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
NMeFOSE	ng/L	235	230	230	98	97	40-150	0	30	
Perfluorobutanesulfonic acid	ng/L	20.9	20.4	20.8	98	98	40-150	2	30	
Perfluorodecanoic acid	ng/L	23.5	22.9	22.8	97	96	40-150	0	30	
Perfluorododecanoic acid	ng/L	23.5	23.4	22.6	99	95	40-150	3	30	
Perfluoroheptanoic acid	ng/L	23.5	23.0	23.1	98	97	40-150	1	30	
Perfluorohexanesulfonic acid	ng/L	21.5	20.2	21.0	94	97	40-150	4	30	
Perfluorohexanoic acid	ng/L	23.5	23.0	22.8	98	96	40-150	1	30	
Perfluorononanoic acid	ng/L	23.5	23.4	23.0	99	97	40-150	2	30	
Perfluorooctanesulfonic acid	ng/L	21.8	21.0	20.1	96	91	40-150	4	30	
Perfluorooctanoic acid	ng/L	23.5	22.6	22.4	96	94	40-150	1	30	
Perfluorotetradecanoic acid	ng/L	23.5	24.1	23.3	102	98	40-150	3	30	
Perfluorotridecanoic acid	ng/L	23.5	20.3	21.4	86	90	40-150	5	30	
Perfluoroundecanoic acid	ng/L	23.5	22.6	22.8	96	96	40-150	1	30	
PFBA	ng/L	94	91.9	91.9	98	97	40-150	0	30	
PFDoS	ng/L	22.8	16.8	19.6	74	85	40-150	15	30	
PFDS	ng/L	22.7	21.5	22.0	95	96	40-150	2	30	
PFEESA	ng/L	41.8	42.9	41.9	102	99	40-150	2	30	
PFHpS	ng/L	22.4	21.9	21.5	98	95	40-150	2	30	
PFMBA	ng/L	47	45.6	44.0	97	93	40-150	4	30	
PFMPA	ng/L	47	45.8	44.3	97	93	40-150	3	30	
PFNS	ng/L	22.6	21.9	21.9	97	96	40-150	0	30	
PFOSA	ng/L	23.5	22.5	22.3	96	94	40-150	1	30	
PFPeA	ng/L	47	46.6	45.1	99	95	40-150	3	30	
PFPeS	ng/L	22.1	20.6	21.3	93	95	40-150	3	30	
13C2-PFDoA (S)	%				81	82	20-150			
13C2-PFTA (S)	%				64	72	20-150			
13C24:2FTS (S)	%				104	97	20-150			
13C26:2FTS (S)	%				102	99	20-150			
13C28:2FTS (S)	%				99	95	20-150			
13C3-PFBS (S)	%				92	89	20-150			
13C3-PFHxS (S)	%				93	88	20-150			
13C3HFPO-DA (S)	%				86	81	20-150			
13C4-PFBA (S)	%				86	84	20-150			
13C4-PFHpA (S)	%				88	85	20-150			
13C5-PFHxA (S)	%				88	85	20-150			
13C5-PFPeA (S)	%				91	89	20-150			
13C6-PFDA (S)	%				88	85	20-150			
13C7-PFUdA (S)	%				87	84	20-150			
13C8-PFOA (S)	%				84	84	20-150			
13C8-PFOS (S)	%				87	88	20-150			
13C8-PFOSA (S)	%				65	66	20-150			
13C9-PFNA (S)	%				84	84	20-150			
d3-MeFOSAA (S)	%				75	78	20-150			
d3-NMeFOSA (S)	%				37	37	20-150			
d5-EtFOSAA (S)	%				68	70	20-150			
d5-NEtFOSA (S)	%				35	34	20-150			
d7-NMeFOSE (S)	%				47	45	20-150			

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE & LCSD: 4851302

4851303

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
d9-NEtFOSE (S)	%.				43	40	20-150			

LABORATORY CONTROL SAMPLE: 4851304

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
11Cl-PF3OUdS	ng/L	7.6	8.7	115	40-150	
3:3 FTCA	ng/L	10	10.7	107	40-150	
4:2 FTS	ng/L	7.5	7.9	105	40-150	
5:3 FTCA	ng/L	50.1	51.5	103	40-150	
6:2 FTS	ng/L	7.6	8.2	107	40-150	
7:3 FTCA	ng/L	50.1	50.9	102	40-150	
8:2 FTS	ng/L	7.7	8.8	115	40-150	
9Cl-PF3ONS	ng/L	7.5	8.8	117	40-150	
ADONA	ng/L	7.6	8.4	111	40-150	
HFPO-DA	ng/L	8	8.6	107	40-150	
NEtFOSA	ng/L	2	2.2	108	40-150	
NEtFOSAA	ng/L	2	2.3	115	40-150	
NEtFOSE	ng/L	20.1	20.5	102	40-150	
NFDHA	ng/L	4	4.2	104	40-150	
NMeFOSA	ng/L	2	2.2	109	40-150	
NMeFOSAA	ng/L	2	2.4	118	40-150	
NMeFOSE	ng/L	20.1	20.6	103	40-150	
Perfluorobutanesulfonic acid	ng/L	1.8	2.0	114	40-150	
Perfluorodecanoic acid	ng/L	2	2.1	106	40-150	
Perfluorododecanoic acid	ng/L	2	2.1	106	40-150	
Perfluoroheptanoic acid	ng/L	2	2.3	112	40-150	
Perfluorohexanesulfonic acid	ng/L	1.8	2.0	110	40-150	
Perfluorohexanoic acid	ng/L	2	2.5	125	40-150	
Perfluorononanoic acid	ng/L	2	2.1	106	40-150	
Perfluorooctanesulfonic acid	ng/L	1.9	2.4	127	40-150	
Perfluorooctanoic acid	ng/L	2	2.3	115	40-150	
Perfluorotetradecanoic acid	ng/L	2	2.1	107	40-150	
Perfluorotridecanoic acid	ng/L	2	2.0	98	40-150	
Perfluoroundecanoic acid	ng/L	2	2.1	104	40-150	
PFBA	ng/L	8	9.5	119	40-150	
PFDoS	ng/L	1.9	1.8	90	40-150	
PFDS	ng/L	1.9	2.0	105	40-150	
PFEESA	ng/L	3.6	4.0	111	40-150	
PFHpS	ng/L	1.9	2.0	106	40-150	
PFMBA	ng/L	4	4.2	104	40-150	
PFMPA	ng/L	4	4.4	110	40-150	
PFNS	ng/L	1.9	2.1	110	40-150	
PFOSA	ng/L	2	2.1	107	40-150	
PFPeA	ng/L	4	4.3	107	40-150	
PFPeS	ng/L	1.9	2.0	106	40-150	

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE: 4851304

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
13C2-PFDoA (S)	%.			84	20-150	
13C2-PFTA (S)	%.			72	20-150	
13C24:2FTS (S)	%.			114	20-150	
13C26:2FTS (S)	%.			108	20-150	
13C28:2FTS (S)	%.			107	20-150	
13C3-PFBS (S)	%.			96	20-150	
13C3-PFHxS (S)	%.			96	20-150	
13C3HFPO-DA (S)	%.			87	20-150	
13C4-PFBA (S)	%.			88	20-150	
13C4-PFHpA (S)	%.			90	20-150	
13C5-PFHxA (S)	%.			89	20-150	
13C5-PFPeA (S)	%.			93	20-150	
13C6-PFDA (S)	%.			90	20-150	
13C7-PFUdA (S)	%.			90	20-150	
13C8-PFOA (S)	%.			86	20-150	
13C8-PFOS (S)	%.			91	20-150	
13C8-PFOSA (S)	%.			71	20-150	
13C9-PFNA (S)	%.			90	20-150	
d3-MeFOSAA (S)	%.			79	20-150	
d3-NMeFOSA (S)	%.			38	20-150	
d5-EtFOSAA (S)	%.			74	20-150	
d5-NEtFOSA (S)	%.			36	20-150	
d7-NMeFOSE (S)	%.			52	20-150	
d9-NEtFOSE (S)	%.			47	20-150	

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QUALITY CONTROL DATA

Project: MPCA-Revised Report
Pace Project No.: 10678538

QC Batch:	925745	Analysis Method:	EPA 1633 DRAFT
QC Batch Method:	EPA 1633 DRAFT	Analysis Description:	1633 W
		Laboratory:	Pace Analytical Services - Minneapolis

Associated Lab Samples: 10678538001

METHOD BLANK: 4861314 Matrix: Water

Associated Lab Samples: 10678538001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
11CI-PF3OUdS	ng/L	ND	4.0	01/04/24 15:52	
3:3 FTCA	ng/L	ND	5.0	01/04/24 15:52	
4:2 FTS	ng/L	ND	4.0	01/04/24 15:52	
5:3 FTCA	ng/L	ND	24.8	01/04/24 15:52	
6:2 FTS	ng/L	ND	4.0	01/04/24 15:52	
7:3 FTCA	ng/L	ND	24.8	01/04/24 15:52	
8:2 FTS	ng/L	ND	4.0	01/04/24 15:52	
9CI-PF3ONS	ng/L	ND	4.0	01/04/24 15:52	
ADONA	ng/L	ND	4.0	01/04/24 15:52	
HFPO-DA	ng/L	ND	4.0	01/04/24 15:52	
NEtFOSA	ng/L	ND	0.99	01/04/24 15:52	
NEtFOSAA	ng/L	ND	0.99	01/04/24 15:52	
NEtFOSE	ng/L	ND	9.9	01/04/24 15:52	
NFDHA	ng/L	ND	2.0	01/04/24 15:52	
NMeFOSA	ng/L	ND	0.99	01/04/24 15:52	
NMeFOSAA	ng/L	ND	0.99	01/04/24 15:52	
NMeFOSE	ng/L	ND	9.9	01/04/24 15:52	
Perfluorobutanesulfonic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorodecanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorododecanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluoroheptanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorohexanesulfonic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorohexanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorononanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorooctanesulfonic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorooctanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorotetradecanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluorotridecanoic acid	ng/L	ND	0.99	01/04/24 15:52	
Perfluoroundecanoic acid	ng/L	ND	0.99	01/04/24 15:52	
PFBA	ng/L	ND	4.0	01/04/24 15:52	
PFDoS	ng/L	ND	0.99	01/04/24 15:52	
PFDS	ng/L	ND	0.99	01/04/24 15:52	
PFEESA	ng/L	ND	2.0	01/04/24 15:52	
PFHpS	ng/L	ND	0.99	01/04/24 15:52	
PFMBA	ng/L	ND	2.0	01/04/24 15:52	
PFMPA	ng/L	ND	2.0	01/04/24 15:52	
PFNS	ng/L	ND	0.99	01/04/24 15:52	
PFOSA	ng/L	ND	0.99	01/04/24 15:52	
PFPeA	ng/L	ND	2.0	01/04/24 15:52	
PFPeS	ng/L	ND	0.99	01/04/24 15:52	

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QUALITY CONTROL DATA

Project: MPCA-Revised Report
Pace Project No.: 10678538

METHOD BLANK: 4861314

Matrix: Water

Associated Lab Samples: 10678538001

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
13C2-PFDaA (S)	%	79	20-150	01/04/24 15:52	
13C2-PFTA (S)	%	75	20-150	01/04/24 15:52	
13C24:2FTS (S)	%	92	20-150	01/04/24 15:52	
13C26:2FTS (S)	%	96	20-150	01/04/24 15:52	
13C28:2FTS (S)	%	89	20-150	01/04/24 15:52	
13C3-PFBS (S)	%	97	20-150	01/04/24 15:52	
13C3-PFHxS (S)	%	92	20-150	01/04/24 15:52	
13C3HFPO-DA (S)	%	96	20-150	01/04/24 15:52	
13C4-PFBA (S)	%	90	20-150	01/04/24 15:52	
13C4-PFHpA (S)	%	80	20-150	01/04/24 15:52	
13C5-PFHxA (S)	%	93	20-150	01/04/24 15:52	
13C5-PFPeA (S)	%	95	20-150	01/04/24 15:52	
13C6-PFDA (S)	%	90	20-150	01/04/24 15:52	
13C7-PFUDa (S)	%	81	20-150	01/04/24 15:52	
13C8-PFOA (S)	%	87	20-150	01/04/24 15:52	
13C8-PFOS (S)	%	93	20-150	01/04/24 15:52	
13C8-PFOSA (S)	%	81	20-150	01/04/24 15:52	
13C9-PFNA (S)	%	93	20-150	01/04/24 15:52	
d3-MeFOSAA (S)	%	102	20-150	01/04/24 15:52	
d3-NMeFOSA (S)	%	52	20-150	01/04/24 15:52	
d5-EtFOSAA (S)	%	88	20-150	01/04/24 15:52	
d5-NEtFOSA (S)	%	47	20-150	01/04/24 15:52	
d7-NMeFOSE (S)	%	63	20-150	01/04/24 15:52	
d9-NEtFOSE (S)	%	58	20-150	01/04/24 15:52	

LABORATORY CONTROL SAMPLE & LCSD: 4861315

4861316

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
11CI-PF3OUdS	ng/L	90.3	86.6	86.0	96	94	40-150	1	30	
3:3 FTCA	ng/L	120	170	166	142	138	40-150	2	30	
4:2 FTS	ng/L	89.7	82.2	81.5	92	90	40-150	1	30	
5:3 FTCA	ng/L	598	599	564	100	94	40-150	6	30	
6:2 FTS	ng/L	90.9	81.8	78.9	90	86	40-150	4	30	
7:3 FTCA	ng/L	598	563	520	94	86	40-150	8	30	
8:2 FTS	ng/L	92.1	87.8	84.3	95	91	40-150	4	30	
9CI-PF3ONS	ng/L	89.7	80.6	75.5	90	83	40-150	7	30	
ADONA	ng/L	90.3	81.8	76.3	91	84	40-150	7	30	
HFPO-DA	ng/L	95.7	91.2	81.8	95	85	40-150	11	30	
NEtFOSA	ng/L	23.9	20.5	20.3	86	84	40-150	1	30	
NEtFOSAA	ng/L	23.9	22.5	20.9	94	87	40-150	7	30	
NEtFOSE	ng/L	239	218	206	91	85	40-150	6	30	
NFDHA	ng/L	47.8	42.2	40.1	88	83	40-150	5	30	
NMeFOSA	ng/L	23.9	21.4	20.4	89	84	40-150	5	30	
NMeFOSAA	ng/L	23.9	22.5	19.9	94	82	40-150	12	30	

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE & LCSD: 4861315			4861316							
Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
NMeFOSE	ng/L	239	229	207	96	86	40-150	10	30	
Perfluorobutanesulfonic acid	ng/L	21.2	19.4	17.7	91	83	40-150	9	30	
Perfluorodecanoic acid	ng/L	23.9	21.4	19.1	90	79	40-150	12	30	
Perfluorododecanoic acid	ng/L	23.9	20.5	19.9	86	83	40-150	3	30	
Perfluoroheptanoic acid	ng/L	23.9	21.6	20.4	90	85	40-150	6	30	
Perfluorohexanesulfonic acid	ng/L	21.9	19.4	17.3	89	78	40-150	11	30	
Perfluorohexanoic acid	ng/L	23.9	21.5	20.0	90	83	40-150	7	30	
Perfluorononanoic acid	ng/L	23.9	21.6	19.6	90	81	40-150	10	30	
Perfluorooctanesulfonic acid	ng/L	22.2	19.8	16.9	89	76	40-150	16	30	
Perfluorooctanoic acid	ng/L	23.9	22.0	20.2	92	84	40-150	9	30	
Perfluorotetradecanoic acid	ng/L	23.9	21.2	19.8	89	82	40-150	7	30	
Perfluorotridecanoic acid	ng/L	23.9	20.3	21.2	85	88	40-150	5	30	
Perfluoroundecanoic acid	ng/L	23.9	22.3	19.9	93	82	40-150	12	30	
PFBA	ng/L	95.7	86.9	81.4	91	84	40-150	7	30	
PFDoS	ng/L	23.2	18.5	16.4	80	70	40-150	12	30	
PFDS	ng/L	23.1	20.0	18.3	86	79	40-150	9	30	
PFEESA	ng/L	42.6	38.9	37.9	91	88	40-150	3	30	
PFHpS	ng/L	22.8	22.1	19.3	97	84	40-150	13	30	
PFMBA	ng/L	47.8	43.1	40.7	90	84	40-150	6	30	
PFMPA	ng/L	47.8	44.9	43.2	94	90	40-150	4	30	
PFNS	ng/L	23	21.3	18.8	92	81	40-150	12	30	
PFOSA	ng/L	23.9	20.0	19.1	84	79	40-150	4	30	
PFPeA	ng/L	47.8	43.1	40.5	90	84	40-150	6	30	
PFPeS	ng/L	22.5	21.6	19.8	96	87	40-150	9	30	
13C2-PFDoA (S)	%				76	76	20-150			
13C2-PFTA (S)	%				68	73	20-150			
13C24:2FTS (S)	%				78	73	20-150			
13C26:2FTS (S)	%				86	82	20-150			
13C28:2FTS (S)	%				84	86	20-150			
13C3-PFBS (S)	%				85	88	20-150			
13C3-PFHxS (S)	%				85	90	20-150			
13C3HFPO-DA (S)	%				86	94	20-150			
13C4-PFBA (S)	%				83	90	20-150			
13C4-PFHpA (S)	%				78	85	20-150			
13C5-PFHxA (S)	%				84	92	20-150			
13C5-PFPeA (S)	%				88	97	20-150			
13C6-PFDA (S)	%				86	89	20-150			
13C7-PFUdA (S)	%				74	80	20-150			
13C8-PFOA (S)	%				84	91	20-150			
13C8-PFOS (S)	%				86	100	20-150			
13C8-PFOSA (S)	%				84	89	20-150			
13C9-PFNA (S)	%				86	93	20-150			
d3-MeFOSAA (S)	%				97	100	20-150			
d3-NMeFOSA (S)	%				59	67	20-150			
d5-EtFOSAA (S)	%				81	87	20-150			
d5-NEtFOSA (S)	%				53	59	20-150			
d7-NMeFOSE (S)	%				62	66	20-150			

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REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE & LCSD: 4861315

4861316

Parameter	Units	Spike Conc.	LCS Result	LCSD Result	LCS % Rec	LCSD % Rec	% Rec Limits	RPD	Max RPD	Qualifiers
d9-NEtFOSE (S)	%.				59	59	20-150			

LABORATORY CONTROL SAMPLE: 4861317

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
11Cl-PF3OUdS	ng/L	7.6	8.1	107	40-150	
3:3 FTCA	ng/L	10.1	15.0	148	40-150	
4:2 FTS	ng/L	7.6	7.9	105	40-150	
5:3 FTCA	ng/L	50.5	54.5	108	40-150	
6:2 FTS	ng/L	7.7	8.7	114	40-150	
7:3 FTCA	ng/L	50.5	52.5	104	40-150	
8:2 FTS	ng/L	7.8	9.3	120	40-150	
9Cl-PF3ONS	ng/L	7.6	7.8	102	40-150	
ADONA	ng/L	7.6	8.0	104	40-150	
HFPO-DA	ng/L	8.1	8.4	104	40-150	
NEtFOSA	ng/L	2	2.0	97	40-150	
NEtFOSAA	ng/L	2	2.4	118	40-150	
NEtFOSE	ng/L	20.2	21.6	107	40-150	
NFDHA	ng/L	4	4.2	104	40-150	
NMeFOSA	ng/L	2	2.1	103	40-150	
NMeFOSAA	ng/L	2	2.2	109	40-150	
NMeFOSE	ng/L	20.2	22.3	111	40-150	
Perfluorobutanesulfonic acid	ng/L	1.8	1.9	106	40-150	
Perfluorodecanoic acid	ng/L	2	2.0	101	40-150	
Perfluorododecanoic acid	ng/L	2	2.1	104	40-150	
Perfluoroheptanoic acid	ng/L	2	2.1	104	40-150	
Perfluorohexanesulfonic acid	ng/L	1.8	2.0	107	40-150	
Perfluorohexanoic acid	ng/L	2	2.2	107	40-150	
Perfluorononanoic acid	ng/L	2	2.1	103	40-150	
Perfluorooctanesulfonic acid	ng/L	1.9	2.1	110	40-150	
Perfluorooctanoic acid	ng/L	2	2.2	111	40-150	
Perfluorotetradecanoic acid	ng/L	2	2.2	108	40-150	
Perfluorotridecanoic acid	ng/L	2	2.1	104	40-150	
Perfluoroundecanoic acid	ng/L	2	2.1	103	40-150	
PFBA	ng/L	8.1	9.4	117	40-150	
PFDoS	ng/L	2	1.9	95	40-150	
PFDS	ng/L	1.9	1.9	97	40-150	
PFEESA	ng/L	3.6	3.8	107	40-150	
PFHpS	ng/L	1.9	2.2	116	40-150	
PFMBA	ng/L	4	4.0	98	40-150	
PFMPA	ng/L	4	4.4	108	40-150	
PFNS	ng/L	1.9	2.0	104	40-150	
PFOSA	ng/L	2	2.2	108	40-150	
PFPeA	ng/L	4	4.5	112	40-150	
PFPeS	ng/L	1.9	2.3	120	40-150	

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QUALITY CONTROL DATA

Project: MPCA-Revised Report

Pace Project No.: 10678538

LABORATORY CONTROL SAMPLE: 4861317

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
13C2-PFDoA (S)	%.			81	20-150	
13C2-PFTA (S)	%.			75	20-150	
13C24:2FTS (S)	%.			89	20-150	
13C26:2FTS (S)	%.			99	20-150	
13C28:2FTS (S)	%.			93	20-150	
13C3-PFBS (S)	%.			93	20-150	
13C3-PFHxS (S)	%.			97	20-150	
13C3HFPO-DA (S)	%.			99	20-150	
13C4-PFBA (S)	%.			90	20-150	
13C4-PFHpA (S)	%.			87	20-150	
13C5-PFHxA (S)	%.			92	20-150	
13C5-PFPeA (S)	%.			96	20-150	
13C6-PFDA (S)	%.			92	20-150	
13C7-PFUdA (S)	%.			87	20-150	
13C8-PFOA (S)	%.			91	20-150	
13C8-PFOS (S)	%.			96	20-150	
13C8-PFOSA (S)	%.			84	20-150	
13C9-PFNA (S)	%.			93	20-150	
d3-MeFOSAA (S)	%.			101	20-150	
d3-NMeFOSA (S)	%.			65	20-150	
d5-EtFOSAA (S)	%.			89	20-150	
d5-NEtFOSA (S)	%.			60	20-150	
d7-NMeFOSE (S)	%.			65	20-150	
d9-NEtFOSE (S)	%.			63	20-150	

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QUALIFIERS

Project: MPCA-Revised Report

Pace Project No.: 10678538

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

TNTC - Too Numerous To Count

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit - The lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Reported results are not rounded until the final step prior to reporting. Therefore, calculated parameters that are typically reported as "Total" may vary slightly from the sum of the reported component parameters.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

REPORT OF LABORATORY ANALYSIS

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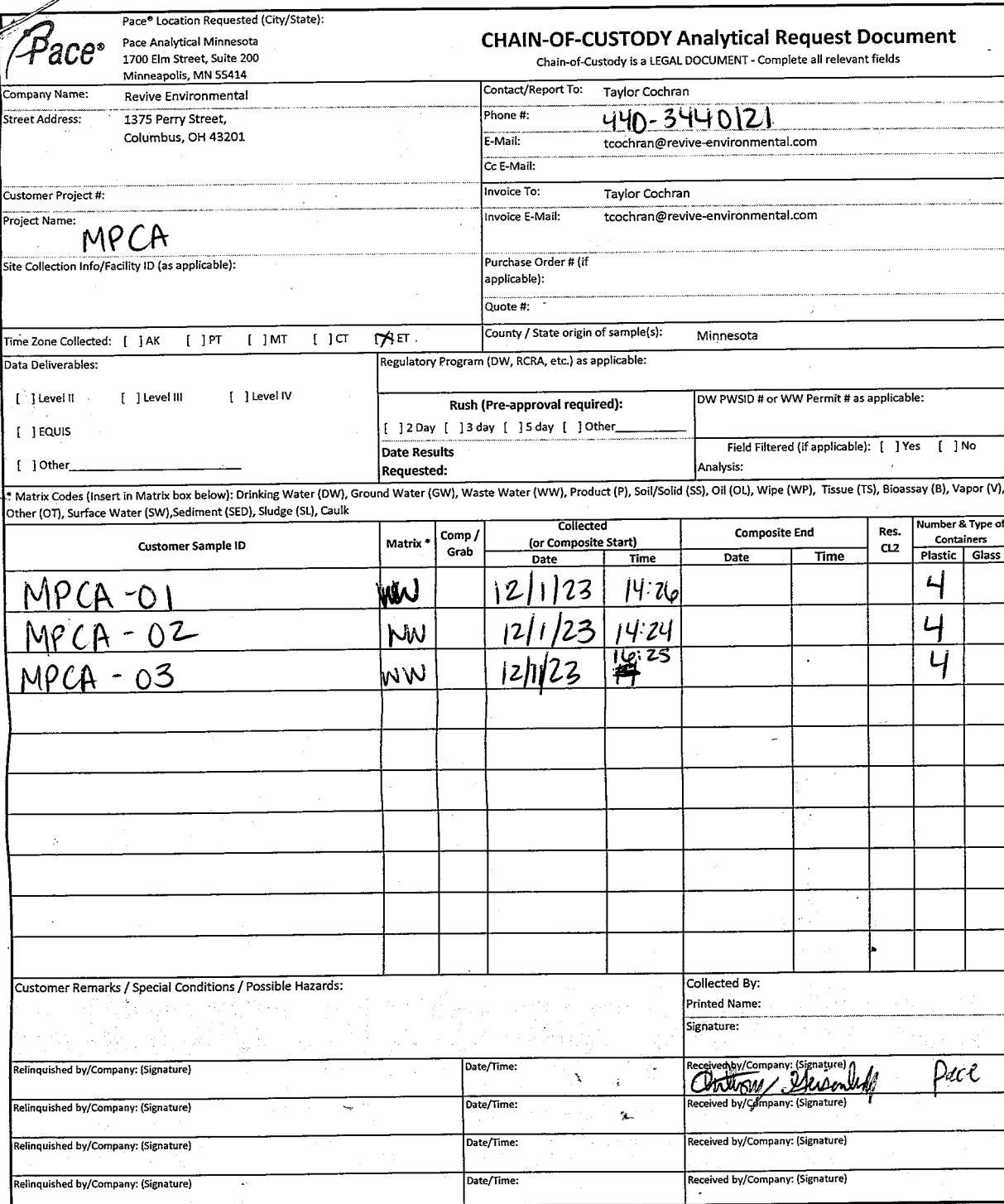


QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: MPCA-Revised Report
Pace Project No.: 10678538

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
10678538001	MPCA-01	EPA 1633 DRAFT	925745	EPA 1633 DRAFT	926286
10678538002	MPCA-02	EPA 1633 DRAFT	923396	EPA 1633 DRAFT	924189
10678538003	MPCA-03	EPA 1633 DRAFT	923396	EPA 1633 DRAFT	924189

REPORT OF LABORATORY ANALYSIS



WO#: 10678538

[illegible]

Customer Remarks / Special Conditions / Possible Hazards:

Collected By:

Printed Name:

Signature:

Additional Instructions from Pace®:

# Coolers:	Thermometer ID:	Correction Factor (°C):	Obs. Temp. (°C)	Corrected Temp. (°C)
	14	True	2.0	2.0

Relinquished by/Company: (Signature)

Date/Time:

Received by/Company: (Signature)

Date/Time:

8:40

Tracking Number:

Relinquished by/Company: (Signature)

Date/Time:

Received by/Company: (Signature)

Date/Time:

Delivered by: ☐ In-Person ☐ Courier

Relinquished by/Company: (Signature)

Date/Time:

Received by/Company: (Signature)

Date/Time:

☐ FedEX ☐ UPS ☐ Other

Relinquished by/Company: (Signature)

Date/Time:

Received by/Company: (Signature)

Date/Time:

Page: 1 of 1

Effective Date: 4/14/2023

Sample Condition Upon Receipt	Client Name: <u>Revive Environmental</u>	Project #: <u>WO# : 10678538</u>	PM: KV Due Date: 12/21/23 CLIENT: Revive Env
Courier: ☒ FedEx ☐ UPS ☐ USPS ☐ Client ☐ Pace ☐ Speedee ☐ Commercial			
Tracking Number: <u>6101 4271 5069</u>		☐ See Exceptions ENV-FRM-MIN4-0142	
Custody Seal on Cooler/Box Present? ☒ Yes ☐ No Seals Intact? ☒ Yes ☐ No		Biological Tissue Frozen? ☐ Yes ☐ No ☒ N/A	
Packing Material: ☒ Bubble Wrap ☐ Bubble Bags ☐ None ☐ Other		Temp Blank? ☒ Yes ☐ No	
Thermometer: ☐ T1 (0461) ☐ T2 (0436) ☐ T3 (0459) ☒ T4 (0402) ☐ T5 (0178) ☐ T6 (0235) ☐ T7 (0042) ☐ T8 (0775) ☐ T9 (0727) ☐ 01339252/1710		Type of Ice: ☒ Wet ☐ Blue ☐ Dry ☐ None ☐ Melted	
Did Samples Originate in West Virginia? ☐ Yes ☒ No Were All Container Temps Taken? ☐ Yes ☐ No ☒ N/A			
Temp should be above freezing to 6 °C		Cooler temp Read w/Temp Blank: <u>2.0</u> °C	
Correction Factor: <u>true</u>		Cooler Temp Corrected w/temp blank: <u>2.0</u> °C	
Average Corrected Temp (no temp blank only): _____ °C		☐ See Exceptions ENV-FRM-MIN4-0142 ☐ 1 Container	
USDA Regulated Soil: ☒ N/A, (water sample/other: _____)			
Did samples originate in a quarantine zone within the United States: AL, AR, AZ, CA, FL, GA, ID, LA, MS, NC, NM, NY, OK, OR, SC, TN, TX, or VA (check maps)? ☐ Yes ☐ No		Did samples originate from a foreign source (internationally, including Hawaii and Puerto Rico)? ☐ Yes ☐ No	
If Yes to either question, fill out a Regulated Soil Checklist (ENV-FRM-MIN4-0154) and include with SCUR/COC paperwork.			
Location (Check one): ☐ Duluth ☒ Minneapolis ☐ Virginia			COMMENTS
Chain of Custody Present and Filled Out?			1.
Chain of Custody Relinquished?			2.
Sampler Name and/or Signature on COC?			3.
Samples Arrived within Hold Time?			4. If fecal: ☐ <8 hrs ☐ >8 hr, <24 ☐ No
Short Hold Time Analysis (<72 hr)?			5. ☐ Fecal Coliform ☐ HPC ☐ Total Coliform/E.coli ☐ BOD/cBOD ☐ Hex Chrom ☐ Turbidity ☐ Nitrate ☐ Nitrite ☐ Orthophos ☐ Other _____
Rush Turn Around Time Requested? *			6.
Sufficient Sample Volume?			7.
Correct Containers Used?			8.
-Pace Containers Used?			
Containers Intact?			9.
Field Filtered Volume Received for Dissolved Tests?			10. Is sediment visible in the dissolved container? ☐ Yes ☐ No
Is sufficient information available to reconcile the samples to the COC?			11. If no, write ID/Date/Time of container below: <u>MPC A003's collection time listed at 12/1/23</u>
Matrix: ☒ Water ☐ Soil ☐ Oil ☐ Other			12. Sample # <u>on bottles.</u>
All containers needing acid/base preservation have been checked?			☐ NaOH ☐ HNO3 ☐ H2SO4 ☐ Zinc Acetate
All containers needing preservation are found to be in compliance with EPA recommendation? (HNO3, H2SO4, <2pH, NaOH >9 Sulfide, NaOH >10 Cyanide)			Positive for Residual Chlorine? ☐ Yes ☐ No ☐ See Exceptions ENV-FRM-MIN4-0142
Exceptions: VOA, Coliform, TOC/DOC Oil and Grease, DRO/8015 (water) and Dioxins/PFAS (*If adding preservative to a container, it must be added to associated field and equipment blanks--verify with PM first.)			pH Paper Lot #
			Residual Chlorine 0-6 Roll 0-6 Strip 0-14 Strip
Headspace in Methyl Mercury Container?			13.
Extra labels present on soil VOA or WIDRO containers?			14. ☐ See Exceptions ENV-FRM-MIN4-0142
Headspace in VOA Vials (greater than 6mm)?			
3 Trip Blanks Present?			15.
Trip Blank Custody Seals Present?			Pace Trip Blank Lot # (if purchased): _____

CLIENT NOTIFICATION/RESOLUTION

Person Contacted: _____

Date/Time: _____

Comments/Resolution: _____

Field Data Required? ☐ Yes ☐ NoProject Manager Review: Kirsten HogbergDate: 12/11/2023

NOTE: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e., out of hold, incorrect preservative, out of temp, incorrect containers).

Labeled By: A66 Line: 2

Customer: NA
Customer Job ID: NA

Quality Control Result

Novem Job ID: CCV
Report Date: 2023-12-14

Sample Information

Continue Calibration Verification (CCV):

Novem Sample ID: 30 ppb IF + 70 ppb TOF = 100 ppb TF

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	C4F9SO3K + NaF	99.5	ppb (µg/L)
Inorganic Fluoride	IC	NaF	29.9	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	69.6	ppb (µg/L)

Calibration standards for Inorganic Fluoride (IF) = 2.5 ppb to 200 ppb. RL for IF = 2.5 ppb

Calibration standard for Total Fluorine (TF) = 10 ppb to 600 ppb. RL for TF = 10 ppb

Total Organic Fluorine (TOF) = Total Fluorine (TF) - Inorganic Fluoride (IF)



2357 Ventura Dr Suite 110
Woodbury MN 55125
info@novemscientific.com

A handwritten signature in black ink, appearing to read "Andrew Christianson".

Reviewed by: Andrew Christianson

Customer: NA
Customer Job ID: NA

Quality Control Result

Novem Job ID: CCV
Report Date: 2023-12-14

Sample Information

Continue Calibration Verification (CCV):

Novem Sample ID: 30 ppb IF + 70 ppb TOF = 100 ppb TF

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	C4F9SO3K + NaF	96.8	ppb (µg/L)
Inorganic Fluoride	IC	NaF	31.2	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	65.6	ppb (µg/L)

Calibration standards for Inorganic Fluoride (IF) = 2.5 ppb to 200 ppb. RL for IF = 2.5 ppb

Calibration standard for Total Fluorine (TF) = 10 ppb to 600 ppb. RL for TF = 10 ppb

Total Organic Fluorine (TOF) = Total Fluorine (TF) - Inorganic Fluoride (IF)



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Chain of Custody

PASI Minnesota Laboratory



Workorder: 10678538

Workorder Name: MPCA

Results Requested By: 12/21/2023

Report / Invoice To
Kongmeng Vang
Pace Analytical Minnesota
1700 Elm Street
Minneapolis, MN 55414
Phone 612-607-6382
Email: kongmeng.vang@pacelabs.com

Subcontract To
Novem Scientific
2357 Ventura Drive
Woodbury, MN 55125

P.O. 10678538

Send Invoice To: invoices@pacelabs.coupanhost.com
State of Sample Origin: MN

NT3U
Unpreserved
Preserved Containers

Item	Sample ID	Collect Date/Time	Lab ID	Matrix	Preserved Containers				Total Fluorine	Requested Analysis										LAB USE ONLY
1	MPCA-01	12/1/2023 14:26	10678538001	Water	1				X											
2	MPCA-02	12/1/2023 14:24	10678538002	Water	1				X											
3	MPCA-03	12/1/2023 16:25	10678538003	Water	1				X											
4																				
5																				
Comments																				
Transfers		Released By	Date/Time	Received By	Date/Time															
1		Bic Conn (PAC)	12/2/23 9:00																	
2																				
3																				
Cooler Temperature on Receipt		°C	Custody Seal	Y or N	Received on Ice	Y or N	Samples Intact Y or N													

Rec'd 12/13/2023
1:25 pm
Al
November 23 - 127

Sample Test Result

Sample Information

Customer Sample ID: MPCA-01

Novem Sample ID: Novem23-127-001

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	4274.6	ppb (µg/L)
Inorganic Fluoride	IC	IF	120.3	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	4154.3	ppb (µg/L)

TOF LOQ (20% of IF) = 24 ppb Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 2.5 ppb to 200 ppb, RL for IF = 2.5 ppb F or dilution factor * 2.5

Calibration standards for TF = 10 ppb to 600 ppb. RL for TF = 10 ppb or dilution factor * 10

Dilution Factor = 10



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Customer: Pace MN
Customer Job ID: 10678538

Sample Test Result

Novem Job ID: Novem23-127-002
Report Date: 2023-12-14

Sample Information

Customer Sample ID: MPCA-02

Novem Sample ID: Novem23-127-002

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	30.4	ppb (µg/L)
Inorganic Fluoride	IC	IF	3.8	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	26.6	ppb (µg/L)

TOF LOQ (20% of IF) = 1 ppb Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 2.5 ppb to 200 ppb, RL for IF = 2.5 ppb F or dilution factor * 2.5

Calibration standards for TF = 10 ppb to 600 ppb. RL for TF = 10 ppb or dilution factor * 10

Dilution Factor = 1



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Reviewed by: Andrew Christianson

Sample Test Result

Sample Information

Customer Sample ID: MPCA-03

Novem Sample ID: Novem23-127-003

Analyst: Yvonne Senevilay

Test	Method	Analyte	Test Value	Unit
Total Fluorine	CIC	TOF + IF	4128.4	ppb (µg/L)
Inorganic Fluoride	IC	IF	3839.8	ppb (µg/L)
TOF = TF - IF	Calculation	TOF	288.7	ppb (µg/L)

TOF LOQ (20% of IF) = 768 ppb Note, if calculated TOF is less than LOQ, then the result is deemed an estimation.

TOF = TF - IF, empty field in Test Value for IF means IF = none detect

"Invalid" in Test Value for TOF means TF = TOF

Calibration standards for Inorganic Fluoride = 2.5 ppb to 200 ppb, RL for IF = 2.5 ppb F or dilution factor * 2.5

Calibration standards for TF = 10 ppb to 600 ppb. RL for TF = 10 ppb or dilution factor * 10

Dilution Factor = 10



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Reviewed by: Andrew Christianson