Exhibits

3M's Comments to
Draft NPDES/SDS Permit No. MN0001449 for
3M Operations LLC Cottage Grove Facility
Cottage Grove, Washington County, Minnesota
August 30, 2024

Volume 1

Exhibit A to Exhibit F-5

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RE: DRAFT NPDES/SDS PERMIT MN0001449

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F-8	March 28, 2024 3M Letter to Commissioner Kessler
F-9	April 3, 2024 MPCA letter re Phase 3 wastewater treatment system
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H	Memorandum from Rock Vitale, CEAC, Environmental Standards, Inc., *Response to MPCA Proposed Intervention Limits for 3M’s Cottage Grove, Minnesota facility, Calendar Average and Daily Maximum* (“Vitale Expert Report”)
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EXHIBIT NO.	EXHIBIT DESCRIPTION
J	Weston Solutions Inc., 3M 2023 Instream PFAS Characterization Study Final Report-Mississippi River, Cottage Grove, Minnesota (June 29, 2023) ("2023 IPC Study")[1]
K	Tables and Figures from the 3M 2023 Instream PFAS Characterization Study Final Report-Mississippi River, Cottage Grove, MN, Weston Solutions, Inc. issued June 29, 2023 ("IPC Study") • Table 1. PFAS Detections in Surface Water from Reaches 02 and 03 • Table 2. PFAS Detections in Fish Fillet from Reaches 02 and 03 (7 fish species) • Figure 2. PFOS Decrease in Pool 2 fish fillet (2005-2021) • Table 3. DT50 and DT90 for PFOS in the Mississippi River Pools 2 and 3 (2005-2021) • Figure 3. PFOS levels in Bde Maka Ska (formerly Calhoun) and Lake Harriet; MPCA Data • Table 4. Comparison of 2021 IPCS to recent instream PFAS studies in scientific literature
L	Settlement Agreement and Compliance Order between MPCA and 3M dated May 2027 ("SACO") •

[1] *Note: 3M hereby incorporates the final version of the 2023 IPC Study by reference due to size limitations. The study was provided to MPCA in draft on April 28, 2023 and in final on June 29, 2023.*

EXHIBIT A

EXHIBIT A-1

Treatability Study

PFAS Treatability Alternatives Identification Plan

Prepared for
3M Cottage Grove Facility

May 2021

PFAS Treatability Alternatives Identification Plan

Prepared for
3M Cottage Grove Facility

May 2021

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PFAS Treatability Alternatives Identification Plan

May 2021

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Certifications

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for sections 1 and 2

	May 28, 2021
Don E. Richard PE #: 21193	Date

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for sections 3, 4, 5, and 6

	May 28, 2021
Kathryn M. Wolohan PE #: 54881	Date

Abbreviations

AIX	anion exchange
BOD	biochemical oxygen demand
COD	chemical oxygen demand
EBCT	empty-bed contact time
GAC	granular activated carbon
HLR	hydraulic loading rate
HQ-115	Bis(trifluoromethylsulfonyl)amine
MeFBSAA	Perfluorobutyl-methyl sulfonamide glycine acid
MGD	million gallons per day
MPCA	Minnesota Pollution Control Agency
NCCW	noncontact cooling water
NF	nanofiltration
ng/L	nanograms per liter
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PFAS	per- and poly-fluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutane sulfonate
PFES	Perfluoroethanesulfonate
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFPA	Perfluoropropionic acid
PFPeA	Perfluoropentanoic acid
PIBA	Perfluoroisobutyl amide
TFA	Trifluoroacetic acid
TFMS	Trifluoromethane sulfonate
TSS	total suspended solids
UV	ultraviolet

1 Introduction

This PFAS Treatability Alternatives Identification Plan (Plan) has been prepared pursuant to corrective action no. 17 of the Notice of Violation (NOV) issued by the Minnesota Pollution Control Agency (MPCA) to the 3M Cottage Grove Center (Facility) dated January 22, 2021, which states as follows:

> *PFAS Treatability Plan: The Regulated Party shall submit a PFAS Treatability Alternative Identification Plan (Plan), by April 15, 2021, for MPCA review and comment. The Plan shall be prepared by a professional engineer registered in the state of Minnesota with expertise and experience in wastewater treatment plant (WWTP) design and operation/maintenance. The Plan shall include a preliminary analysis of all potential feasible treatment alternatives/technologies that may be capable of meeting the applicable effluent, water quality, and public health requirements for 20 years. The plan shall include the technical feasibility, economic feasibility (including cost-effectiveness), energy consumption, and the potential for media shifting of pollutants within the plan. The plan shall utilize Minn. R. 7077.0272, subp. 2., as a guide. The Plan shall be modified pursuant to MPCA review.*

The focus of this Plan is the evaluation of PFAS treatment alternatives for combined treated wastewater effluent, noncontact cooling water (NCCW), and partial stormwater from the Facility under existing Minnesota National Pollutant Discharge Elimination System (NPDES) and Surface Discharge System (SDS) Permit MN0001449 (NPDES/SDS Permit MN0001449).

1.1 Background

The wastewater collection system at the Facility collects wastewater from multiple processes for treatment through one of three main phases of treatment:

- Phase 1, the inorganic treatment system adjusts the pH and removes suspended solids from the process wastewater.
- Phase 2, the organic treatment system, treats organic material and nutrients in process wastewater and sanitary wastewater from across the Facility.
- Phase 3 treats wastewater from the on-site incinerator.

Treated wastewater from the combined Phase 1/2 systems currently receives final treatment through granular activated carbon (GAC) for polishing, followed by ultraviolet (UV) disinfection. Treated wastewater from the Phase 3 system also receives final treatment through GAC for polishing in a separate GAC system.

After GAC treatment and UV disinfection (Phase 1/2 only), effluent from all three phases flows to Outfall SD001 (SD001). Combined NCCW and stormwater from a portion of the site flows to Outfall SD002 (SD002). Effluent from SD001 and SD002 combines at Outfall 003 (SD003) before discharging from the Facility to the Mississippi River via an unnamed creek.

1.2 Plan Objective

The objective of this Plan is to evaluate potential water treatment technologies and alternatives that may be capable of meeting potential PFAS effluent requirements for wastewater discharges for the next 20 years.

1.3 Scope of Evaluation

To complete this Plan, Barr Engineering Co. (Barr) conducted a preliminary analysis of potential treatment technologies and alternatives that may be capable of meeting applicable potential PFAS effluent requirements for the next 20 years.

This analysis involved:

1. Identifying influent water quantity and quality as well as water quality targets (Section 2).
2. Identifying potential PFAS treatment technologies (Section 3).
3. Screening potential PFAS technologies against threshold criteria for use at this Facility (Section 3).
4. Developing five treatment alternatives (Section 4).
5. Conducting a detailed screening of five treatment alternatives (Section 5) using:
    a. Technical feasibility.
    b. Economic feasibility, including an estimate of potential capital and operating expenses for each alternative.
    c. Energy consumption.
    d. Potential for media shifting of pollutants.
6. Summarizing the alternatives evaluation results (Section 6).

2 Conceptual Treatment Design Basis

For the purposes of this Plan, "water" refers to the combined flow from SD001 (treated wastewater) and SD002 (stormwater), as described in Section 2.1. Additionally, "water quality" refers to PFAS and/or general chemistry parameters' concentrations in various water streams.

This section describes the conceptual operating framework for the PFAS water treatment technologies and alternatives evaluated in this Plan, including flows, water quality, and PFAS treatment targets. Representative influent flows and water quality were established based on historical monitoring data of the Facility discharges from SD001 and SD002. 3M provided data and information regarding operation of the existing wastewater treatment system, and Barr used the MPCA-proposed intervention limits for PFOS (7 ng/L calendar month average and 14 ng/L daily maximum) to comply with the current site-specific criteria for PFOS of 0.05 ng/L as treatment targets.

2.1 Conceptual Design Flow

The conceptual PFAS water treatment alternatives evaluated in this Plan were sized based on the following flows, based on flow monitoring data from October 2016 through December 2020:

- Combined Phase 1/2 and Phase 3 treated wastewater, upstream of existing GAC treatment: 3.6 million gallons per day (MGD) (current maximum daily discharge rate from SD001)
- NCCW/stormwater: 4.7 MGD (current maximum daily discharge rate from SD002)

These flows produce a combined conceptual treatment design flow of 8.3 MGD.

2.2 Conceptual Design Influent Water Quality

3M monitors water quality (PFAS and general chemistry) at multiple locations within the Facility. Figure 2-1 shows sampling locations relevant to this Plan, which include:

- N01: Phase 1/2 GAC effluent
- N02: Phase 1/2 GAC influent
- N06: Phase 3 GAC effluent
- N07: Phase 3 GAC influent
- E01: Wastewater Carbon System combined effluent – Outfall SD001
    - The Wastewater Carbon System provides polishing treatment for Phase 1/2 and Phase 3 wastewater.
- E02: NCCW/stormwater effluent – Outfall SD002

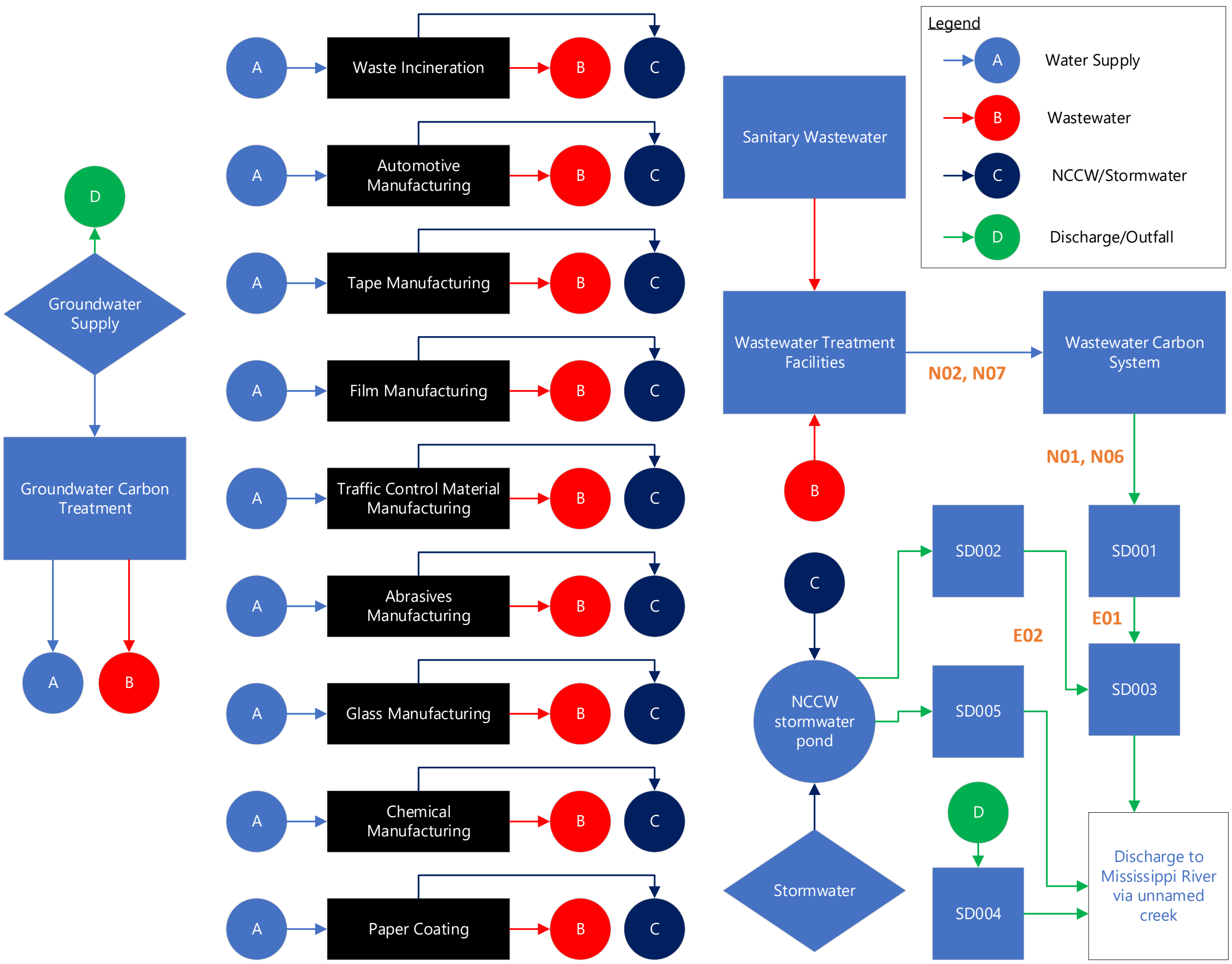

Figure 2-1 Facility Process Water Quality Locations Relevant to Conceptual Design Influent Water Quality

2.2.1 Influent PFAS Concentrations

To evaluate PFAS treatment alternatives, Barr summarized data from the following locations to provide representative influent PFAS concentrations:

- E01: Wastewater Carbon System combined effluent – Outfall SD001
- E02: NCCW/stormwater effluent – Outfall SD002

Table 2-1 contains a summary of the estimated influent PFAS concentrations from April 2020 through January 2021 and from a single sample event on February 23, 2021, based on a flow-weighted average of data collected by 3M from SD001 and SD002. This conceptual treatment location assumes that the existing Wastewater Carbon System for Phases 1/2 and 3 remains in service.

Table 2-1 SD001 and SD002 PFAS Concentrations (all in ng/L or parts per trillion)

PFAS Abbreviation	Observation[(1)] or Estimated Average[(2)]			Max Observed		
	SD001	SD002	Combined[(3)]	SD001	SD002	Combined[(3)]
TFA	17,585	3,720	17,585	288,000	11,100	17,585
TFMS	18,931	3,268	18,931	91,300	5,780	18,931
TFMS lithium salt[(4)]	--	--	--	--	--	--
2,2,3,3-TFPA	1,848	<1,000	<1,000	9,880	<1,000	<1,000
2,3,3,3-TFPA	2,861	<5,000	2,861	11,100	<5,000	2,861
PFPA	237,063	6,035	237,063	4,430,000	15,900	237,063
PFES	478	72	478	2,370	96	478
HQ-115	1,159	14,375	1,159	33,400	501,000	1,159
PFBA	56,668	7,350	56,668	391,000	13,800	56,668
PIBA	234	240	234	133	236	234
PFPeA	110	180	110	636	466	110
PFBSi[(5)]	<20	<20	<20	<20	<20	<20
FBSA[(4)]	--	--	--	--	--	--
PFBS	103	222	103	110	834	103
FBSE	<50	<50	<50	<50	<50	<50
MeFBSAA	<20	20	<20	<20	25	<20
PBSA	<40	<40	<40	<40	<40	<40
FBSEE Diol	<20.2	22	<20.2	<20.2	108	<20.2
FBSEE-DA	<20	<20	<20	<20	<20	<20
FBSAA	<200	<200	<200	<200	<200	<200
PFHxA	29	137	29	39	533	29
HFPO-DA	<199	<199	<199	<199	<199	<199
PFHpA	<25	51	<25	<25	226	<25
PFHxS	44	321	44	156	1,950	44
PFOA	44	366	44	182	2,390	44
PFNA[(1)]	<3.8	<3.6	<3.8	--	--	--
PFOSA	32	34	32	74	62	32
PFOS[(6)]	24	77	24	36	459	24
PFDA[(1)]	<3.8	<3.6	<3.8	--	--	--
PFUnA[(1)]	<3.8	<3.6	<3.8	--	--	--

PFAS Abbreviation	Observation[1] or Estimated Average[2]			Max Observed		
	SD001	SD002	Combined[3]	SD001	SD002	Combined[3]
PFDoA[1]	<3.8	<3.6	<3.8	--	--	--
PFTrDA[1]	<3.8	<3.6	<3.8	--	--	--

(1) For compounds with only one measurement, collected on February 23, 2021, that observation is listed here and no maximum is shown.
(2) PFAS results below the reporting limit were assumed to be equal to the reporting limit for this averaging exercise and calculation.
(3) Combined influent design concentrations are flow-weighted averages, using the flows and concentrations from SD001 and SD002.
(4) Data were not available for the following PFAS listed as monitoring parameters: TFMS lithium salt, FBSA.
(5) Two chemical names were provided by MPCA for the abbreviation PFBSi. Based on publically available information, these two chemical names refer to the same PFAS structure.
(6) MPCA-proposed intervention limits to comply with the current site-specific criteria for PFOS of 0.05 ng/L are 7 ng/L (calendar month average) and 14 ng/L (daily maximum).

2.2.2 Other Water Quality Considerations

Table 2-2 contains a summary of general chemistry water quality at SD001 (sampling location E01) and SD002 (E02). Generally, water flowing to SD001 and SD002 has an alkalinity of 200 to 250 mg/L as $CaCO_3$ with chemical oxygen demand (COD) less than 50 mg/L. Concentrations of metal foulants like iron and manganese are less than 0.05 mg/L, with average sulfate concentrations in the range of 27 to 140 mg/L and average nitrate concentrations ranging from 7 to 30 mg/L.

Table 2-2 SD001 and SD002 General Chemistry Water Quality and Estimated Combined Treatment Alternative Influent

Parameter(1)	Units	SD001	SD002	Combined Influent(3)
Conceptual design flow	MGD	3.6	4.7	8.3
Biochemical oxygen demand (BOD), maximum	mg/L	< 6.0	7.2	NA
BOD, average	mg/L	NA	0.53	NA
Total suspended solids (TSS), maximum	mg/L	34	27	30
TSS, average	mg/L	1.1	1.4	1.2
Ammonia, maximum	mg/L	0.45	< 0.10	NA
Ammonia, average	mg/L	NA	NA	NA
Number of samples	--	1-1,553	1-222	--
Parameter(2)	**Units**	**SD001**	**SD002**	**Combined Influent(3)**
Total dissolved solids (TDS)	mg/L	905	409	624
Chemical oxygen demand (COD)	mg/L	<50	<50	<50
Sodium (Na)	mg/L	214	346	289
Calcium (Ca)	mg/L	54	81	69
Magnesium (Mg)	mg/L	22	28	25
Potassium (K)	mg/L	57	3	26
Iron (Fe)	mg/L	<0.05	<0.05	<0.05
Manganese (Mn)	mg/L	0.005	0.003	0.004
Barium (Ba)	mg/L	0.052	0.045	0.048
Sulfate (SO_4)	mg/L	140	27	76
Chloride (Cl)	mg/L	127	64	92
Ammonia (NH_3-N)	mg/L	0.45	<0.1	0.2
Nitrate (NO_3-N)	mg/L	29	7.8	17
pH	SU	8.4	8.2	8.3
Alkalinity	mg/L as $CaCO_3$	248	226	236
Number of samples	--	1	1	--

NA = not available
(1) BOD, TSS, and ammonia data from recent EPA Form 2C entries for SD001 and SD002.
(2) Other water quality data from February 2021 sampling event.
(3) Barr calculated combined influent water quality estimates as flow-weighted averages of the conceptual design flow rates.

2.3 PFAS Characteristics and Groupings

3M is required to monitor for the presence of additional PFAS in its SD001 and SD002 discharges on a monthly basis. The complete list of PFAS monitored monthly at these locations is provided in Large Table 1. To consider treatment effectiveness, Barr organized these constituents into three groups based on molecular weights, the number of fluorinated carbons, and log K_{ow} values (also referred to as log P). The three groups of PFAS are summarized in Table 2-3 and detailed in Large Table 1. Log K_{ow} is the partition coefficient of a chemical between two liquid phases (n-octanol and water) in one system and is used as an indicator of a chemical's hydrophobicity and hence used here as a proxy for potential GAC and anion exchange (AIX) removal efficiency. Because removal efficiencies by treatment technology are not known for each individual PFAS, for this Plan, literature-based removal efficiencies for specific PFAS with known removal efficiencies have been assumed to apply to the entire respective group.

Table 2-3 Summary of Characteristics for PFAS Groupings

Group	Total Carbons	Fluorinated Carbons	Molecular Weight Range (g/mol)	Boiling Point Range (degrees C)	Log K_{ow} Range	Example PFAS
1	1–5	1–4	114–281	72–287	-2.6 to 2.8	PFBA, PFPA, TFA
2	4–9	4–7	284–414	115–339	1.8 to 3.8	PFBS, PFHxS, PFOA
3	8–13	8–12	464–664	194–286	5.8 to 8.2	PFOS

3 Identification of Feasible PFAS Treatment Technologies

Barr employed a threshold screening process to select the most promising technologies for potential application at the Facility. Technologies retained from this screening process include both primary and secondary treatment technologies. Primary technologies are those that would be applied to treat the total conceptual design flow rate. Secondary technologies would treat residual media or concentrate streams.

This section provides a brief description of each of the retained technologies, including a preliminary estimate of removal efficiencies by PFAS group (as described in Table 2-3). The estimate provides the basis for identifying potential treatment alternatives (Section 4).

3.1 Threshold Screening

Barr identified several potentially feasible PFAS water treatment technologies through a review of recently published literature, communication with treatment technology vendors, and first-hand engineering experience with the treatment of PFAS-impacted water at similar facilities. These technologies were initially screened for potential application at the Facility using the two threshold criteria:

1. Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale).

2. Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers.

These criteria were selected to separate potentially viable technologies from those not expected to meet applicable effluent water quality requirements due to limitations in performance, reliability, or scalability.

Large Table 2 provides a brief description and threshold screening outcomes for each technology. Technologies meeting both threshold criteria include:

1. Granular activated carbon

2. Anion exchange resin (both single-use and regenerable)

3. Membrane separation (reverse osmosis or nanofiltration)

Following threshold screening, retained technologies also included thermal evaporation with crystallization as a potential secondary treatment technology to manage concentrate from membrane separation. Similarly, incineration was retained as a potential management option for exhausted sorption media or the concentrate from regeneration of anion exchange media. Section 3.2 includes an evaluation of these technologies.

3.2 Treatment Technology Evaluation

The following sections provide a high-level evaluation of each treatment technology passing the threshold screening.

3.2.1 Granular Activated Carbon

GAC removes PFAS from water via a mass-transfer process in which PFAS partitions to the GAC surface due to hydrophobic/van der Waals interactions. Sorption of PFAS is a function of several factors, including loading rates (i.e., water flow and concentration), PFAS chain length and functional groups, water chemistry characteristics (e.g., dissolved organic carbon concentration), and time in operation. The mass loading onto GAC increases with higher influent concentrations and lower flow rates. Removal efficiency for GAC declines with time as sorption sites become occupied. For loading of mixtures of chemical constituents, chemicals with greater affinity for sorption may displace loosely bound chemicals. For example, PFAS with long carbon chains (greater than four carbons) and sulfonate functional groups tend to be sorbed more efficiently and displace PFAS with short carbon chains (four carbons or less) and carboxylic acid functional groups from GAC.

GAC, alone, is a non-destructive technology. PFAS that are sorbed to GAC and removed from water retain their original structure and, as noted above, can be displaced from the GAC by other chemicals. GAC can then be reactivated, incinerated, or disposed of in a permitted landfill. Reactivation removes the PFAS for thermal destruction (similar to incineration) in the gas phase, while the GAC is retained and can be used again to treat water. Incineration of the GAC destroys both the media and the sorbed chemicals.

GAC is a mature, field-demonstrated technology for PFAS water treatment. GAC media specifications for PFAS treatment can be variable by site and supplier; typically, reagglomerated bituminous coal-based GAC is used (screened to 12x40 or 8x30 mesh). GAC is typically applied in down-flow, fixed-bed pressure vessels in series, using a lead-lag configuration (i.e., two equally sized vessels in-series). Vessels are sized to achieve a target empty-bed contact time (EBCT) in the range of 7 to 20 minutes with a hydraulic loading rate (HLR) ranging from 1 to 10 gallons per minute per square foot (gpm/ft^2) (ITRC 2020, Ross et al. 2018). GAC treatment is typically operated until a designated concentration threshold is observed between the lead and lag vessels. Once this threshold is observed, the lead vessel is taken out of service, and the GAC media is exchanged for virgin or reactivated media.

GAC is retained in the detailed treatment alternatives screening because it is a mature and scalable PFAS water treatment technology currently used at the Facility. For this Plan, additional GAC would be used to treat the combined flow from SD001 and SD002 to meet existing and potentially applicable effluent and water quality requirements for the next 20 years. GAC is also retained as a potential option for concentrate management from membrane treatment.

3.2.2 Anion Exchange Resin

Anion exchange (AIX) resin removes PFAS from water via electrostatic interactions between the charged functional group of the PFAS (negatively charged) and the AIX functional group (positively charged). Hydrophobic interactions also occur between the fluorinated carbon chains and the polystyrene resin support. Removal efficiencies of specific PFAS with AIX treatment depend on several factors, including loading rates (i.e., water flow and concentration), PFAS chain length and functional groups, water chemistry characteristics (e.g., dissolved organic carbon and competing ion concentrations), and time in operation. Removal efficiency declines with time as sorption sites become occupied. PFAS with long carbon chains (greater than four carbons) and sulfonate functional groups tend to be removed more efficiently by AIX than PFAS with short carbon chains (four carbons or less) and carboxylic acid functional groups. Compared to GAC, AIX resins typically have higher removal efficiencies and throughput for short-chain PFAS.

Like GAC, AIX alone is a non-destructive technology and can be applied in regenerable or single-use applications. Regenerable applications allow PFAS that are exchanged onto the AIX resin to be removed into a concentrated stream using a brine/solvent solution. Options for on-site media regeneration are commercially available and may be a viable Facility option at the conceptual design flow rate. The concentrated stream removed during the regeneration process would subsequently be incinerated directly or treated with a smaller volume of media for indirect incineration or landfilling of the media. The regeneration solution could then be reused for subsequent regeneration processes. Alternatively, the AIX resin can be incinerated with the PFAS in lieu of regeneration or disposed of in a permitted landfill.

The application of AIX for PFAS water treatment is gaining in popularity and is a demonstrated, effective alternative to GAC. AIX resins for PFAS treatment are typically strong base, anion exchange resins with quaternary amine functional groups made from a polystyrene support. Like GAC, AIX resin is typically applied in down-flow, fixed-bed pressure vessels in a lead-lag configuration. AIX resin treatment systems typically have a smaller footprint than GAC treatment systems sized for equivalent flow because the targeted EBCT is shorter (2–5 minutes), and HLRs are higher (6–12 gallons per minute per square foot) (ITRC 2020). AIX treatment is typically operated until a designated concentration threshold has been observed between the lead and lag vessels. Once this threshold is observed, the lead vessel is taken out of service, and the AIX resin is exchanged for virgin media or regenerated (as described above).

AIX is retained in the detailed treatment alternatives screening as an alternative to GAC treatment because it is an effective, field-demonstrated technology, particularly for short-chain PFAS. It is also retained as a potential option for management of concentrate from membrane treatment and condensate from thermal evaporators.

3.2.3 Membrane Separation

Membrane separation technologies physically separate PFAS from the primary water stream by applying high pressure to drive water through a semi-permeable membrane, generating a clean permeate. PFAS are retained (along with other dissolved constituents) with a fraction of the influent water by the semi-permeable membrane as a concentrated brine. PFAS and dissolved constituents are retained by size-exclusion (i.e., pore sizes are smaller than the ions and molecules retained) and hindered diffusion through the membrane pores. Membrane recovery, or the percentage of water recovered as permeate, can vary depending on water chemistry characteristics (especially for foulants/scalants) and equipment (the membrane type and configuration) but typically varies between 50–95%.

Two types of membrane separation technologies have been successfully applied for PFAS water treatment: reverse osmosis (RO) and nanofiltration (NF). These two technologies use pressure to push water through a membrane, with RO membranes operating at higher pressures than NF membranes. Rejection of solutes within the water by membranes is primarily a function of size exclusion, with RO membranes generally having the smallest pore sizes. RO membranes retain monovalent ions (such as chloride) with an approximate nominal molecular weight range of up to 100 daltons (equivalent to g/mol). In contrast, NF membranes have slightly larger pore sizes that allow monovalent ions to pass through into the permeate while retaining divalent ions (such as sulfate) with an approximate nominal molecular weight range of 100 to 300 daltons. Manufacturers of both RO and NF membranes may also modify the chemistry of the active layer, for example, the hydrophobicity, to improve the passage of water at lower pressures while improving the rejection of specific solutes.

The degree of PFAS retention across membranes depends, in part, on the size and charge of the PFAS. In general, both membrane separation technologies can be effective for concentrating a broad range of PFAS (Appleman 2013; Soriano 2019; Franke 2019). Actual, site-specific rejection efficiencies for specific PFAS groups will be dependent on water chemistry characteristics (pH, temperature, ionic strength) as well as membrane type and operating conditions (cross-membrane pressure, flow velocity).

Membrane separation technologies (RO and NF) have been retained in the advanced water treatment screening evaluation as alternatives to GAC because they are effective, field-demonstrated technologies for PFAS treatment.

The concentrated waste stream from membrane separation requires additional management. For this evaluation, three management strategies are combined with membrane separation: GAC treatment, AIX treatment, and thermal evaporation with crystallization.

3.2.4 Thermal Evaporation/Crystallization

In a thermal evaporator, heat is applied to remove most of the water (up to the water's boiling temperature) from the liquid (concentrate) stream, leaving a slurry with a high solids content. Crystallization further removes water from a slurry producing a dry product that can be managed as a solid.

Thermal evaporation and crystallization are not destructive technologies for PFAS. Instead, the crystallized solids retain the PFAS compounds. A mist-eliminator system would be used to capture any PFAS that could potentially volatilize within the condensate during the evaporation and crystallization process.

Equipment options available for thermal evaporation and crystallization vary depending on flow rates, need for water recovery, waste heat availability, and final disposal considerations.

Barr has retained thermal evaporation and crystallization for evaluation as a secondary treatment for concentrated streams from membrane separation.

3.2.5 Incineration

Incineration is a process that applies high temperatures to thermally degrade PFAS. Reported temperatures required to degrade PFAS are typically near 1,000 degrees Celsius (USEPA 2020B, ITRC 2020). The efficacy of incineration for PFAS destruction is an active area of research—particularly to identify appropriate incinerator residence times that minimize or eliminate the formation of incomplete combustion products.

Barr retained incineration as an option for spent-media management from GAC or AIX treatment and for residual solids from membrane separation followed by thermal evaporation and crystallization of the concentrate stream.

4 Treatment Alternatives Descriptions

Based on the technologies evaluated in the threshold screening process (described in Section 3.1), Barr has developed five potentially feasible PFAS treatment alternatives for further evaluation. This section describes the five treatment alternatives, including a preliminary description of the process flow. These alternatives are carried through to the alternative screening process described in Section 5.

All five alternatives would treat a combined stream consisting of Wastewater Carbon System effluent routed to SD001 and NCCW/stormwater routed to SD002. For this analysis, we assumed that the existing Wastewater Carbon System would remain in service and operate with the same conditions and change-out frequency reflected between April 2020 and January 2021 (the period when PFAS sampling data was evaluated). This assumption was made to provide a consistent basis for alternatives evaluation. Other locations for treatment may be considered during design of the preferred alternative identified from this evaluation. We describe the five alternatives in the following sections.

4.1 Alternative 1 – Modified GAC

In this alternative scenario, the combined SD001 and SD002 flow would be routed through additional GAC-filled pressure vessels, similar to the existing Wastewater Carbon System. Figure 4-1 shows a simple block flow diagram for this alternative.

Figure 4-1 Block Flow Diagram for Alternative 1 – Modified GAC

Breakthrough of short-chain, Group 1 PFAS will likely limit GAC performance in this application because they are present in high concentrations relative to the other PFAS of interest and does not sorb strongly to GAC, and can be outcompeted for sorption sites by other, more strongly sorbing compounds like TOC and longer-chain PFAS. PFBA is the Group 1 PFAS with the most consistent historical monitoring data, and serves as a proxy for Group 1 PFAS. Given the high concentrations of PFBA in effluent from the existing Wastewater Carbon System, Alternative 1 GAC treatment operations would require more vessels and shorter change-out frequencies than current operations to consistently remove PFBA. GAC performance and change-out frequency will depend on future treatment requirements as well as the extent and frequency of this variation. Exhausted GAC would be managed via incineration or reactivation.

4.2 Alternative 2 – AIX

In this alternative scenario, the combined SD001 and SD002 flow would be routed through AIX-filled pressure vessels. Figure 4-2 shows a simple block flow diagram for this alternative.

Figure 4-2 Block Flow Diagram for Alternative 2 – AIX

Like Alternative 1, PFBA, as the representative of Group 1 PFAS, breakthrough will likely determine AIX performance because it is present in high concentrations relative to the other PFAS of interest. AIX has a slightly higher affinity for short-chain PFAS than does GAC and is subsequently expected to use less media than GAC. The equipment footprint is also expected to be smaller than for GAC because of the lower EBCT design value. Exhausted AIX resin would be incinerated. On-site media regeneration for this alternative may be considered at a later stage of evaluation and design.

4.3 Alternative 3 – NF with GAC

For this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using NF membranes. Concentrate from NF would be routed through GAC to remove PFAS. Most of the GAC- treated concentrate would be recirculated back to the membrane feed (total NF design flow of 11.9 MGD). The advantage of this option over Alternative 1 (GAC only) is the anticipated increase in media sorption capacity in treating more concentrated streams (Franke, 2019). This has the potential to decrease media use rates by a factor of 1.5 to 2.0. Figure 4-3 shows a simple block flow diagram for this alternative.

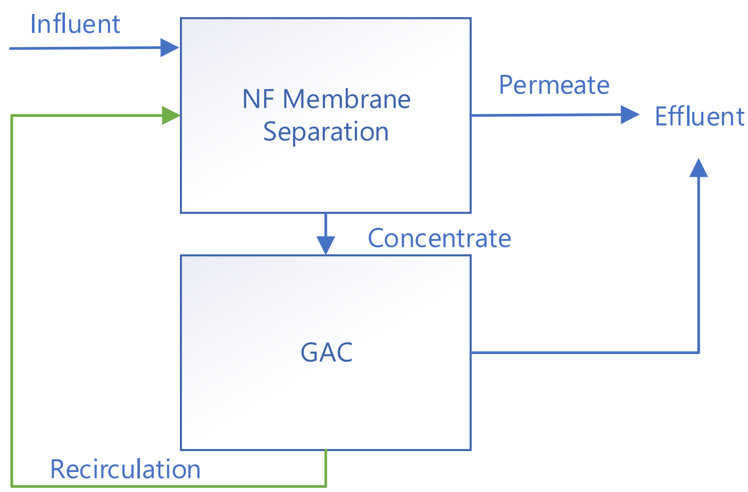

Figure 4-3 Block Flow Diagram for Alternative 3 – NF with GAC

NF membranes were selected over RO for this alternative to allow monovalent salts to pass through to the permeate, limiting their upcycling in the treatment loop. A small portion of the GAC effluent (likely 5%–25%) would need to be removed from the recycle loop and discharged as effluent to control upcycling of polyvalent salts in the treatment loop or would need to be treated using thermal evaporation if the concentrations of PFAS in the GAC effluent result in concentrations above discharge limits for the blended effluent. We assumed an NF recovery of 70%, meaning that 3M would route 75% of the NF feed to permeate and 25% to concentrate and GAC adsorption. This is lower recovery than the RO alternatives described below because NF is expected to see higher concentrations of mineral foulants as a result of concentrate recycling.

Because the PFAS concentrations in the concentrate stream will be higher than in the primary influent stream, the GAC vessels would be sized and operated with an extended EBCT to maximize sorption and removal of PFAS. This could potentially decrease the GAC usage rate by a factor of about two (Franke, 2019). Exhausted GAC would be managed via incineration or reactivation.

4.4 Alternative 4 – Two-Stage RO with Thermal Evaporation/Crystallization

In this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using RO membranes. This evaluation assumed an overall recovery of 95% for two-stage RO, meaning that 95% of the influent flow would become treated permeate, while 5% would become concentrate routed to thermal evaporation and crystallization for additional treatment. None of the treated concentrate would need to be returned to the membrane separation process.

The solids in the concentrate, including the PFAS compounds, would be converted to a solid phase for disposal in the thermal evaporation/crystallization process. Water vapor from the thermal evaporation and crystallization process would be recaptured as condensate, which allows some heat recovery and decreases energy usage. Condensate would be blended with the RO permeate for discharge. This evaluation assumes that all PFAS remain in the solid or liquid phase through thermal evaporation and are not routed to condensate. Figure 4-4 shows a simple block flow diagram for this alternative.

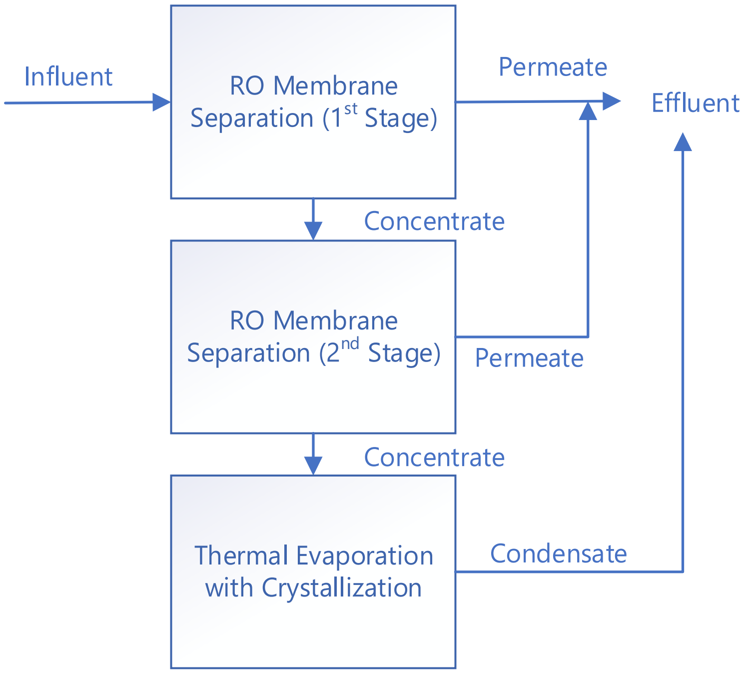

Figure 4-4 Block Flow Diagram for Alternative 4 – Two-Stage RO with Thermal Evaporation/Crystallization

4.5 Alternative 5 – RO with AIX

For this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using RO membranes. Concentrate would be routed through AIX to remove PFAS and then combined with permeate for discharge. This evaluation assumed an overall recovery of 85% for RO, meaning that 85% of the RO feed would be routed to permeate, and 15% would be routed to concentrate and AIX treatment. The advantage of this option over Alternative 2 (single-use AIX only) is the anticipated increase in media sorption capacity in treating more concentrated streams (Franke, 2019). This has the potential to decrease media use rates by a factor of two to three. Figure 4-5 shows a simple block flow diagram of this alternative.

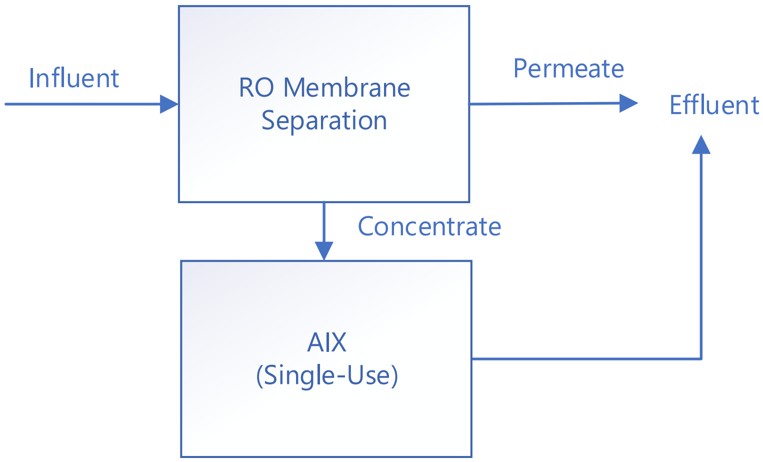

Figure 4-5 Block Flow Diagram for Alternative 5 – RO with AIX

The AIX process would be operated with an extended EBCT to improve sorption of Group 1 PFAS. As a result of the extended EBCT, the resin usage rate for this alternative is expected to be lower than for the primary AIX treatment in Alternative 2 by a factor of about two (Franke, 2019). Exhausted AIX resin would be incinerated. On-site media regeneration for this alternative may be an option for consideration at a later stage of evaluation and design.

5 Treatment Alternatives Screening

Barr conducted a detailed screening of the five treatment alternatives described in Section 4, using the criteria and sub-criteria as set forth below:

- Technical feasibility
  - Group 1 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
  - Group 2 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
  - Group 3 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
  - General complexity of operation and maintenance of primary technology
  - Operator and public health risks
- Economic feasibility
  - Capital costs for primary technology (and secondary technology, where applicable)
  - Operations and maintenance (O&M) costs for primary technology (and secondary technology, where applicable)
- Energy consumption
  - Energy consumption of primary technology (and secondary technology, where applicable)
- Potential for media shifting of pollutants
  - Relative quantity of residuals generated

Barr screened the treatment alternatives using the following steps:

1. Barr weighed each sub-criteria on a scale of 1 to 4, with 4 indicating the highest importance.
2. Barr ranked each alternative for each sub-criteria on a scale of 1 to 3, with 3 as the most favorable ranking.
3. Barr determined alternative rankings for each criteria category based on the weighted sum of sub-criteria rankings.
4. Barr added up rankings for each criteria category to determine overall rankings for each alternative.

Ten State standards and other design requirements are deemed to be similar for all scenarios and would not affect the relative evaluation of the different alternatives. Large Table 3 summarizes the treatment alternative screening process and outcomes. The following sections highlight details for each screening criteria.

5.1 Technical Feasibility

Table 5-1 summarizes estimated removal efficiencies for the three primary treatment technologies included in the alternatives for each of the three PFAS groups (refer to Table 2-3 for descriptions of the PFAS groups). Removal efficiencies are based on a combination of literature values as well as observations from data collected during operation of existing GAC at the Facility for polishing of Phase 1/2 and Phase 3 wastewater. Barr used these removal efficiencies to rank the technical feasibility of the treatment alternatives.

PFAS removal efficiencies for GAC and AIX are typically high with new, virgin media, but removal efficiencies decrease over time as sorption sites are exhausted and breakthrough occurs. Thus, removal efficiency is a function of how long media has been in service. Operational settings, such as EBCT, media specifications, and hydraulic loading rate, also affect removal efficiency. Removal efficiencies shown in Table 5-1 are based on literature references and engineering judgment, and would change significantly for GAC and AIX during the course of media bed life. To account for diminished performance with service life, the values shown for GAC and AIX reflect estimated removal efficiencies after treatment of 5,000 bed volumes with an EBCT of approximately 5 minutes. Note that Barr does not expect the removal efficiencies (i.e., rejection efficiency) for the membrane treatment alternative to change with service time. This exercise is intended to compare relative removal efficiency of the treatment technologies. It is not predictive of actual performance at the Facility. Facility-specific breakthrough characteristics and removal efficiencies should be examined at a later stage of evaluation.

Observed PFBA (Group 1 PFAS) removal efficiencies for existing GAC systems at the Facility after approximately 5,000 bed volumes were about 20% to 30% for Phase 1/2 treatment and ranged from -150% to 50% for Phase 3 treatment, likely due to the large variations in influent PFAS. Other PFAS were not measured in the GAC effluent past the first 2,500 bed volumes.

Table 5-1 Estimated Removal Efficiencies of Primary Treatment Technologies by PFAS Group

Technology	Group 1 PFAS (including PFBA)	Group 2 PFAS (including PFBS, PFHxS, and PFOA)	Group 3 PFAS (including PFOS)	References
GAC (5,000 bed volumes)	0–60%(1)	40–75%	60–90%	(Franke 2019) (Woodard 2017)
AIX (5,000 bed volumes)	40–90%	65–99%	90–99%	(Franke 2019) (Woodard 2017)
RO	80-99%	75-99%	95–99%	(Appleman 2014) (ITRC 2020) (Soriano 2019)
NF(2)	25-90%	50-95%	80-95%	(Appleman 2013) (ITRC 2020) (Franke 2019) (Soriano 2019)

(1) PFBA removal across the Facility's existing Wastewater Carbon System is about 38% at 5,000 bed volumes for Phase 1/2 GAC treatment.

(2) Publicly available data for NF rejections of PFAS are limited, especially for group 1 PFAS. Ranges shown are based on available literature data and engineering judgment.

Using these estimated removal efficiencies and the influent PFAS concentrations, the technical feasibility of each alternative was ranked and scored in Large Table 3. Generally, RO scored slightly better than NF while AIX scored better than GAC, with the differences in removal efficiencies for Group 1 PFAS, providing the primary differentiator for technical effectiveness between the alternatives.

5.2 Economic Feasibility

Barr developed Class 5 capital and operating costs with an accuracy range of –50% to +100% to support technology screening. To size the conceptual GAC and AIX treatment systems for Alternatives 1–5, assumptions listed in Table 5-2 were made. In all cases, we assumed that vessels would operate in a lead/lag configuration. Note that the throughputs presented are meant only to facilitate conceptual treatment alternative equipment sizing and operational costs; they should not be interpreted as actual throughput values for the Facility. Note that Barr sized all treatment alternatives assuming they would follow the existing Wastewater Carbon System, which provides 40–45 minutes of GAC EBCT at the maximum flow rate through the existing system of 2.8 MGD.

Table 5-2 Conceptual Design Assumptions for GAC and AIX Sizing

Assumed Parameter	Units	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Primary treatment technology	--	GAC	AIX	NF	RO	RO
Media type	--	GAC	AIX	GAC	None	AIX
Media vessel sizing to support capital costs						
Maximum flow to primary treatment	MGD	8.3	8.3	11.9(1)	10.0(1)	8.3
Membrane recovery	%	--	--	70%	95%	85%
Maximum flow to media	MGD	8.3	8.3	3.6	0.4 to TE/C	1.2
Total EBCT at the maximum flow(2)	minutes	20(5)	10(6)	40(7)	--	20(8)
Breakthrough estimates to support operating costs						
Average flow to media(1)	MGD	5.4	5.4	2.3	0.4 to TE/C	0.8
Throughput at the average flow(3)	m^3/kg	8(5)	9.8(6)	4.8(7)	--	4.4(8)
Time to lead vessel change-out(4)	days	49	37	58	--	66
Media use rate	lb of media per month	170,000	140,000	120,000	--	47,000
Media use rate	m^3 of media per month	137	91	98	--	30

(1) Membrane separation feed flows for Alternatives 3 and 4 consider total flows routed to membranes. For Alternative 3, this reflects steady-state flows including recycle of GAC effluent. For Alternative 4, this includes feed to first-pass membranes as well as to second-pass membranes.

(2) Total EBCT is the EBCT of both the lead and lag vessels (divide by two for the EBCT per vessel). The EBCT is used to estimate the number of vessels needed.

(3) The throughput is an estimate of the volume of water that can be passed through media before PFBA (proxy for Group 1 PFAS) breakthrough occurs. The value used for Alternative 1 is based on an EPA review study (Burckhart et al., 2019), and calculation of subsequent values are described below in separate table footnotes. These values were used to estimate relative media use rates for the different alternatives to support operating cost comparisons, and should be updated when water treatment targets are established. Treatability testing should be conducted to establish site-specific throughput values prior to detailed project planning.

(4) The time to lead vessel change-out is based on the estimated throughput.

(5) For Alternative 1, Barr estimated the total EBCT from the industry standard (10 minutes per vessel) and the throughput from Burckhart et al. (2019) for PFBA breakthrough.

(6) For Alternative 2, Barr estimated the total EBCT for AIX to be one-half the EBCT required for vessels in Alternative 1 (based on data presented in Woodard et al. (2017)) and the throughput to be 50% longer (a factor of 1.5) for a given volume of media. We assumed a bulk media density of 0.57 kg/L for GAC and 0.7 kg/L for AIX, so the throughput increased by a factor of 1.5×0.57/0.7.

(7) For Alternative 3, Barr estimated the total EBCT to be two times the EBCT for vessels in Alternative 1 to maximize PFAS sorption. The mass of PFAS removed per mass of media is estimated to be twice that of Alternative 1 (Franke 2019). However, the same PFAS mass is distributed in 30% as much water as in Alternative 1 (i.e., the PFAS is concentrated up, assuming 70% water recovery from NF). Thus, the throughput of water (m^3 of water per kg of media) for Alternative 3 changes by a factor of 2×0.3.

(8) For Alternative 5, Barr estimated the total EBCT to be two times the EBCT of vessels in Alternative 2 to maximize PFAS sorption. We estimated the mass of PFAS removed per mass of media to be three times that of Alternative 2 (Franke 2019). However, the same PFAS mass is distributed in 15% as much water as in Alternative 2 (i.e., the PFAS is concentrated up assuming 85% water recovery from RO). Thus, the throughput of water (m^3 of water per kg of media) changes by a factor of 3×0.15.

The reduction of PFAS into a smaller volume using NF or RO in Alternatives 3 through 5 reduces the volume of flow to the secondary treatment processes, but assumptions of increased residence time requirements offset the effect of this reduction on equipment sizing. Similarly, the increased PFAS concentrations in the flows to secondary treatment processes were assumed to decrease the relative media usage rates (i.e., increased mass of PFAS adsorbed per mass of media) based on recent studies reporting increases in mass loading to GAC and AIX from NF concentrate (Franke, 2019; Franke, 2021).

Costs for each alternative are scored in Large Table 3 using separately weighted scales for both capital and operating costs. Capital costs are weighted higher than operating costs because they occur immediately, while operating costs can potentially be optimized or improved over the life of a project. The bases for capital and operating costs for the alternatives are described separately in the following paragraphs.

5.2.1 Capital Cost Estimates

Barr developed capital cost estimates for the five alternatives using the conceptual design flows indicated in Table 5-2. Costs are Class 5 ranges based on previous project experience. Cost estimating focused on the treatment systems and related buildings and control systems. For this evaluation, Barr did not include ancillary items needed to complete installation of an alternative but deemed similar for all scenarios and would not affect the relative costs of alternatives.

NF recovery for Alternative 3 was assumed to be 70%, RO recovery for Alternative 4 was assumed to be 95%, and RO recovery for Alternative 5 was assumed to be 85%. While NF recovery is typically higher than RO recovery, the NF application in Alternative 3 will have more salt in the feed water than the RO application in Alternative 4 due to concentrate recycling. In Alternative 3, Barr sized the NF membrane separation for a total flow rate of 11.9 MGD, the calculated steady-state conceptual design flow rate, assuming 30% of the flow recycles to the front of the process after passing through GAC treatment.

For Alternatives 1-5, Barr estimated costs for GAC and AIX treatment equipment based on recent vendor quotes for similar systems using 20,000-pound GAC vessels and 420-cubic-foot AIX vessels. We also based cost estimates for RO, NF, and crystallization on previous vendor quotes for similar systems. Table 5-3 provides the capital cost estimate summary.

Table 5-3 Capital Cost Estimate Summary(1)

Alternative Number	1	2	3	4	5
Description	GAC	AIX (single use)	NF with GAC	RO with TE/C	RO with AIX (single use)
Estimated capital cost range(1)	$14.8 - $59.2 MM	$12.9 - $51.4 MM	$27.4 - $109.6 MM	$53.6 - $214.4 MM	$18.5 - $73.8 MM

TE/C = thermal evaporation/crystallization

(1) Capital costs are considered Class 5 estimates with an accuracy range of –50% to +100%. Costs are to design and construct each alternative.

5.2.2 Operating Cost Estimates

Barr developed operations and maintenance cost estimates for the five alternatives using the conceptual design flows indicated in Table 5-2. Costs are presented as Class 5 ranges based on previous project experience. We also assumed that media change-out would occur for lead vessels in a lead-lag arrangement, with lag vessels moved to lead position at the frequency indicated in Table 5-2. Table 5-4 provides the O&M cost estimate summary. These costs include building and equipment electricity, consumables such as RO chemicals, media replacement and disposal, salt residuals management, supply of RO membranes, and O&M labor, including operations and shift maintenance staff.

Table 5-4 Operations and Maintenance Cost Summary(1)

Alternative Number	1	2	3	4	5
Description	GAC	AIX (single use)	NF with GAC	RO with TE/C	RO with AIX (single use)
Estimated annual O&M cost range(1)	$3.8 – $15.0 MM	$5.6 – $22.2 MM	$4.2 – $16.6 MM	$6.1 - $24.4 MM	$2.9 – $11.6 MM
O&M unit cost ($/1,000 gallons treated)	$2.48	$3.67	$2.75	$4.04	$1.92

TE/C = thermal evaporation/crystallization

(1) O&M costs are considered Class 5 estimates with an accuracy range of –50% to +100%.

5.2.3 Cost Estimate Assumptions

The opinions of probable capital and O&M costs provided in this report are made based on Barr's experience and qualifications and represent our best judgment as experienced and qualified professionals familiar with the Facility. The cost opinions are based on Facility-related information available to Barr at this time and include a conceptual-level design of the alternatives. The opinions of cost may change as 3M completes further design. In addition, since we have no control over the cost of labor, materials, equipment, or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from the opinions of probable capital and O&M costs prepared by Barr. Barr can provide further accuracy in the opinions of probable capital and O&M cost with further design.

Barr has based this feasibility-level (Class 5, 0–2% design completion per ASTM E 2516-06) cost estimate on 1% designs, alignments, quantities, and unit prices. Costs will change with further design. We have not included time value-of-money escalation costs. Contingency is an allowance for the net sum of costs that will be in the final total cost for each alternative at the time of design completion but not included at this level of alternatives definition. The estimated accuracy range for the opinions of cost provided as the alternatives are defined is -50% to +100%. Barr has based the accuracy range on professional judgment considering the level of design completed, the complexity, and the uncertainties associated with each alternative. The accuracy range does not include costs for future scope changes that are not part of the conceptualized alternatives or risk contingency costs.

5.3 Energy Consumption

Table 5-5 outlines estimates for relative energy use for each alternative. The thermal evaporation and crystallization process requires the highest energy, whereas energy requirements for GAC and AIX should be considerably lower. The energy requirement for nanofiltration and reverse osmosis is higher when compared to GAC and AIX; however, lower than thermal evaporation and crystallization.

Table 5-5 Estimated Energy Consumption by Alternative

Alternative Number	1	2	3	4	5
Description	GAC	AIX (single use)	NF with GAC	RO with TE/C	RO with AIX (single use)
Major energy uses	GAC incineration(1)	AIX resin incineration or regeneration(1)	NF high-pressure pumping, GAC incineration	RO high- pressure pumping, evaporation	RO high-pressure pumping, AIX resin incineration, or regeneration
Estimated annual total energy use (MWh)	100-400	100-200	3,000-12,000	23,000-89,000	2,000-8,000

(1) Alternatives 1 and 2 require pumping, although energy is assumed to be negligible compared to the cost of media management and the high-pressure pumping required for NF and RO.

5.4 Media Shifting of Pollutants

Barr considered the final fate of PFAS in each alternative to evaluate potential "media shifting" of PFAS, in which PFAS in the water phase shifts to another media. As shown in Table 5-6, PFAS in all alternatives are ultimately incinerated at temperatures high enough to be thermally destroyed.

Table 5-6 PFAS Fate and Media Shifting Potential by Alternative

Alternative Number	1	2	3	4	5
Description	GAC	AIX (single use)	NF with GAC	RO with TE/C	RO with AIX (single use)
Final phase of PFAS	Spent GAC	Spent AIX resin	Spent GAC	Crystallizer salts	Spent AIX resin
Media use rate (lbs per month)	170,000	140,000	120,000	--	47,000
Media use rate (m^3 per month)	137	91	98	--	30
Final fate of PFAS-containing residuals	Incineration or reactivation with incineration of gas (same as current GAC)	Incineration or landfilling	Incineration or reactivation with incineration of gas (same as current GAC)	Incineration or landfilling	Incineration or landfilling

6 PFAS Treatability Alternatives Summary

Screening efforts identified three primary treatment technologies that may effectively remove PFAS from water at the Facility based on demonstrated efficacy, scalability, and commercial availability. These technologies include:

- Granular activated carbon adsorption
- Anion exchange resin sorption
- Membrane separation (including both NF and RO)

Barr assembled five potential alternatives using these treatment technologies, alone or in combination, along with two secondary technologies (thermal evaporation/crystallization and incineration) that may be applicable for treating concentrated or residual streams generated by one or more of the primary technologies. Screening of the five potential treatment alternatives based on weighted criteria or effectiveness, cost, energy consumption, and media shifting revealed that while each alternative had unique advantages and disadvantages, the AIX-based alternatives may offer a better potential for success. These include Alternative 2 (single-use AIX) and Alternative 5 (RO with single-use AIX for concentrate management). Selection of AIX over GAC, with or without the addition of a membrane separation step, is predicated on better performance for removal of the Group 1 PFAS, particularly PFBA, which is reported in recent literature (citation) and confirmed by ongoing testing performed by 3M.

When comparing Alternative 2 and Alternative 5, the membrane separation process provides better separation of the PFAS from the treated effluent, while preconcentration of PFAS using membranes helps reduce the volume of AIX media needed for adsorption, based on the improved mass transfer onto the media at higher influent concentrations. The increased TDS loading to the sorptive media in the concentrate along with increased PFAS does not appear to reduce PFAS loading. Increased capital costs for RO separation ahead of AIX appear to be offset by decreased disposal and media replacement costs in less than 20 years.

3M will need to address several Facility-specific factors before followed by on-site pilot testing of AIX-based treatment, including the following steps:

- Assessing site-specific flows within the Facility to optimize treatment effectiveness and performance for existing and new treatment processes.
- Verifying the most appropriate location within the Facility for advanced PFAS water treatment based on water quality characteristics and PFAS loading.
- Performing pilot testing in collaboration with AIX vendor ECT2, per the workplan attached as Appendix A. Pilot testing should confirm the following design parameters and submitting the results of the study to the MPCA, pursuant to paragraph no. 18 of the NOV:

- Flux rate and PFAS rejection performance to evaluate potential design loading rates for membrane separation from multiple membranes to evaluate site-specific performance

- AIX design parameters:

  - Empty bed contact times
  - Hydraulic loading rates
  - Time to breakthrough for PFBA and other PFAS of interest

- Performance of regenerable and non-regenerable ion exchange media

- Impacts of site-specific general water quality characteristics (non-PFAS) on technology performance

3M will develop a schedule for addressing these uncertainties per the other complementary elements of the NOV and the existing NPDES/SDS Permit requirements for the Facility pending approval of this PFAS Treatability Alternatives Identification Plan. A proposed schedule and milestones for piloting, developed by 3M and ECT2, is outlined below, with submission of the Pilot Test Report on December 1, 2021.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
PFAS Treatability Plan Submission	■						
Pilot Work Plan Submission	■						
Pilot Fabrication/Installation	■						
Pilot Operation		■	■	■			
Pilot Analysis and Report			■	■	■	■	
Pilot Test Report Submission							■

7 References

Appleman, T.D.; Dickenson, E.R.V.; Bellona, C. Nanofiltration and granular activated carbon treatment of perfluoroalkyl acids. *J. Haz, Mat.*, 2013, 260, 740-746.

Appleman, T.D.; Higgins, C.P.; Quiñones, O.; Vanderford, B.J.; Kolstad, C.; Zeigler-Holady, J.C.; Dickenson, E.R.V. Treatment of poly- and perfluoroalkyl substances in U.S. full-scale water treatment systems. *Wat. Res.*, 2014, 51, 246-255.

Barpaga, D.; Zheng, J.; Han, K.S.; Soltis, J.A.; Shutthanandan, V.; Basuray, S.; McGrail, B.P.; Chatterjee, S. Probing the Sorption of Perfluorooctanesulfonate Using Mesoporous Metal–Organic Frameworks from Aqueous Solutions. *Inorg. Chem*., 2019, 58, 8339-8346.

Burckhardt, J; et al. Modeling Pilot-Scale GAC PFAS Adsorption for the Simulation of Full-Scale Performance and Costs. Presented at *AWWA Water Quality Technology Conference*. November 2019.

Cui, J.; Gao, P.; Deng, Y. Destruction of Per- and Polyfluoroalkyl Substances (PFAS) with Advanced Reduction Processes (ARPs): A Critical Review. *Environ. Sci. Technol.*, 2020, 54, 7, 3752–3766.

Franke, V.; McCleaf, P.; Lindegren, K.; Ahrens, L. Efficient removal of per- and polyfluoroalkyl substances (PFASs) in drinking water treatment: nanofiltration combined with active carbon or anion exchange. *Environ. Sci.: Water Res. Technol.*, 2019, 5, 1836-1843.

Franke, V.; Ullberg, M.; McLeaf, P.; Wålinder, M.; Köhler, S.; Ahrens, L. The Price of Really Clean Water: Combining Nanofiltration with Granular Activated Carbon and Anion Exchange Resins for the Removal of Per- And Polyfluoralkyl Substances (PFASs) in Drinking Water Production. *ACS EST Water*, 2021.

Huang, P.J.; Hwangbo, M.; Chen, Z.; Liu, Y.; Kameoka, J.; Chu, K.H. Reusable Functionalized Hydrogel Sorbents for Removing Longand Short-Chain Perfluoroalkyl Acids (PFAAs) and GenX from Aqueous Solution. *ACS Omega*, 2018, 3, 17447-17455.

ITRC. PFAS – Per- and Polyfluoroalkyl Substance: Treatment Technologies. September 2020. https://pfas-1.itrcweb.org/12-treatment-technologies/

Kim, S.; Chen, J.; Cheng, T.; Gindulyte, A.; He, J.; He, S.; Li, Q.; Shoemaker, B.A.; Thiessen, P.A.; Yu, B.; Zaslavsky L.; Zhang, J.; Bolton, E.E. PubChem in 2021: new data content and improved web interfaces. *Nucleic Acids Res.*, 2021, 47, D1388-D1395. DOI: 10.1093/nar/gkaa971.

Kumarasamy, E.; Manning, I.M.; Collins, L.B.; Coronell, O.; Leibfarth, F.A. Ionic Fluorogels for Remediation of Per- and Polyfluorinated Alkyl Substances from Water. *ACS Central Science*, 2020, 6, 487-492.

Murray, C.C.; Vatankhah, H.; McDonough, C.A.; Nickerson, A.; Hedtke, T.T.; Tzahi, Y.C.; Higgins, C.P.; Bellona, C.L. Removal of Per- and Polyfluoroalkyl Substances Using Super-Fine Powder Activated Carbon and Ceramic Membrane Filtration. *J. Haz. Mat.*, 2019, 366, 160-168.

Nau-Hix, C.; Multari, N.; Singh, R.K.; Richardson, S.; Kulkarni, P.; Anderson, R.H.; Holsen, T.M.; Thagard, S.M. Field Demonstration of a Pilot-Scale Plasma Reactor for the Rapid Removal of Poly- and Perfluoroalkyl Substances in Groundwater. *ACS EST Water*, 2021, 1, 680-687.

Ross, I.; McDonough, J.; Miles, J.; Storch, P.; Kochunarayanan, P.T.; Kalve, E.; Hurst, J.; Dasgupta, S.S.; Burdick, J. A review of emerging technologies for remediation of PFASs. *Remediation*, 2018, 28, 101-126.

SERDP ESTCP. Plasma Based Treatment Processes for PFAS Investigation Derived Waste. ER18-1624. 2020A. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1624

SERDP ESTCP. Supercritical Water Oxidation (SCWO) for Complete PFAS Destruction. ER20-5350. 2020B. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER20-5350/(language)/eng-US

Soriano, Á.; Gorri, D.; Urtiaga, A. Selection of High Flux Membrane for the Effective Removal of Short-Chain Perfluorocarboxylic Acids. *Ind. Eng. Chem. Res.*, 2019, 58, 3329-3338.

US EPA. Cement Kiln and Waste to Energy Incineration of Spent Media. Presentation. February 2020A. https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=539978&Lab=CESER

US EPA. Estimation Programs Interface Suite, v 4.11. 2012, United States Environmental Protection Agency, Washington, DC, USA.

US EPA. Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams. Technical Brief. February 2020B.

US EPA. Potential PFAS Destruction Technology: Electrochemical Oxidation. Research Brief. January 2021A.

US EPA. Potential PFAS Destruction Technology: Supercritical Water Oxidation. Research Brief. January 2021B.

US EPA. Thermal Treatment of PFAS in Environmental Media: A review of the state-of-the-science. Presentation. February 2020C.
https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=539973&Lab=CESER

Woodard, S.; Berry, J.; Newman, B. Ion exchange resin for PFAS removal and pilot test comparison to GAC. *Remediation*, 2017, 27, 19–27.

Zeng, C.; Atkinson, A.; Sharma, N.; Ashani, H.; Hjelmstad, A.; Venkatesh, K.; Westerhoff, P. Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns. *AWWA Water Science*, 2020. DOI: 10.1002/aws2.1172

Large Tables

Large Table 1 PFAS Groupings for Removal Efficiencies Determination

No.	Abbreviation	Name	CAS Number	Total No. C atoms	Number of fluorinated C atoms	MW	log K_{ow} [1,2]	BP_{exp} (deg. C)[1,3]	BP_{calc} (deg. C)[1]
Group 1 (C: 1-5; CF: 1-4, MW: 114-281, logK_{ow}: -2.6-2.8)									
1	TFA	Trifluoroacetic acid	76-05-1	2	1	114	0.5	72	106
2	TFMS	Trifluoromethane sulfonate	1493-13-6	1	1	150	-0.49	166	203
3	TFMS lithium salt	Trifluoromethane sulfonate lithium salt	33454-82-9	1	1	156	-2.63	na	441
4	2,2,3,3-TFPA	2,2,3,3-tetrafluoropropionic acid	756-09-2 (71592-16-0 potassium salt)	3	2	146	0.86	134	117
5	2,3,3,3-TFPA	2,3,3,3-tetrafluoropropionic acid	359-49-9	3	2	146	0.86	na	117
6	PFPA	Perfluoropropionic acid	422-64-0	3	2	164	1.47	97	110
7	PFES	Perfluoroethanesulfonate	354-88-1	2	2	200	0.48	178	207
8	HQ-115	Bis(trifluoromethylsulfonyl)amine	98837-98-0 (90076-65-6 lithium salt)	2	2	281	2.07	na	287
9	PFBA	Perfluorobutanoic acid	375-22-4	4	3	214	2.14	121	123
10	PIBA	Perfluoroisobutyl amide	662-20-4	4	3	213	0.81	na	178
11	PFPeA	Perfluoropentanoic acid	2706-90-3	5	4	264	2.81	na	145
Group 2 (C: 4-9; CF: 4-7, MW: 284-414, logK_{ow}: 1.8-4.8)									
12	PFBSi	Perfluorobutanesulfinic acid[4]	34642-43-8	4	4	284	1.82	212	201
13	PFBSi	Nonafluorobutane-1-sulfinic acid[4]	34642-43-8	4	4	284	1.82	212	201
14	FBSA	Perfluorobutanesulfonamide	30334-69-1	4	4	299	3.13	115	178
15	PFBS	Perfluorobutane sulfonate	375-73-5	4	4	300	1.82 (0.25)	200	214
16	FBSE	Nonafluoro-N-(2-hydroxyethyl)butane-1-sulfonamide	34454-99-4	6	4	343	2.62	251	270.31
17	MeFBSAA	Perfluorobutyl-methyl sulfonamide glycine acid	159381-10-9	7	4	371	na	na	na
18	PBSA	N-[3-(dimethylamino)propyl]-1,1,2,2,3,3,4,4,4-nonafluoro-butane-1-sulfonamide	68555-77-1	9	4	384	3.78	na	274.01
19	FBSEE Diol	Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide	34455-00-0	8	4	387	2.26	na	339.24
20	FBSEE-DA	[(Nonafluorobutane-1-sulfonyl)-carboxymethylamino] acetic acid	1268835-43-3	8	4	415	na	na	na
21	FBSAA	Perfluorobutyl sulfonamide glycine acid	1910057-70-3	6	4	357	na	na	na
22	PFHxA	Perfluorohexanoic acid	307-24-4	6	5	314	3.48 (0.18)	157	165.08
23	HFPO-DA	Hexafluoropropylene oxide dimer acid	13252-13-6	6	5	330	3.36	na	186.86
24	PFHpA	Perfluoroheptanoic acid	375-85-9	7	6	364	4.15 (0.88)	177	184.82
25	PFHxS	Perfluorohexane sulfonate	355-46-4	6	6	400	3.16 (1.65)	239	221.92
26	PFOA	Perfluorooctanoic acid	335-67-1	8	7	414	4.81 (1.58)	189	203.77
Group 3 (C:8-13; CF: 8-12, MW: 464-664, logK_{ow}: 4.5-8.2)									
27	PFNA	Perfluorononanoic acid	375-95-1	9	8	464	5.48 (2.28)	na	221.92
28	PFOSA	Perfluorooctane sulfonamide	754-91-6	8	8	499	5.8	na	193.87
29	PFOS	Perfluorooctane sulfonate	1763-23-1	8	8	500	4.49 (3.05)	249	229.28
30	PFDA	Perfluorodecanoic acid	335-76-2	10	9	514	6.15	218	239.28
31	PFUnA	Perfluoroundecanoic acid	2058-94-8	11	10	564	6.82	na	255.83
32	PFDoA	Perfluorododecanoic acid	307-55-1	12	11	614	7.49	249	271.58
33	PFTrDA	Perfluorotridecanonic acid	72629-94-8	13	12	664	8.16	na	286.54

(1) US EPA. Estimation Programs Interface Suite, v 4.11. 2012, United States Environmental Protection Agency, Washington, DC, USA.
(2) LogD values are shown in parentheses for select PFAS at pH 7.4. LogD values are n-octanol-water partition coefficients that account for the acid dissciation constant of the PFAS for a given pH of the water phase. From: Zeng, C.; Atkinson, A.; Sharma, N.; Ashani, H.; Hjelmstad, A.; Venkatesh, K.; Westerhoff, P. Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns. *AWWA Water Science*, 2020. DOI: 10.1002/aws2.1172
(3) Kim, S.; Chen, J.; Cheng, T.; Gindulyte, A.; He, J.; He, S.; Li, Q.; Shoemaker, B.A.; Thiessen, P.A.; Yu, B.; Zaslavsky L.; Zhang, J.; Bolton, E.E. PubChem in 2021: new data content and improved web interfaces. *Nucleic Acids Res.* 2021, 47, D1388-D1395. doi: 10.1093/nar/gkaa971.
(4) Two chemical names were provided by MPCA for the abbreviation PFBSi. Based on publically available information, these two chemical names refer to the same PFAS structure.
CF=number of fluorinated carbon atoms; MW=molecular weight in g/mol; logK_{ow}=logarithmic transformation of the n-octanol-water partion coefficient; BP=boiling point in degrees Celcius (experimental and calculated values are shown where available).
na=not available; publically available information was not identified.

Large Table 2 PFAS Treatment Technologies Threshold Screening

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Sorption Technologies							
Granular Activated Carbon (GAC)	PFAS sorbs to hydrophobic GAC surface in a fixed-bed pressure vessel.	Yes	Yes	Yes (baseline)	Primary or Secondary	GAC is a mature technology for PFAS water treatment. It is retained in the analysis as the baseline for comparison of other retained technologies.	(ITRC 2020)
Powdered Activated Carbon (PAC)	Similar to GAC, PFAS are removed via sorption to the hydrophobic surface of PAC. PAC is added directly in process or tank (not fixed bed). Spent PAC is wasted and separated by settling or with low-pressure membrane filtration.	Yes	Yes	No	--	PAC is a mature treatment technology and is able to remove PFAS. PAC is not being retained, however, because its application is more logistically complex than GAC due to the need to continually replenish and waste media.	(Ross 2018)
Super-Fine Powdered Activated Carbon (S-PAC)	PFAS sorbs to PAC that has been ground to a super-fine powder and added in the process (e.g., within a tank). S-PAC is removed via membrane filtration.	Yes	No	No	--	Technology is not commercially available. Would require a near continuous supply of fresh super-fine PAC.	(Murray 2019)
Anion Exchange Resin (single use media)	PFAS attaches to resin via electrostatic interactions with charged functional groups and via hydrophobic interactions with resin support material in a fixed bed pressure vessel. Once exhausted, media is removed and disposed.	Yes	Yes	Yes	Primary or Secondary	Technology is effective for PFAS treatment and commercially available. Equipment is typically smaller than GAC equipment. Modestly higher efficacy than GAC for treatment of short-chain PFAS.	(ITRC 2020)
Anion Exchange Resin (regenerable media)	PFAS attaches to resin via electrostatic interactions with charged functional groups and via hydrophobic interactions with resin support material in a fixed-bed pressure vessel. Once exhausted, media is regenerated on-site using a brine/solvent mixture and returned to service.	Yes	No	No[(1)]	--	Technology is effective for PFAS treatment, however, regeneration equipment at the required scale is not commercially available.	(ITRC 2020)
Synthesized Gel Polymeric Absorbents	PFAS sorbs to synthetic polymer materials with tunable functional groups and various support materials meant to optimize PFAS removal from water.	Yes	No	No	--	Technology is effective for PFAS treatment, but is not commercially available. These technologies are currently only on the laboratory-scale.	(Huang 2019) (Kumarasamy 2020)
Modified Adsorbents	PFAS sorbs to modified adsorbent media, which can include modified natural materials: polymer-coated sand, modified cyclodextrin, or modified cellulose.	Limited	No	No	--	Technologies can be effective. While commercial products are under development, they are not available at the scale required.	(ITRC 2020) (Ross 2018)
Metal-Organic Frameworks (MOF)	PFAS sorbs to an organic coordination network (repeating structures) with complexed metal ions tuned for PFAS sorption.	No	No	No	--	MOF technologies are not commercially available for PFAS treatment. Technologies are currently only on the laboratory scale.	(Ross 2018) (Barpaga 2019)
Separation Technologies							
Reverse Osmosis (RO) or Nanofiltration (NF)	PFAS are separated into a concentrate stream by physical separation via high-pressure membranes. NF membranes typically have higher water recovery than RO due to larger membrane pore sizes.	Yes	Yes	Yes	Primary	RO and NF have demonstrated efficacy for PFAS treatment and equipment is commercially available. NF may have slightly lower removal efficiencies than RO, but has higher water recovery.	(ITRC 2020) (Franke 2019)
Thermal Evaporation with Crystallizer	Water is evaporated, with most PFAS and other dissolved constituents remaining in a slurry requiring management (for example, dewatering and disposal in a landfill or via incineration). Some short-chain PFAS may evaporate with water.	No	Yes	Yes	Secondary	Thermal evaporation with crystallizer is being retained as an option for concentrate management from RO, not as primary PFAS treatment option.	--

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Foam Fractionation	PFAS are stripped from liquid phase as foam using fine air or ozone bubbles. This technology takes advantage of the surfactant properties of PFAS at high concentrations.	Limited	Limited	No	--	Foam fractionation is an emerging technology for PFAS treatment. It is not commercially available at the scale needed. This technology may be most applicable for concentrating up high concentration PFAS streams.	(ITRC 2020) (Ross 2018)
Precipitation/ Coagulation/ Flocculation	PFAS are removed via sorption to or incorporation with coagulated and flocculated solids and removed via settling with other solids. Treatment is similar to conventional coagulation and flocculation.	Limited	Yes	No	--	Treatment efficacy of precipitation is limited. Partial removal of PFAS is possible, but typically limited to longer chain PFAS.	(ITRC 2020)
Destructive Technologies (on-site)							
Plasma	Plasma reactors use charged gases, such as argon, to degrade PFAS via reactions with reactive intermediates (electrons and radicals).	Limited	No	No(1)	--	Plasma reactors are an emerging technology for PFAS treatment and degradation. Reactors specifically for PFAS treatment are not commercially available.	(ITRC 2020) (SERDP 2020A) (Nau-Hix 2021)
Super Critical Water Oxidation (SCWO)	PFAS is degraded by water heated and pressurized to a super critical state (above a temperature of 374°C and pressure of 221 bar).	Limited	Limited	No	--	SCWO is an emerging technology for PFAS treatment and degradation. There are commercial applications of SCWO, but few specifically for PFAS treatment.	(US EPA 2021B) (SERDP 2020B)
Advanced Oxidation Processes (AOP)	AOP use oxidants, such as ozone, peroxide, persulfate, UV light, and/or combinations thereof to degrade PFAS via reaction with reactive intermediates such as hydroxyl radicals.	Limited	Yes	No	--	While AOP technologies are available on commercial scales, they have relatively low efficacy for PFAS treatment and result in incomplete PFAS degradation.	(ITRC 2020)
Electrochemical Oxidation	Electrochemical oxidation uses electrical currents passed through water to degrade PFAS. PFAS are oxidized at the anode of the electrochemical cell.	Yes	Limited	No	--	Electrochemical oxidation of PFAS has been demonstrated to be effective, but is still an active area of research. Electrochemical reactors specifically for PFAS water treatment are not commercially available.	(ITRC 2020) (US EPA 2021A)
Advanced Reduction Processes (ARPs)	ARPs generate hydrated electrons and hydrogen radicals by application of reductants (such as iodide or sulfite) with a source of activating energy (such as ultrasound or UV light). The hydrated electrons and hydrogen radicals have the potential to cleave C-F bonds.	Limited	No	No	--	ARP technologies are emerging as potential options for PFAS water treatment. ARPs have the potential to degrade PFAS, but efficacy is still an active area of research. Technologies are not commercially available.	(ITRC 2020) (Cui 2020)
Biological Treatment	PFAS are (partially) degraded via microbial degradation under aerobic or anaerobic conditions.	No	Yes	No	--	Partial microbial degradation of PFAS is possible for select classes of PFAS (for example, fluorotelomers and PFAS precursors). To date, microbial degradation of PFAS is incomplete and results in formation of shorter chain, stable perfluoroalkyl acids.	(ITRC 2020)
Sonolysis	Sonolysis (or sonochemical oxidation) uses ultrasound waves in water to cause cavitation. Cavitation generates radicals that can degrade PFAS.	Yes	No	No	--	Sonolysis has been shown to be effective for PFAS treatment in the laboratory and pilot scales, but reactors are not commercially available. Treatment efficacy is an active area of research.	(ITRC 2020)

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Destructive Technologies (offsite)							
Incineration	PFAS (sorbed to media or in a concentrated stream) are thermally degraded at high temperature.	Yes	Yes	Yes	Secondary	This technology is mature, but is not viable as a primary treatment technology for PFAS due to scale constraints. It is being retained as a secondary technology for management of residuals. Efficacy of PFAS destruction in incinerators is an active area of investigation.	(ITRC 2020) (US EPA 2020B)
Cement Kiln	Similar to incineration, PFAS (sorbed to media or in a concentrated stream) are thermally degraded at high temperature.	Limited	Yes	No	--	This technology is not viable as a primary treatment option due to scale constraints. It may be appropriate for management of spent media and other residuals. Efficacy of PFAS destruction in cement kilns is an active area of investigation.	(USEPA 2020A) (US EPA 2020C)

(1) While these experimental technologies have not yet been demonstrated at full-scale and/or commercially available, 3M plans to proceed with testing regenerable AIX and plasma reactors at one or more facilities.

Large Table 3 PFAS Treatment Alternatives Screening

Category	Criteria Weight	Ranking Key	**Alternative 1** Modified Granular Activated Carbon	**Alternative 2** Anion Exchange (Single Use)	**Alternative 3** Nanofiltration with Granular Activated Carbon	**Alternative 4** Two-Stage Reverse Osmosis with Thermal Evaporation/ Crystallization	**Alternative 5** Reverse Osmosis with Anion Exchange (Single Use)
Technical Feasibility			***21***	***30***	***19***	***31***	***34***
Group 1 PFAS removal efficiency(1)	3	1 - <50% removal efficiency 2 - >50% and <75% removal efficiency 3 - >75% removal efficiency	1	2	1	3	3
Group 2 PFAS removal efficiency(1)	3	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	1	2	1	3	3
Group 3 PFAS removal efficiency(1)	3	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	2	3	2	3	3
General complexity of operation/maintenance of primary technology	2	1 - most complex 3 - most simple	3	3	2	1	2
Operator and public health risks	1	1 - significant additional health risk 3 - no additional health risk	3	3	3	2	3
Economic Feasibility			***15***	***15***	***9***	***9***	***15***
Capital costs for primary technology (and secondary technology, where applicable)	3	1 - high relative capital cost 3 - low relative capital cost	3	3	2	1	2
O&M costs for primary technology (and secondary technology, where applicable)	3	1 - high relative O&M cost 3 - low relative O&M cost	2	2	1	2	3
Energy Consumption			***6***	***6***	***4***	***2***	***4***
Energy consumption of primary technology (and secondary technology, where applicable)	2	1 - high energy consumption 3 - low energy consumption	3	3	2	1	2
Potential for Media Shifting of Pollutants			***2***	***2***	***2***	***6***	***4***
Relative quantity of residuals generated	2	1 - high 2 - average 3 - low	1	1	1	3	2
		Total Score	**44**	**53**	**34**	**48**	**57**

(1) Removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes.

Appendix A

Pilot Testing Workplan, 5/12/2021

Montrose Environmental Group

Pilot Test Workplan

3M

Cottage Grove, MN Facility

Submission Date: 5/27/2021

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1.0 ECT2 Understanding of the Project Objectives

Based on a technical review meeting between 3M and ECT2, we understand that 3M already operates four separate granular activated carbon (GAC) treatment systems to treat PFAS-impacted water at the site:

Source	Description	Current Treatment
Potable Supply Wells Avg Flow = 1.4 MGD	These wells supply water for domestic and manufacturing use	Currently treated with 3 pairs of Calgon Model 10 systems
Non-Potable Supply Wells Avg Flow = 4.9 MGD	These wells supply water for non-contact cooling water, manufacturing, and scrubber makeup for the on-site incinerator	Currently treated with 6 pairs of Calgon Model 10 systems
Phase 3 Wastewater Avg Flow = 0.7 MGD	Phase 3 wastewater includes scrubber blowdown from the on-site incinerator	Currently treated with 4 pairs of Norit Model 10 systems
Phase 1 & 2 Wastewater Avg Flow = 2.1 MGD	Phase 1 & 2 wastewater includes all other wastewater from the facility from inorganic manufacturing ("Phase 1") and domestic/organic manufacturing ("Phase 2") sources.	Currently treated with 9 pairs of Norit Model 10 systems

ECT2 further understands that 3M is required by the Minnesota Pollution Control Agency (MPCA) to perform a pilot test to demonstrate treatment technologies to remove PFAS from the facility prior to discharge to the Mississippi. A pilot test workplan is due to the MPCA by June 1, 2021 and the pilot test must be completed and report submitted no later than 180 days from MPCA approval of the pilot test workplan.

3M has expressed a desire to pilot test the PFAS treatment technologies currently being designed and/or tested at other 3M facilities. These technologies include Reverse Osmosis coupled with ECT2's regenerable ion-exchange (IX) resin. Major pretreatment technologies for these processes include ultrafiltration (UF) (to pretreat incoming water to the RO membranes) and LGAC (to treat RO reject for TOC, iron and long-chain PFAS compounds prior to ECT2's regenerable IX resin treatment).

The pilot test work at the Cottage Grove plant will focus on evaluating the performance of RO and regenerable IX (along with LGAC and single-use IX for comparison purposes) to evaluate PFAS removal capacities and develop breakthrough curves. On-site regeneration, multi-cycling, and subsequent PFAS destruction of the regenerant still bottoms are not planned for this pilot test, as 3M is already pilot testing these parameters and technologies at other sites. However, regeneration of each column will be performed off-site at ECT2's laboratory to demonstrate that the regenerant formula used by ECT2 can remove the site-specific PFAS loaded onto the media.

ECT2 plans to pilot test 3M's proprietary Liquid-Liquid PFAS extraction technology on one of the RO reject trains to evaluate its potential for full-scale application. Currently, the plan is to test this technology on the RO Reject from the Phase 3 WWTP test.

In addition to PFAS treatment testing, ECT2 also plans to evaluate how well the UF performs at zinc removal during the Phase 3 WWTP test.

2.0 Pilot Testing Description

The proposed overall scope of the pilot test is to:

- Demonstrate the PFAS removal capacity of RO membranes
- Develop breakthrough curves of RO reject water for LGAC, single-use AIX and regenerable AIX resins in three main process trains:
    - NCCW Stormwater (Outfall SD002)
    - Phase 1 & 2 WWTP effluent
    - Phase 3 WWTP effluent
- Demonstrate the ability to remove PFAS compounds from the regenerable AIX media using ECT2's proprietary blend of solvent and brine solution at ECT2's lab in Rochester, NY.
- Evaluate the effectiveness of UF membranes to sufficiently pre-treat the water for use in RO membranes
- Evaluate 3Ms proprietary Liquid-Liquid extraction technology for PFAS removal. The scope of this effort will be developed in collaboration with 3M.
- Evaluate zinc removal efficiency of the UF for the Phase 3 WW.

Pilot testing of all 3 areas of the plant will not be performed simultaneously, but rather in series, in order to reduce the amount of equipment needed to be deployed to the site. We envision testing the cleanest water first (NCCW Stormwater Pond) and the Phase 3 WW last.

ECT2 plans to deploy the PFAS pilot testing equipment in one or more Conex boxes. The equipment includes:

- Influent equalization tank
- Feed pumps and break tanks for the UF and RO influent, permeate and reject flows
- UF membrane skid
- RO membrane skid with integral pump, controls, instrumentation
- 9 trains of single-use or regenerable AIX columns in lead-lag configuration (2 columns per train). Each train will have its own dedicated peristaltic pump.
- Piping, valves, instrumentation, flow meters, sample ports and appurtenances for the above major units.

Additional details for the pilot testing can be found in the following attachments:

- Figure 1 – Pilot Test Block Flow Diagrams
- Table 1 – Pilot Test Setup
- Table 2 – Sampling and Analysis Plan

Pilot Test Program Description

ECT2 anticipates that the pilot test equipment will operate for approximately 7 weeks in order to complete the scope of work described above. 4 additional weeks will be staffed onsite for mobilization, relocation of the equipment around the site, and demobilization.

- ECT2 will be onsite to set up the pilot skids and tanks; load the media in each column; hydrate the media, install filter membranes, and pressure test the system.
- ECT2 will staff the operations of the pilot test for the duration of the test. Core ECT2 responsibilities onsite will include:
    - Record process instrument data in a log book (pressures, temperatures, flow rates and flow totals);
    - Collect samples according to the sampling plan;
    - Collect and analyze field parameters;
    - Label, package and ship samples to Enthalpy Analytical for laboratory analysis of PFAS and background chemistry compounds.
- During the first week of operations, ECT2 will focus our efforts on optimizing the UF and RO skids without operating any treatment columns. Once ECT2 has confirmed the UF and RO units are operating according to design, treatment of RO Reject and RO permeate through the different trains of media will begin.

The sampling plan is provided in Table 2, which incorporates PFAS as well as background chemistry testing. The SAP is designed to provide an adequate number of samples to evaluate RO treatment capacity as well as capture break through curves of each media treating RO Reject. The SAP calls for collection and analysis of approximately 293 PFAS samples during forward flow operations and off-site regeneration and 126 for background water chemistry. Hold samples will be collected and sent in if needed to fill in data gaps where needed.

	Forward Flow	**Off-Site Regen**	**Liquid-Liquid Extraction**	**Total**
PFAS Samples	263	30	TBD	293
Background Chemistry	126	0	TBD	126

We have assumed 12 samples will be collected from the Phase 3 WW pilot and submitted to an off-site laboratory for analysis for zinc.

ect2
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3.0 Project Schedule

ECT2 will immediately begin procurement of equipment upon PO acceptance. The estimated project schedule is provided below:

Date	Scope Description
June 1, 2021	No later than June 1, 2021, 3M submits pilot test workplan to MPCA
May/June 2021	Pilot System Fabrication/Installation on site, pending workplan approval
July – Sept 2021	Pilot System Operation, pending workplan approval
Dec 1, 2021	3M Submits Pilot Test Report to MPCA

This schedule assumes pilot testing will start on site in July of 2021 and concluding in September of 2021, based on acceptance of PO in May 2021. ECT2 has budgeted for 11 weeks of onsite labor to compete the install, startup, pilot testing & demobilization described in this workplan.

ECT2 will provide a Pilot Testing Report that includes our conclusions and recommendations within 2-4 weeks of receipt of all analytical data (from 3M and/or commercial lab).

ECT2 is aware that the pilot test report must be submitted within 180 days of MPCA approval of the pilot test workplan.

TABLE 2 - SAMPLING AND ANALYSIS PLAN - FORWARD FLOW

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

Flow Rate - RO Influent	mL/min	2,361
	gpd	898
	gpm	0.62
Flow Rate - RO Permeate	mL/min	2,053
	gpd	781
Flow Rate - RO Reject	mL/min	308
	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

NCCW & STORMWATER POND

Start Date/Time: 7/12/21 8:00

				Daily Flows			Cumulative Flows			RO STREAMS			
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject	INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT
				gal	gal	gal	gal	gal	gal				
7/11/2021	SUN												
7/12/2021	MON	12:00	7/12/21 12:00	150	130	20	150	130	20	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/13/2021	TUE	12:00	7/13/21 12:00	898	781	117	1,048	911	137	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/14/2021	WED	12:00	7/14/21 12:00	898	781	117	1,946	1,692	254	PFAS	PFAS	PFAS	PFAS
7/15/2021	THU	12:00	7/15/21 12:00	898	781	117	2,844	2,473	371	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/16/2021	FRI	12:00	7/16/21 12:00	898	781	117	3,742	3,254	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/17/2021	SAT	12:00	7/17/21 12:00	898	781	117	4,641	4,035	605				
7/18/2021	SUN	12:00	7/18/21 12:00	898	781	117	5,539	4,816	722				
7/19/2021	MON	12:00	7/19/21 12:00	898	781	117	6,437	5,597	840	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/20/2021	TUE	12:00	7/20/21 12:00	898	781	117	7,335	6,378	957	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/21/2021	WED	12:00	7/21/21 12:00	898	781	117	8,233	7,159	1,074	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/22/2021	THU	12:00	7/22/21 12:00	898	781	117	9,131	7,940	1,191	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/23/2021	FRI	12:00	7/23/21 12:00	898	781	117	10,030	8,721	1,308	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/24/2021	SAT	12:00	7/24/21 12:00	898	781	117	10,928	9,502	1,425				
7/25/2021	SUN	12:00	7/25/21 12:00	898	781	117	11,826	10,283	1,543				
7/26/2021	MON	12:00	7/26/21 12:00	898	781	117	12,724	11,064	1,660	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/27/2021	TUE	12:00	7/27/21 12:00										
7/28/2021	WED	12:00	7/28/21 12:00										
7/29/2021	THU	12:00	7/29/21 12:00										
7/30/2021	FRI	12:00	7/30/21 12:00										
7/31/2021	SAT	12:00	7/31/21 12:00										

Setup pilot system for Phase 1/2 WW

	Cumulative Flows (Trains A & B)					TRAIN A				TRAIN B				Cumulative Flows (Train C)			TRAIN C	
Date	To TRAINS A & B	GAC1	GAC2	IX1	IX2	GAC1-A	GAC2-A	IX1-A	IX2-A	GAC1-B	GAC2-B	IXR1-B	IXR2-B	To TRAIN C	IX1	IX2	IX1-C	IX2-C
	gal	BVs	BVs	BVs	BVs	(PRETREATMENT)		(SINGLE-USE IX)		(PRETREATMENT)		(REGENERABLE IX)		gal	BVs	BVs	(SINGLE-USE IX)	
7/11/2021																		
7/12/2021	10	16	8	16	8	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	49	80	40	PFAS	PFAS
7/13/2021	68	112	56	112	56	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	342	560	280	PFAS (H)	PFAS (H)
7/14/2021	127	208	104	208	104	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	635	1,040	520	PFAS+BC	PFAS+BC
7/15/2021	185	304	152	304	152	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	927	1,520	760	PFAS (H)	PFAS (H)
7/16/2021	244	400	200	400	200	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	1,220	2,000	1,000	PFAS	PFAS
7/17/2021	303	496	248	496	248	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,513	2,480	1,240	PFAS (H)	PFAS (H)
7/18/2021	361	592	296	592	296	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,806	2,960	1,480	PFAS (H)	PFAS (H)
7/19/2021	420	688	344	688	344	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,099	3,440	1,720	PFAS (H)	PFAS (H)
7/20/2021	478	784	392	784	392	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	2,392	3,920	1,960	PFAS+BC	PFAS+BC
7/21/2021	537	880	440	880	440	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,685	4,400	2,200	PFAS (H)	PFAS (H)
7/22/2021	596	976	488	976	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,978	4,880	2,440	PFAS (H)	PFAS (H)
7/23/2021	654	1,072	536	1,072	536	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,271	5,360	2,680	PFAS (H)	PFAS (H)
7/24/2021	713	1,168	584	1,168	584	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	3,563	5,840	2,920	PFAS	PFAS
7/25/2021	771	1,264	632	1,264	632	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,856	6,320	3,160	PFAS (H)	PFAS (H)
7/26/2021	830	1,360	680	1,360	680	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	4,149	6,800	3,400	PFAS+BC	PFAS+BC
7/27/2021																		
7/28/2021																		
7/29/2021																		
7/30/2021																		
7/31/2021																		

TABLE 2 - SAMPLING AND ANALYSIS PLAN - FORWARD FLOW

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

Flow Rate - RO Influent	mL/min	2,361
	gpd	898
	gpm	0.62
Flow Rate - RO Permeate	mL/min	2,053
	gpd	781
Flow Rate - RO Reject	mL/min	308
	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

PHASE 1 & 2 WASTEWATER (PRE-LGAC)

Start Date/Time: 8/2/21 8:00

				Daily Flows			Cumulative Flows			*RO STREAMS*			
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject	INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT
				gal	gal	gal	gal	gal	gal				
8/1/2021	SUN												
8/2/2021	MON	12:00	8/2/21 12:00	150	130	20	150	130	20	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/3/2021	TUE	12:00	8/3/21 12:00	898	781	117	1,048	911	137	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/4/2021	WED	12:00	8/4/21 12:00	898	781	117	1,946	1,692	254	PFAS	PFAS	PFAS	PFAS
8/5/2021	THU	12:00	8/5/21 12:00	898	781	117	2,844	2,473	371	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/6/2021	FRI	12:00	8/6/21 12:00	898	781	117	3,742	3,254	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/7/2021	SAT	12:00	8/7/21 12:00	898	781	117	4,641	4,035	605				
8/8/2021	SUN	12:00	8/8/21 12:00	898	781	117	5,539	4,816	722				
8/9/2021	MON	12:00	8/9/21 12:00	898	781	117	6,437	5,597	840	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/10/2021	TUE	12:00	8/10/21 12:00	898	781	117	7,335	6,378	957	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/11/2021	WED	12:00	8/11/21 12:00	898	781	117	8,233	7,159	1,074	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/12/2021	THU	12:00	8/12/21 12:00	898	781	117	9,131	7,940	1,191	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/13/2021	FRI	12:00	8/13/21 12:00	898	781	117	10,030	8,721	1,308	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/14/2021	SAT	12:00	8/14/21 12:00	898	781	117	10,928	9,502	1,425				
8/15/2021	SUN	12:00	8/15/21 12:00	898	781	117	11,826	10,283	1,543				
8/16/2021	MON	12:00	8/16/21 12:00	898	781	117	12,724	11,064	1,660	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/17/2021	TUE	12:00	8/17/21 12:00										
8/18/2021	WED	12:00	8/18/21 12:00										
8/19/2021	THU	12:00	8/19/21 12:00										
8/20/2021	FRI	12:00	8/20/21 12:00										
8/21/2021	SAT	12:00	8/21/21 12:00										

Setup pilot system for Phase 3 WW

	Cumulative Flows (Trains D & E)					TRAIN D				TRAIN E				Cumulative Flows (Train F)			TRAIN F	
Date	To TRAINS D & E	GAC1	GAC2	IX1	IX2	GAC1-D	GAC2-D	IX1-D	IX2-D	GAC1-E	GAC2-E	IXR1-E	IXR2-E	To TRAIN F	IX1	IX2	IX1-F	IX2-F
	gal	BVs	BVs	BVs	BVs	(PRETREATMENT)		(SINGLE-USE IX)		(PRETREATMENT)		(REGENERABLE IX)		gal	BVs	BVs	(SINGLE-USE IX)	
8/1/2021																		
8/2/2021	10	16	8	16	8	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	49	80	40	PFAS	PFAS
8/3/2021	68	112	56	112	56	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	342	560	280	PFAS (H)	PFAS (H)
8/4/2021	127	208	104	208	104	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	635	1,040	520	PFAS+BC	PFAS+BC
8/5/2021	185	304	152	304	152	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	927	1,520	760	PFAS (H)	PFAS (H)
8/6/2021	244	400	200	400	200	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	1,220	2,000	1,000	PFAS	PFAS
8/7/2021	303	496	248	496	248	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,513	2,480	1,240	PFAS (H)	PFAS (H)
8/8/2021	361	592	296	592	296	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,806	2,960	1,480	PFAS (H)	PFAS (H)
8/9/2021	420	688	344	688	344	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,099	3,440	1,720	PFAS (H)	PFAS (H)
8/10/2021	478	784	392	784	392	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	2,392	3,920	1,960	PFAS+BC	PFAS+BC
8/11/2021	537	880	440	880	440	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,685	4,400	2,200	PFAS (H)	PFAS (H)
8/12/2021	596	976	488	976	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,978	4,880	2,440	PFAS (H)	PFAS (H)
8/13/2021	654	1,072	536	1,072	536	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,271	5,360	2,680	PFAS (H)	PFAS (H)
8/14/2021	713	1,168	584	1,168	584	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	3,563	5,840	2,920	PFAS	PFAS
8/15/2021	771	1,264	632	1,264	632	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,856	6,320	3,160	PFAS (H)	PFAS (H)
8/16/2021	830	1,360	680	1,360	680	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	4,149	6,800	3,400	PFAS+BC	PFAS+BC
8/17/2021																		
8/18/2021																		
8/19/2021																		
8/20/2021																		
8/21/2021																		

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ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

Flow Rate - RO Influent	mL/min	2,361
	gpd	898
	gpm	0.62
Flow Rate - RO Permeate	mL/min	2,053
	gpd	781
Flow Rate - RO Reject	mL/min	308
	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

PHASE 3 WASTEWATER (PRE-LGAC)

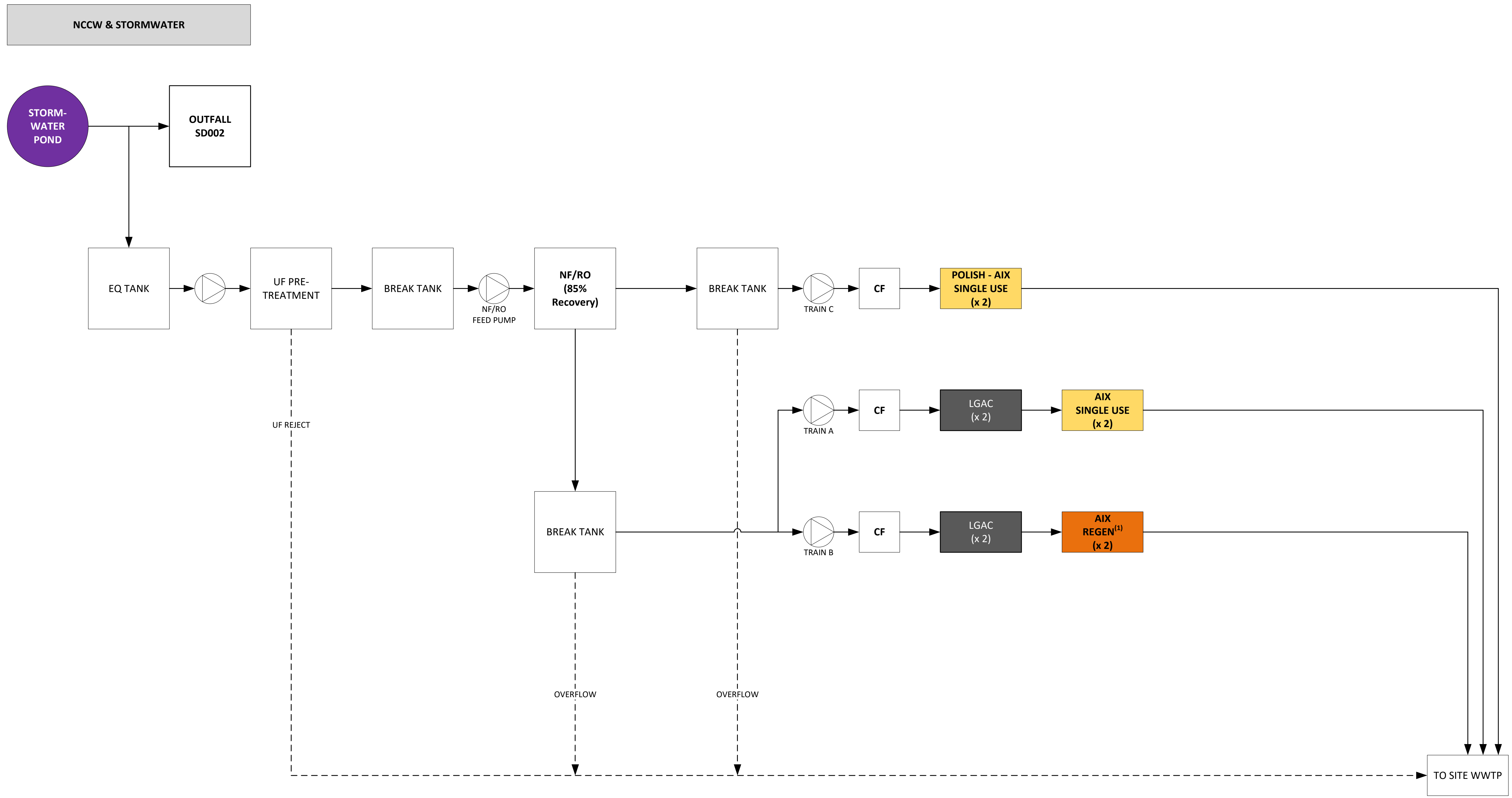
Start Date/Time: 8/23/21 8:00

				Daily Flows			Cumulative Flows			RO STREAMS			
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject	INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT
				gal	gal	gal	gal	gal	gal				
8/22/2021	SUN												
8/23/2021	MON	12:00	8/23/21 12:00	150	130	20	150	130	20	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/24/2021	TUE	12:00	8/24/21 12:00	898	781	117	1,048	911	137	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/25/2021	WED	12:00	8/25/21 12:00	898	781	117	1,946	1,692	254	PFAS	PFAS	PFAS	PFAS
8/26/2021	THU	12:00	8/26/21 12:00	898	781	117	2,844	2,473	371	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/27/2021	FRI	12:00	8/27/21 12:00	898	781	117	3,742	3,254	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/28/2021	SAT	12:00	8/28/21 12:00	898	781	117	4,641	4,035	605				
8/29/2021	SUN	12:00	8/29/21 12:00	898	781	117	5,539	4,816	722				
8/30/2021	MON	12:00	8/30/21 12:00	898	781	117	6,437	5,597	840	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/31/2021	TUE	12:00	8/31/21 12:00	898	781	117	7,335	6,378	957	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
9/1/2021	WED	12:00	9/1/21 12:00	898	781	117	8,233	7,159	1,074	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/2/2021	THU	12:00	9/2/21 12:00	898	781	117	9,131	7,940	1,191	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/3/2021	FRI	12:00	9/3/21 12:00	898	781	117	10,030	8,721	1,308	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/4/2021	SAT	12:00	9/4/21 12:00	898	781	117	10,928	9,502	1,425				
9/5/2021	SUN	12:00	9/5/21 12:00	898	781	117	11,826	10,283	1,543				
9/6/2021	MON	12:00	9/6/21 12:00	898	781	117	12,724	11,064	1,660	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
9/7/2021	TUE	12:00	9/7/21 12:00										
9/8/2021	WED	12:00	9/8/21 12:00										
9/9/2021	THU	12:00	9/9/21 12:00										
9/10/2021	FRI	12:00	9/10/21 12:00										
9/11/2021	SAT	12:00	9/11/21 12:00										

End of test or extend to perform additional testing.

	Cumulative Flows (Trains G & H)					TRAIN G				TRAIN H			
Date	To TRAINS G & H	GAC1	GAC2	IX1	IX2	GAC1-G	GAC2-G	IX1-G	IX2-G	GAC1-H	GAC2-H	IXR1-H	IXR2-H
	gal	BVs	BVs	BVs	BVs	(PRETREATMENT)		(SINGLE-USE IX)		(PRETREATMENT)		(REGENERABLE IX)	
8/22/2021													
8/23/2021	10	16	8	16	8	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
8/24/2021	68	112	56	112	56	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/25/2021	127	208	104	208	104	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/26/2021	185	304	152	304	152	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/27/2021	244	400	200	400	200	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
8/28/2021	303	496	248	496	248	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/29/2021	361	592	296	592	296	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/30/2021	420	688	344	688	344	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/31/2021	478	784	392	784	392	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
9/1/2021	537	880	440	880	440	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/2/2021	596	976	488	976	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/3/2021	654	1,072	536	1,072	536	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/4/2021	713	1,168	584	1,168	584	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
9/5/2021	771	1,264	632	1,264	632	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
9/6/2021	830	1,360	680	1,360	680	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
9/7/2021													
9/8/2021													
9/9/2021													
9/10/2021													
9/11/2021													

	Cumulative Flows (Train I)			TRAIN I	
Date	To TRAIN I	IX1	IX2	IX1-I	IX2-I
	gal	BVs	BVs	(SINGLE-USE IX)	
8/22/2021					
8/23/2021	49	80	40	PFAS	PFAS
8/24/2021	342	560	280	PFAS (H)	PFAS (H)
8/25/2021	635	1,040	520	PFAS+BC	PFAS+BC
8/26/2021	927	1,520	760	PFAS (H)	PFAS (H)
8/27/2021	1,220	2,000	1,000	PFAS	PFAS
8/28/2021	1,513	2,480	1,240	PFAS (H)	PFAS (H)
8/29/2021	1,806	2,960	1,480	PFAS (H)	PFAS (H)
8/30/2021	2,099	3,440	1,720	PFAS (H)	PFAS (H)
8/31/2021	2,392	3,920	1,960	PFAS+BC	PFAS+BC
9/1/2021	2,685	4,400	2,200	PFAS (H)	PFAS (H)
9/2/2021	2,978	4,880	2,440	PFAS (H)	PFAS (H)
9/3/2021	3,271	5,360	2,680	PFAS (H)	PFAS (H)
9/4/2021	3,563	5,840	2,920	PFAS	PFAS
9/5/2021	3,856	6,320	3,160	PFAS (H)	PFAS (H)
9/6/2021	4,149	6,800	3,400	PFAS+BC	PFAS+BC
9/7/2021					
9/8/2021					
9/9/2021					
9/10/2021					
9/11/2021					

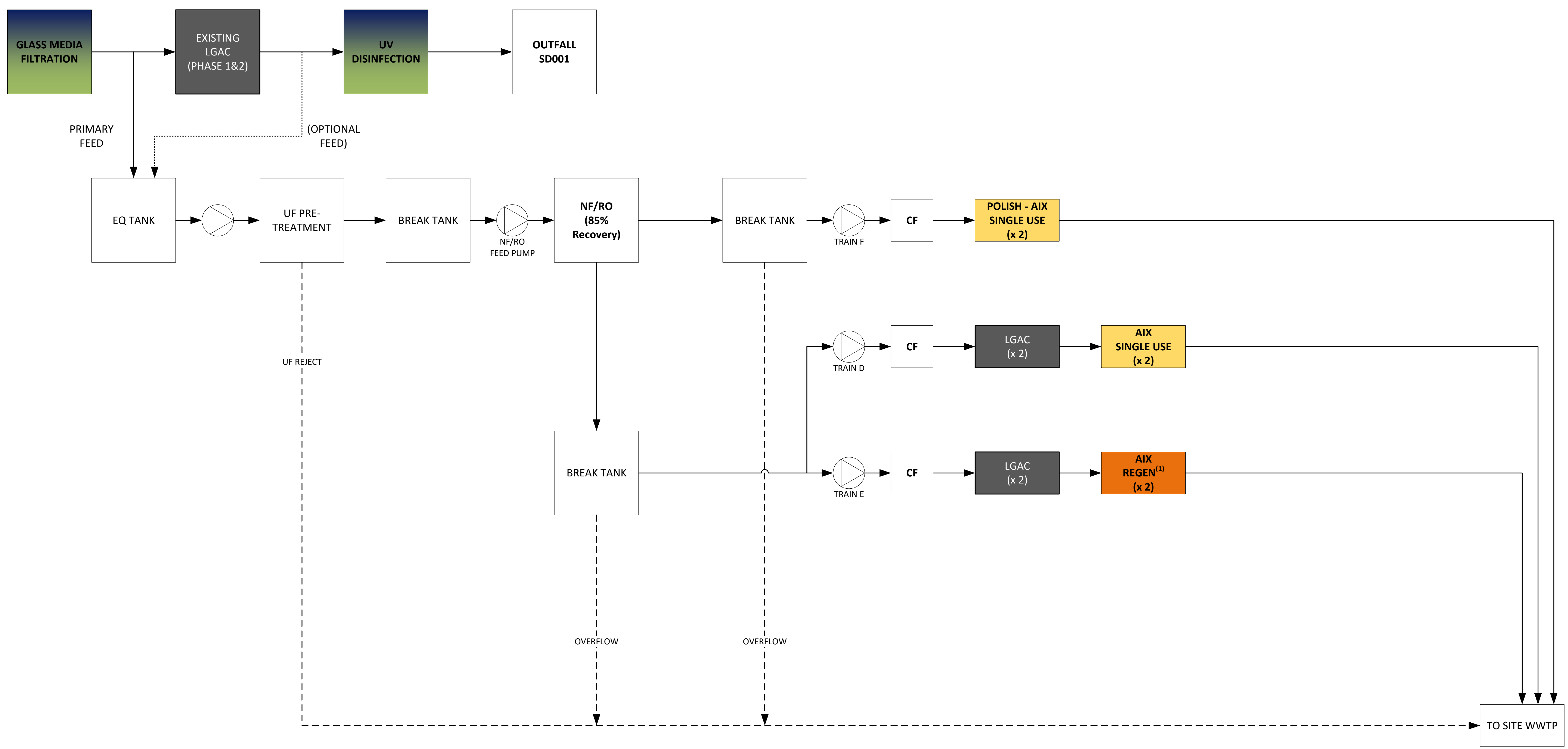


NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration

FIGURE 1A: PILOT TESTING BLOCK FLOW DIAGRAM – NCCW & STORMWATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

ECT2
www.ect2.com

PHASE 1 & 2 WASTE WATER



NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration

FIGURE 1B: PILOT TESTING BLOCK FLOW DIAGRAM – PHASE 1 & 2 WASTE WATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

ECT2
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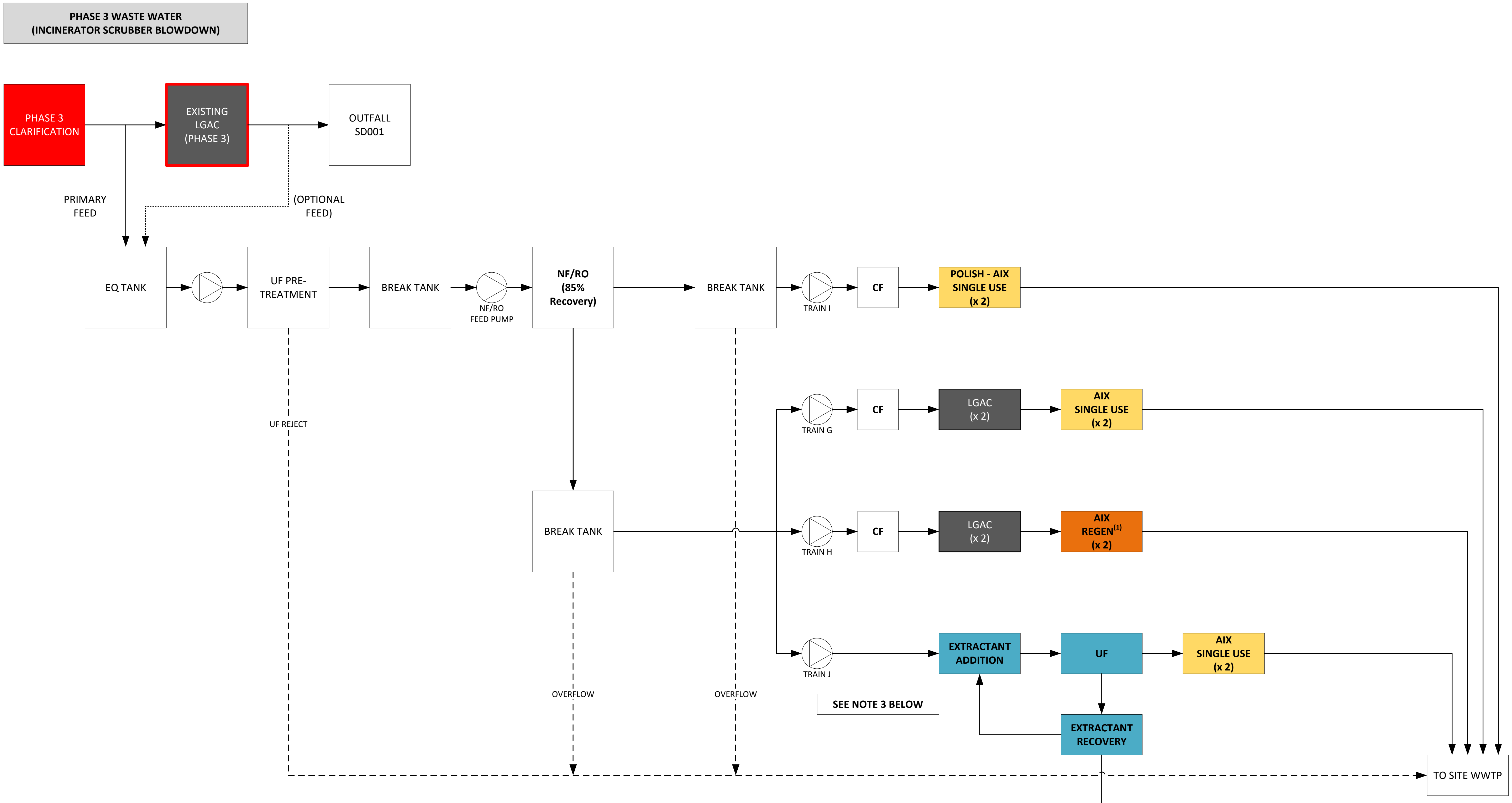
Montrose Environmental Group



NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration.
(2) Samples from the UF reject and RO reject will be sent to ECT2's lab for metals (zinc) removal testing.
(3) Details/scope of Train J to be developed at a later date.

FIGURE 1C: PILOT TESTING BLOCK FLOW DIAGRAM – PHASE 3 WASTEWATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

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EXHIBIT A-2

Updated Treatability Study

PFAS Treatability Alternatives Identification Plan (Update)

Prepared for
3M Cottage Grove Facility

July 2021

\\DC - 069539/000044 - 16195049 v1

BARR

PFAS Treatability Alternatives Identification Plan (Update)

Prepared for
3M Cottage Grove Facility

3M

July 2021

\\DC - 069539/000044 - 16195049 v1

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PFAS Treatability Alternatives Identification Plan (Update)

July 2021

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Certifications

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for sections 1 and 2

July 7, 2021

Don E. Richard
PE #: 21193

Date

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for sections 3, 4, 5, and 6

July 7, 2021

Kathryn M. Wolohan
PE #: 54881

Date

Abbreviations

AIX	anion exchange
BOD	biochemical oxygen demand
COD	chemical oxygen demand
EBCT	empty-bed contact time
GAC	granular activated carbon
HLR	hydraulic loading rate
HQ-115	Bis(trifluoromethylsulfonyl)amine
MeFBSAA	Perfluorobutyl-methyl sulfonamide glycine acid
MGD	million gallons per day
MPCA	Minnesota Pollution Control Agency
NCCW	noncontact cooling water
NF	nanofiltration
ng/L	nanograms per liter
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PFAS	per- and poly-fluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutane sulfonate
PFES	Perfluoroethanesulfonate
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFPA	Perfluoropropionic acid
PFPeA	Perfluoropentanoic acid
PIBA	Perfluoroisobutyl amide
TFA	Trifluoroacetic acid
TFMS	Trifluoromethane sulfonate
TSS	total suspended solids
UV	ultraviolet

1 Introduction

This PFAS Treatability Alternatives Identification Plan (Plan) has been prepared pursuant to corrective action no. 17 of the Notice of Violation (NOV) issued by the Minnesota Pollution Control Agency (MPCA) to the 3M Cottage Grove Center (Facility) dated January 22, 2021, which states as follows:

> *PFAS Treatability Plan: The Regulated Party shall submit a PFAS Treatability Alternative Identification Plan (Plan), by April 15, 2021, for MPCA review and comment. The Plan shall be prepared by a professional engineer registered in the state of Minnesota with expertise and experience in wastewater treatment plant (WWTP) design and operation/maintenance. The Plan shall include a preliminary analysis of all potential feasible treatment alternatives/technologies that may be capable of meeting the applicable effluent, water quality, and public health requirements for 20 years. The plan shall include the technical feasibility, economic feasibility (including cost-effectiveness), energy consumption, and the potential for media shifting of pollutants within the plan. The plan shall utilize Minn. R. 7077.0272, subp. 2., as a guide. The Plan shall be modified pursuant to MPCA review.*

The focus of this Plan is the evaluation of PFAS treatment alternatives for combined treated wastewater effluent, noncontact cooling water (NCCW), and partial stormwater from the Facility under existing Minnesota National Pollutant Discharge Elimination System (NPDES) and Surface Discharge System (SDS) Permit MN0001449 (NPDES/SDS Permit MN0001449).

1.1 Background

The wastewater collection system at the Facility collects wastewater from multiple processes for treatment through one of three main phases of treatment:

- Phase 1, the inorganic treatment system adjusts the pH and removes suspended solids from the process wastewater.
- Phase 2, the organic treatment system, treats organic material and nutrients in process wastewater and sanitary wastewater from across the Facility.
- Phase 3 treats wastewater from the on-site incinerator.

Treated wastewater from the combined Phase 1/2 systems currently receives final treatment through granular activated carbon (GAC) for polishing, followed by ultraviolet (UV) disinfection. Treated wastewater from the Phase 3 system also receives final treatment through GAC for polishing in a separate GAC system.

After GAC treatment and UV disinfection (Phase 1/2 only), effluent from all three phases flows to Outfall SD001 (SD001). Combined NCCW and stormwater from a portion of the site flows to Outfall SD002 (SD002). Effluent from SD001 and SD002 combines at Outfall 003 (SD003) before discharging from the Facility to the Mississippi River via an unnamed creek.

1.2 Plan Objective

The objective of this Plan is to evaluate potential water treatment technologies and alternatives that may be capable of meeting potential PFAS effluent requirements for wastewater discharges for the next 20 years.

1.3 Scope of Evaluation

To complete this Plan, Barr Engineering Co. (Barr) conducted a preliminary analysis of potential treatment technologies and alternatives that may be capable of meeting applicable potential PFAS effluent requirements for the next 20 years.

This analysis involved:

1. Identifying influent water quantity and quality as well as water quality targets (Section 2).
2. Identifying potential PFAS treatment technologies (Section 3).
3. Screening potential PFAS technologies against threshold criteria for use at this Facility (Section 3).
4. Developing six treatment alternatives (Section 4).
5. Conducting a detailed screening of six treatment alternatives (Section 5) using:
    a. Technical feasibility.
    b. Economic feasibility, including an estimate of potential capital and operating expenses for each alternative.
    c. Energy consumption.
    d. Potential for media shifting of pollutants.
6. Summarizing the alternatives evaluation results (Section 6).

2 Conceptual Treatment Design Basis

For the purposes of this Plan, "water" refers to the combined flow from SD001 (treated wastewater) and SD002 (stormwater), as described in Section 2.1. Additionally, "water quality" refers to PFAS and/or general chemistry parameters' concentrations in various water streams.

This section describes the conceptual operating framework for the PFAS water treatment technologies and alternatives evaluated in this Plan, including flows, water quality, and PFAS treatment targets. Representative influent flows and water quality were established based on historical monitoring data of the Facility discharges from SD001 and SD002. 3M provided data and information regarding operation of the existing wastewater treatment system, and Barr used the MPCA-proposed intervention limits for PFOS (7 ng/L calendar month average and 14 ng/L daily maximum) to comply with the current site-specific criteria for PFOS of 0.05 ng/L as treatment targets.

2.1 Conceptual Design Flow

The conceptual PFAS water treatment alternatives evaluated in this Plan were sized based on the following flows, based on flow monitoring data from October 2016 through December 2020:

- Combined Phase 1/2 and Phase 3 treated wastewater, upstream of existing GAC treatment: 3.6 million gallons per day (MGD) (current maximum daily discharge rate from SD001)
- NCCW/stormwater: 4.7 MGD (current maximum daily discharge rate from SD002)

These flows produce a combined conceptual treatment design flow of 8.3 MGD.

2.2 Conceptual Design Influent Water Quality

3M monitors water quality (PFAS and general chemistry) at multiple locations within the Facility. Figure 2-1 shows sampling locations relevant to this Plan, which include:

- N01: Phase 1/2 GAC effluent
- N02: Phase 1/2 GAC influent
- N06: Phase 3 GAC effluent
- N07: Phase 3 GAC influent
- E01: Wastewater Carbon System combined effluent – Outfall SD001
    - The Wastewater Carbon System provides polishing treatment for Phase 1/2 and Phase 3 wastewater.
- E02: NCCW/stormwater effluent – Outfall SD002

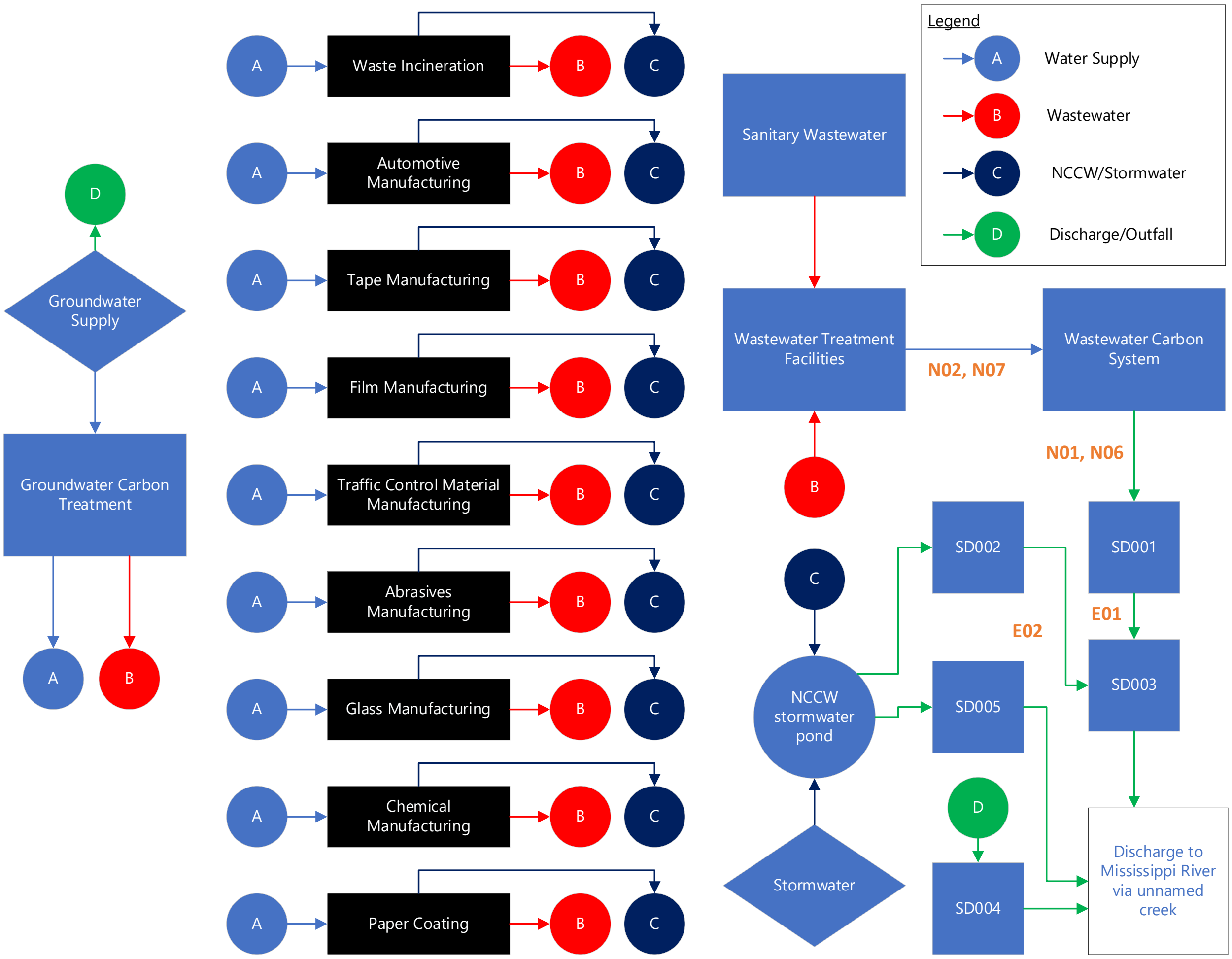

Figure 2-1 Facility Process Water Quality Locations Relevant to Conceptual Design Influent Water Quality

2.2.1 Influent PFAS Concentrations

To evaluate PFAS treatment alternatives, Barr summarized data from the following locations to provide representative influent PFAS concentrations:

- E01: Wastewater Carbon System combined effluent – Outfall SD001
- E02: NCCW/stormwater effluent – Outfall SD002

Table 2-1 contains a summary of the estimated influent PFAS concentrations from April 2020 through January 2021 and from a single sample event on February 23, 2021, based on a flow-weighted average of data collected by 3M from SD001 and SD002. This conceptual treatment location assumes that the existing Wastewater Carbon System for Phases 1/2 and 3 remains in service.

Table 2-1 SD001 and SD002 PFAS Concentrations (all in ng/L or parts per trillion)

PFAS Abbreviation	Observation[1] or Estimated Average[2]			Max Observed		
	SD001	SD002	Combined[3]	SD001	SD002	Combined[3]
TFA	17,585	3,720	10,396	288,000	11,100	131,201
TFMS	18,931	3,268	10,809	91,300	5,780	42,873
TFMS lithium salt[4]	--	--	--	--	--	--
2,2,3,3-TFPA	1,848	<1,000	3,482	9,880	<1,000	4,852
2,3,3,3-TFPA	2,861	<5,000	3,970	11,100	<5,000	7,646
PFPA	237,063	6,035	117,271	4,430,000	15,900	1,930,449
PFES	478	72	267	2,370	96	1,082
HQ-115	1,159	14,375	8,012	33,400	501,000	298,186
PFBA	56,668	7,350	31,095	391,000	13,800	177,405
PIBA	234	240	237	133	236	191
PFPeA	110	180	147	636	466	540
PFBSi[5]	<20	<20	<20	<20	<20	<20
FBSA[4]	--	--	--	--	--	--
PFBS	103	222	164	110	834	520
FBSE	<50	<50	<50	<50	<50	<50
MeFBSAA	<20	20	<20	<20	25	23
PBSA	<40	<40	<40	<40	<40	<40
FBSEE Diol	<20.2	22	21	<20.2	108	70
FBSEE-DA	<20	<20	<20	<20	<20	<20
FBSAA	<200	<200	<200	<200	<200	<200
PFHxA	29	137	85	39	533	319
HFPO-DA	<199	<199	<199	<199	<199	<199
PFHpA	<25	51	39	<25	226	139
PFHxS	44	321	188	156	1,950	1,172
PFOA	44	366	211	182	2,390	1,432
PFNA[1]	<3.8	<3.6	< 3.8	--	--	--
PFOSA	32	34	33	74	62	67
PFOS[6]	24	77	52	36	459	276
PFDA[1]	<3.8	<3.6	< 3.8	--	--	--
PFUnA[1]	<3.8	<3.6	< 3.8	--	--	--

PFAS Abbreviation	Observation(1) or Estimated Average(2)			Max Observed		
	SD001	SD002	Combined(3)	SD001	SD002	Combined(3)
PFDoA(1)	<3.8	<3.6	< 3.8	--	--	--
PFTrDA(1)	<3.8	<3.6	< 3.8	--	--	--

(1) For compounds with only one measurement, collected on February 23, 2021, that observation is listed here and no maximum is shown.
(2) PFAS results below the reporting limit were assumed to be equal to the reporting limit for this averaging exercise and calculation.
(3) Combined influent design concentrations are flow-weighted averages, using the flows and concentrations from SD001 and SD002.
(4) Data were not available for the following PFAS listed as monitoring parameters: TFMS lithium salt, FBSA.
(5) Two chemical names were provided by MPCA for the abbreviation PFBSi. Based on publically available information, these two chemical names refer to the same PFAS structure.
(6) MPCA-proposed intervention limits to comply with the current site-specific criteria for PFOS of 0.05 ng/L are 7 ng/L (calendar month average) and 14 ng/L (daily maximum).

2.2.2 Other Water Quality Considerations

Table 2-2 contains a summary of general chemistry water quality at SD001 (sampling location E01) and SD002 (E02). Generally, water flowing to SD001 and SD002 has an alkalinity of 200 to 250 mg/L as $CaCO_3$ with chemical oxygen demand (COD) less than 50 mg/L. Concentrations of metal foulants like iron and manganese are less than 0.05 mg/L, with average sulfate concentrations in the range of 27 to 140 mg/L and average nitrate concentrations ranging from 7 to 30 mg/L.

Table 2-2 SD001 and SD002 General Chemistry Water Quality and Estimated Combined Treatment Alternative Influent

Parameter(1)	Units	SD001	SD002	Combined Influent(3)
Conceptual design flow	MGD	3.6	4.7	8.3
Biochemical oxygen demand (BOD), maximum	mg/L	< 6.0	7.2	NA
BOD, average	mg/L	NA	0.53	NA
Total suspended solids (TSS), maximum	mg/L	34	27	30
TSS, average	mg/L	1.1	1.4	1.2
Ammonia, maximum	mg/L	0.45	< 0.10	NA
Ammonia, average	mg/L	NA	NA	NA
Number of samples	--	1-1,553	1-222	--
Parameter(2)	**Units**	**SD001**	**SD002**	**Combined Influent(3)**
Total dissolved solids (TDS)	mg/L	905	409	624
Chemical oxygen demand (COD)	mg/L	<50	<50	<50
Sodium (Na)	mg/L	214	346	289
Calcium (Ca)	mg/L	54	81	69
Magnesium (Mg)	mg/L	22	28	25
Potassium (K)	mg/L	57	3	26
Iron (Fe)	mg/L	<0.05	<0.05	<0.05
Manganese (Mn)	mg/L	0.005	0.003	0.004
Barium (Ba)	mg/L	0.052	0.045	0.048
Sulfate (SO_4)	mg/L	140	27	76
Chloride (Cl)	mg/L	127	64	92
Ammonia (NH_3-N)	mg/L	0.45	<0.1	0.2
Nitrate (NO_3-N)	mg/L	29	7.8	17
pH	SU	8.4	8.2	8.3
Alkalinity	mg/L as $CaCO_3$	248	226	236
Number of samples	--	1	1	--

NA = not available
(1) BOD, TSS, and ammonia data from recent EPA Form 2C entries for SD001 and SD002.
(2) Other water quality data from February 2021 sampling event.
(3) Barr calculated combined influent water quality estimates as flow-weighted averages of the conceptual design flow rates.

2.3 PFAS Characteristics and Groupings

3M is required to monitor for the presence of additional PFAS in its SD001 and SD002 discharges on a monthly basis. The complete list of PFAS monitored monthly at these locations is provided in Large Table 1. To consider treatment effectiveness, Barr organized these constituents into three groups based on molecular weights, the number of fluorinated carbons, and log K_{ow} values (also referred to as log P). The three groups of PFAS are summarized in Table 2-3 and detailed in Large Table 1. Log K_{ow} is the partition coefficient of a chemical between two liquid phases (n-octanol and water) in one system and is used as an indicator of a chemical's hydrophobicity and hence used here as a proxy for potential GAC and anion exchange (AIX) removal efficiency. Because removal efficiencies by treatment technology are not known for each individual PFAS, for this Plan, literature-based removal efficiencies for specific PFAS with known removal efficiencies have been assumed to apply to the entire respective group.

Table 2-3 Summary of Characteristics for PFAS Groupings

Group	Total Carbons	Fluorinated Carbons	Molecular Weight Range (g/mol)	Boiling Point Range (degrees C)	Log K_{ow} Range	Example PFAS
1	1–5	1–4	114–281	72–287	-2.6 to 2.8	PFBA, PFPA, TFA
2	4–9	4–7	284–414	115–339	1.8 to 3.8	PFBS, PFHxS, PFOA
3	8–13	8–12	464–664	194–286	5.8 to 8.2	PFOS

3 Identification of Feasible PFAS Treatment Technologies

Barr employed a threshold screening process to select the most promising technologies for potential application at the Facility. Technologies retained from this screening process include both primary and secondary treatment technologies. Primary technologies are those that would be applied to treat the total conceptual design flow rate. Secondary technologies would treat residual media or concentrate streams.

This section provides a brief description of each of the retained technologies, including a preliminary estimate of removal efficiencies by PFAS group (as described in Table 2-3). The estimate provides the basis for identifying potential treatment alternatives (Section 4).

3.1 Threshold Screening

Barr identified several potentially feasible PFAS water treatment technologies through a review of recently published literature, communication with treatment technology vendors, and first-hand engineering experience with the treatment of PFAS-impacted water at similar facilities. These technologies were initially screened for potential application at the Facility using the two threshold criteria:

1. Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale).
2. Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers.

These criteria were selected to separate potentially viable technologies from those not expected to meet applicable effluent water quality requirements due to limitations in performance, reliability, or scalability.

Large Table 2 provides a brief description and threshold screening outcomes for each technology. Technologies meeting both threshold criteria include:

1. Granular activated carbon
2. Anion exchange resin (both single-use and regenerable)
3. Membrane separation (reverse osmosis or nanofiltration)

Following threshold screening, retained technologies also included thermal evaporation with crystallization as a potential secondary treatment technology to manage concentrate from membrane separation. Similarly, incineration was retained as a potential management option for exhausted sorption media or the concentrate from regeneration of anion exchange media. Section 3.2 includes an evaluation of these technologies.

3.2 Treatment Technology Evaluation

The following sections provide a high-level evaluation of each treatment technology passing the threshold screening.

3.2.1 Granular Activated Carbon

GAC removes PFAS from water via a mass-transfer process in which PFAS partitions to the GAC surface due to hydrophobic/van der Waals interactions. Sorption of PFAS is a function of several factors, including loading rates (i.e., water flow and concentration), PFAS chain length and functional groups, water chemistry characteristics (e.g., dissolved organic carbon concentration), and time in operation. The mass loading onto GAC increases with higher influent concentrations and lower flow rates. Removal efficiency for GAC declines with time as sorption sites become occupied. For loading of mixtures of chemical constituents, chemicals with greater affinity for sorption may displace loosely bound chemicals. For example, PFAS with long carbon chains (greater than four carbons) and sulfonate functional groups tend to be sorbed more efficiently and displace PFAS with short carbon chains (four carbons or less) and carboxylic acid functional groups from GAC.

GAC, alone, is a non-destructive technology. PFAS that are sorbed to GAC and removed from water retain their original structure and, as noted above, can be displaced from the GAC by other chemicals. GAC can then be reactivated, incinerated, or disposed of in a permitted landfill. Reactivation removes the PFAS for thermal destruction (similar to incineration) in the gas phase, while the GAC is retained and can be used again to treat water. Incineration of the GAC destroys both the media and the sorbed chemicals.

GAC is a mature, field-demonstrated technology for PFAS water treatment. GAC media specifications for PFAS treatment can be variable by site and supplier; typically, reagglomerated bituminous coal-based GAC is used (screened to 12x40 or 8x30 mesh). GAC is typically applied in down-flow, fixed-bed pressure vessels in series, using a lead-lag configuration (i.e., two equally sized vessels in-series). Vessels are sized to achieve a target empty-bed contact time (EBCT) in the range of 7 to 20 minutes with a hydraulic loading rate (HLR) ranging from 1 to 10 gallons per minute per square foot (gpm/ft^2) (ITRC 2020, Ross et al. 2018). GAC treatment is typically operated until a designated concentration threshold is observed between the lead and lag vessels. Once this threshold is observed, the lead vessel is taken out of service, and the GAC media is exchanged for virgin or reactivated media.

GAC is retained in the detailed treatment alternatives screening because it is a mature and scalable PFAS water treatment technology currently used at the Facility. For this Plan, additional GAC would be used to treat the combined flow from SD001 and SD002 to meet existing and potentially applicable effluent and water quality requirements for the next 20 years. GAC is also retained as a potential option for concentrate management from membrane treatment.

3.2.2 Anion Exchange Resin

Anion exchange (AIX) resin removes PFAS from water via electrostatic interactions between the charged functional group of the PFAS (negatively charged) and the AIX functional group (positively charged). Hydrophobic interactions also occur between the fluorinated carbon chains and the polystyrene resin support. Removal efficiencies of specific PFAS with AIX treatment depend on several factors, including loading rates (i.e., water flow and concentration), PFAS chain length and functional groups, water chemistry characteristics (e.g., dissolved organic carbon and competing ion concentrations), and time in operation. Removal efficiency declines with time as sorption sites become occupied. PFAS with long carbon chains (greater than four carbons) and sulfonate functional groups tend to be removed more efficiently by AIX than PFAS with short carbon chains (four carbons or less) and carboxylic acid functional groups. Compared to GAC, AIX resins typically have higher removal efficiencies and throughput for short-chain PFAS.

Like GAC, AIX alone is a non-destructive technology and can be applied in regenerable or single-use applications. Regenerable applications allow PFAS that are exchanged onto the AIX resin to be removed into a concentrated stream using a brine/solvent solution. Options for on-site media regeneration are commercially available and may be a viable Facility option at the conceptual design flow rate. The concentrated stream removed during the regeneration process would subsequently be incinerated directly or treated with a smaller volume of media for indirect incineration or landfilling of the media. The regeneration solution could then be reused for subsequent regeneration processes. Alternatively, the AIX resin can be incinerated with the PFAS in lieu of regeneration or disposed of in a permitted landfill.

The application of AIX for PFAS water treatment is gaining in popularity and is a demonstrated, effective alternative to GAC. AIX resins for PFAS treatment are typically strong base, anion exchange resins with quaternary amine functional groups made from a polystyrene support. Like GAC, AIX resin is typically applied in down-flow, fixed-bed pressure vessels in a lead-lag configuration. AIX resin treatment systems typically have a smaller footprint than GAC treatment systems sized for equivalent flow because the targeted EBCT is shorter (2–5 minutes), and HLRs are higher (6–12 gallons per minute per square foot) (ITRC 2020). AIX treatment is typically operated until a designated concentration threshold has been observed between the lead and lag vessels. Once this threshold is observed, the lead vessel is taken out of service, and the AIX resin is exchanged for virgin media or regenerated (as described above).

AIX is retained in the detailed treatment alternatives screening as an alternative to GAC treatment because it is an effective, field-demonstrated technology, particularly for short-chain PFAS. It is also retained as a potential option for management of concentrate from membrane treatment and condensate from thermal evaporators.

3.2.3 Membrane Separation

Membrane separation technologies physically separate PFAS from the primary water stream by applying high pressure to drive water through a semi-permeable membrane, generating a clean permeate. PFAS are retained (along with other dissolved constituents) with a fraction of the influent water by the semi-permeable membrane as a concentrated brine. PFAS and dissolved constituents are retained by size-exclusion (i.e., pore sizes are smaller than the ions and molecules retained) and hindered diffusion through the membrane pores. Membrane recovery, or the percentage of water recovered as permeate, can vary depending on water chemistry characteristics (especially for foulants/scalants) and equipment (the membrane type and configuration) but typically varies between 50–95%.

Two types of membrane separation technologies have been successfully applied for PFAS water treatment: reverse osmosis (RO) and nanofiltration (NF). These two technologies use pressure to push water through a membrane, with RO membranes operating at higher pressures than NF membranes. Rejection of solutes within the water by membranes is primarily a function of size exclusion, with RO membranes generally having the smallest pore sizes. RO membranes retain monovalent ions (such as chloride) with an approximate nominal molecular weight range of up to 100 daltons (equivalent to g/mol). In contrast, NF membranes have slightly larger pore sizes that allow monovalent ions to pass through into the permeate while retaining divalent ions (such as sulfate) with an approximate nominal molecular weight range of 100 to 300 daltons. Manufacturers of both RO and NF membranes may also modify the chemistry of the active layer, for example, the hydrophobicity, to improve the passage of water at lower pressures while improving the rejection of specific solutes.

The degree of PFAS retention across membranes depends, in part, on the size and charge of the PFAS. In general, both membrane separation technologies can be effective for concentrating a broad range of PFAS (Appleman 2013; Soriano 2019; Franke 2019). Actual, site-specific rejection efficiencies for specific PFAS groups will be dependent on water chemistry characteristics (pH, temperature, ionic strength) as well as membrane type and operating conditions (cross-membrane pressure, flow velocity).

Membrane separation technologies (RO and NF) have been retained in the advanced water treatment screening evaluation as alternatives to GAC because they are effective, field-demonstrated technologies for PFAS treatment.

The concentrated waste stream from membrane separation requires additional management. For this evaluation, three management strategies are combined with membrane separation: GAC treatment, AIX treatment, and thermal evaporation with crystallization.

3.2.4 Thermal Evaporation/Crystallization

In a thermal evaporator, heat is applied to remove most of the water (up to the water's boiling temperature) from the liquid (concentrate) stream, leaving a slurry with a high solids content. Crystallization further removes water from a slurry producing a dry product that can be managed as a solid.

Thermal evaporation and crystallization are not destructive technologies for PFAS. Instead, the crystallized solids retain the PFAS compounds. A mist-eliminator system would be used to capture any PFAS that could potentially volatilize within the condensate during the evaporation and crystallization process.

Equipment options available for thermal evaporation and crystallization vary depending on flow rates, need for water recovery, waste heat availability, and final disposal considerations.

Barr has retained thermal evaporation and crystallization for evaluation as a secondary treatment for concentrated streams from membrane separation.

3.2.5 Incineration

Incineration is a process that applies high temperatures to thermally degrade PFAS. Reported temperatures required to degrade PFAS are typically near 1,000 degrees Celsius (USEPA 2020B, ITRC 2020). The efficacy of incineration for PFAS destruction is an active area of research—particularly to identify appropriate incinerator residence times that minimize or eliminate the formation of incomplete combustion products.

Barr retained incineration as an option for spent-media management from GAC or AIX treatment and for residual solids from membrane separation followed by thermal evaporation and crystallization of the concentrate stream.

4 Treatment Alternatives Descriptions

Based on the technologies evaluated in the threshold screening process (described in Section 3.1), Barr has developed six potentially feasible PFAS treatment alternatives for further evaluation. This section describes the six treatment alternatives, including a preliminary description of the process flow. These alternatives are carried through to the alternative screening process described in Section 5.

All six alternatives would treat a combined stream consisting of Wastewater Carbon System effluent routed to SD001 and NCCW/stormwater routed to SD002. For this analysis, we assumed that the existing Wastewater Carbon System would remain in service and operate with the same conditions and change-out frequency reflected between April 2020 and January 2021 (the period when PFAS sampling data was evaluated). This assumption was made to provide a consistent basis for alternatives evaluation. Other locations for treatment may be considered during design of the preferred alternative identified from this evaluation. We describe the six alternatives in the following sections.

4.1 Alternative 1 – Modified GAC

In this alternative scenario, the combined SD001 and SD002 flow would be routed through additional GAC-filled pressure vessels, similar to the existing Wastewater Carbon System. Figure 4-1 shows a simple block flow diagram for this alternative.

Figure 4-1 Block Flow Diagram for Alternative 1 – Modified GAC

Breakthrough of short-chain, Group 1 PFAS will likely limit GAC performance in this application because they are present in high concentrations relative to the other PFAS of interest and does not sorb strongly to GAC, and can be outcompeted for sorption sites by other, more strongly sorbing compounds like TOC and longer-chain PFAS. PFBA is the Group 1 PFAS with the most consistent historical monitoring data, and serves as a proxy for Group 1 PFAS. Given the high concentrations of PFBA in effluent from the existing Wastewater Carbon System, Alternative 1 GAC treatment operations would require more vessels and shorter change-out frequencies than current operations to consistently remove PFBA. GAC performance and change-out frequency will depend on future treatment requirements as well as the extent and frequency of this variation. Exhausted GAC would be managed via incineration or reactivation.

4.2 Alternative 2 – AIX

In this alternative scenario, the combined SD001 and SD002 flow would be routed through AIX-filled pressure vessels. Figure 4-2 shows a simple block flow diagram for this alternative.

Figure 4-2 Block Flow Diagram for Alternative 2 – AIX

Like Alternative 1, PFBA, as the representative of Group 1 PFAS, breakthrough will likely determine AIX performance because it is present in high concentrations relative to the other PFAS of interest. AIX has a slightly higher affinity for short-chain PFAS than does GAC and is subsequently expected to use less media than GAC. The equipment footprint is also expected to be smaller than for GAC because of the lower EBCT design value. Exhausted AIX resin would be incinerated. On-site media regeneration for this alternative may be considered at a later stage of evaluation and design.

4.3 Alternative 3 – NF with GAC

For this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using NF membranes. Concentrate from NF would be routed through GAC to remove PFAS. Most of the GAC- treated concentrate would be recirculated back to the membrane feed (total NF design flow of 11.9 MGD). The advantage of this option over Alternative 1 (GAC only) is the anticipated increase in media sorption capacity in treating more concentrated streams (Franke, 2019). This has the potential to decrease media use rates by a factor of 1.5 to 2.0. Figure 4-3 shows a simple block flow diagram for this alternative.

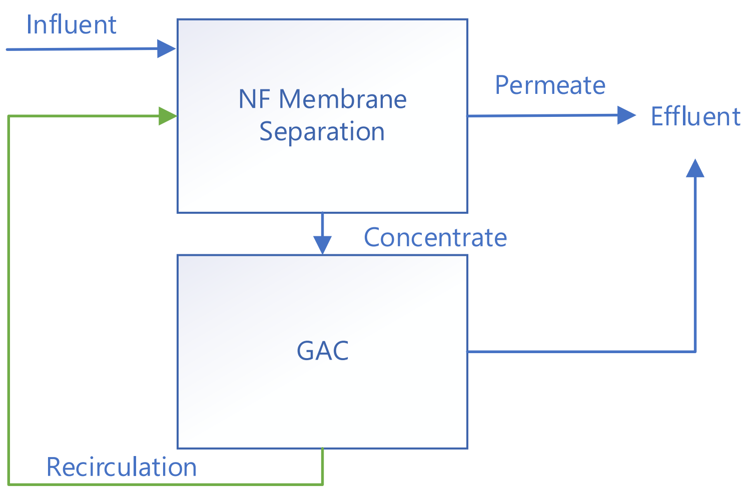

Figure 4-3 Block Flow Diagram for Alternative 3 – NF with GAC

NF membranes were selected over RO for this alternative to allow monovalent salts to pass through to the permeate, limiting their upcycling in the treatment loop. A small portion of the GAC effluent (likely 5%–25%) would need to be removed from the recycle loop and discharged as effluent to control upcycling of polyvalent salts in the treatment loop or would need to be treated using thermal evaporation if the concentrations of PFAS in the GAC effluent result in concentrations above discharge limits for the blended effluent. We assumed an NF recovery of 70%, meaning that 3M would route 75% of the NF feed to permeate and 25% to concentrate and GAC adsorption. This is lower recovery than the RO alternatives described below because NF is expected to see higher concentrations of mineral foulants as a result of concentrate recycling.

Because the PFAS concentrations in the concentrate stream will be higher than in the primary influent stream, the GAC vessels would be sized and operated with an extended EBCT to maximize sorption and removal of PFAS. This could potentially decrease the GAC usage rate by a factor of about two (Franke, 2019). Exhausted GAC would be managed via incineration or reactivation.

4.4 Alternative 4 – Two-Stage RO with Thermal Evaporation/Crystallization

In this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using RO membranes. This evaluation assumed an overall recovery of 95% for two-stage RO, meaning that 95% of the influent flow would become treated permeate, while 5% would become concentrate routed to thermal evaporation and crystallization for additional treatment. None of the treated concentrate would need to be returned to the membrane separation process.

The solids in the concentrate, including the PFAS compounds, would be converted to a solid phase for disposal in the thermal evaporation/crystallization process. Water vapor from the thermal evaporation and crystallization process would be recaptured as condensate, which allows some heat recovery and decreases energy usage. Condensate would be blended with the RO permeate for discharge. This evaluation assumes that all PFAS remain in the solid or liquid phase through thermal evaporation and are not routed to condensate. Figure 4-4 shows a simple block flow diagram for this alternative.

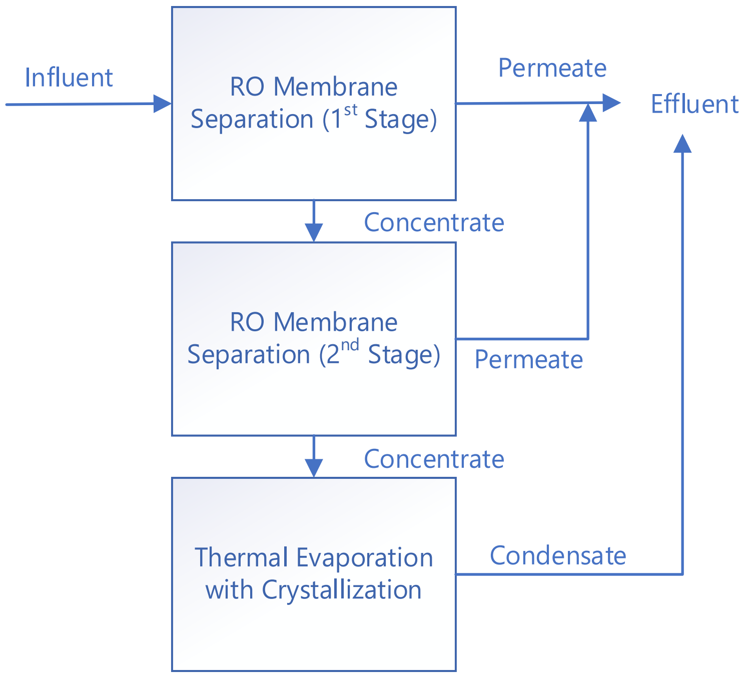

Figure 4-4 Block Flow Diagram for Alternative 4 – Two-Stage RO with Thermal Evaporation/Crystallization

4.5 Alternative 5 – RO with AIX

For this alternative scenario, the combined SD001 and SD002 flow would be routed through membrane separation using RO membranes. Concentrate would be routed through AIX to remove PFAS and then combined with permeate for discharge. This evaluation assumed an overall recovery of 85% for RO, meaning that 85% of the RO feed would be routed to permeate, and 15% would be routed to concentrate and AIX treatment. The advantage of this option over Alternative 2 (single-use AIX only) is the anticipated increase in media sorption capacity in treating more concentrated streams (Franke, 2019). This has the potential to decrease media use rates by a factor of two to three. Figure 4-5 shows a simple block flow diagram of this alternative.

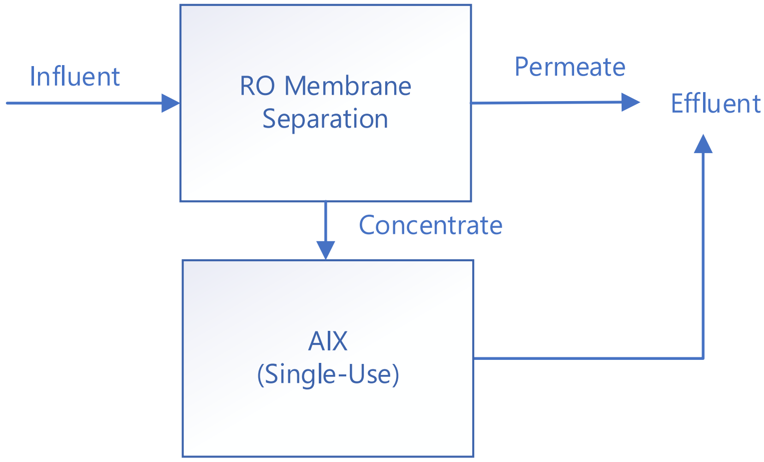

Figure 4-5 Block Flow Diagram for Alternative 5 – RO with AIX

The AIX process would be operated with an extended EBCT to improve sorption of Group 1 PFAS. As a result of the extended EBCT, the resin usage rate for this alternative is expected to be lower than for the primary AIX treatment in Alternative 2 by a factor of about three (Franke, 2019). Exhausted AIX resin would be incinerated. On-site media regeneration for this alternative may be an option for consideration at a later stage of evaluation and design.

4.6 Alternative 6 – Two-Stage RO with AIX

This alternative is a combination of the two-stage RO process introduced with Alternative 4 and the AIX concentrate treatment introduced with Alternative 5. Assuming an overall RO recovery of 95%, only 5% of flow would be routed to AIX for concentrate treatment. The AIX process would be operated with a further extended EBCT with resin usage rate estimated at four times lower than for the primary AIX treatment in Alternative 2. Similar to Alternative 5, incineration of exhausted single-use AIX resin was assumed, but as on-site media regeneration may be considered in the future. Figure 4-6 shows a simple block flow diagram of this alternative.

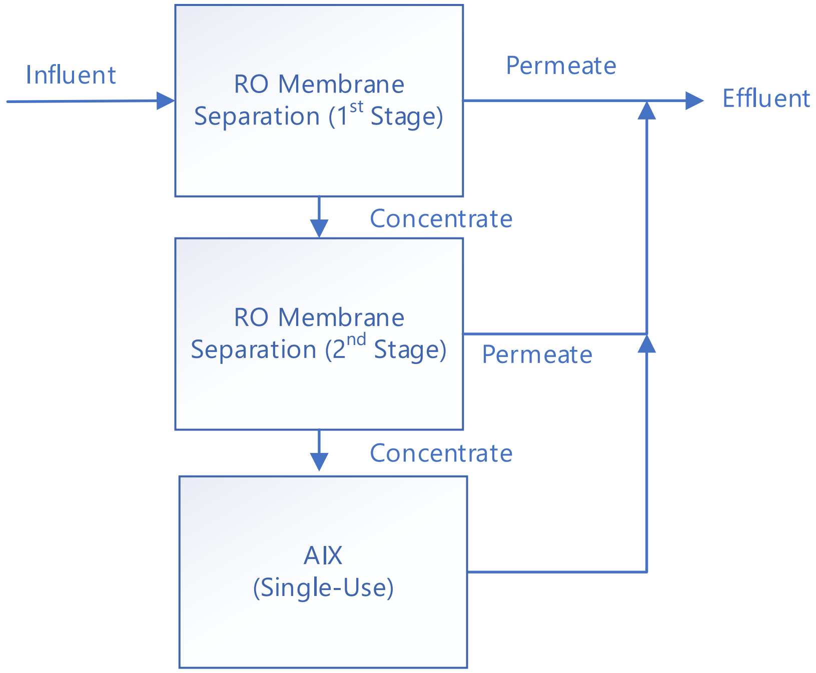

Figure 4-6 Block Flow Diagram for Alternative 6 – Two-Stage RO with AIX

5 Treatment Alternatives Screening

Barr conducted a detailed screening of the six treatment alternatives described in Section 4, using the criteria and sub-criteria as set forth below:

- Technical feasibility
    - Group 1 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
    - Group 2 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
    - Group 3 PFAS removal efficiency (removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes)
    - General complexity of operation and maintenance of primary technology
    - Operator and public health risks
- Economic feasibility
    - Capital costs for primary technology (and secondary technology, where applicable)
    - Operations and maintenance (O&M) costs for primary technology (and secondary technology, where applicable)
- Energy consumption
    - Energy consumption of primary technology (and secondary technology, where applicable)
- Potential for media shifting of pollutants
    - Relative quantity of residuals generated

Barr screened the treatment alternatives using the following steps:

1. Barr weighed each sub-criteria on a scale of 1 to 4, with 4 indicating the highest importance.
2. Barr ranked each alternative for each sub-criteria on a scale of 1 to 3, with 3 as the most favorable ranking.
3. Barr determined alternative rankings for each criteria category based on the weighted sum of sub-criteria rankings.
4. Barr added up rankings for each criteria category to determine overall rankings for each alternative.

Ten State standards and other design requirements are deemed to be similar for all scenarios and would not affect the relative evaluation of the different alternatives. Large Table 3 summarizes the treatment alternative screening process and outcomes. The following sections highlight details for each screening criteria.

5.1 Technical Feasibility

Table 5-1 summarizes estimated removal efficiencies for the three primary treatment technologies included in the alternatives for each of the three PFAS groups (refer to Table 2-3 for descriptions of the PFAS groups). Removal efficiencies are based on a combination of literature values as well as observations from data collected during operation of existing GAC at the Facility for polishing of Phase 1/2 and Phase 3 wastewater. Barr used these removal efficiencies to rank the technical feasibility of the treatment alternatives.

PFAS removal efficiencies for GAC and AIX are typically high with new, virgin media, but removal efficiencies decrease over time as sorption sites are exhausted and breakthrough occurs. Thus, removal efficiency is a function of how long media has been in service. Operational settings, such as EBCT, media specifications, and hydraulic loading rate, also affect removal efficiency. Removal efficiencies shown in Table 5-1 are based on literature references and engineering judgment, and would change significantly for GAC and AIX during the course of media bed life. To account for diminished performance with service life, the values shown for GAC and AIX reflect estimated removal efficiencies after treatment of 5,000 bed volumes with an EBCT of approximately 5 minutes. Note that Barr does not expect the removal efficiencies (i.e., rejection efficiency) for the membrane treatment alternative to change with service time. This exercise is intended to compare relative removal efficiency of the treatment technologies. It is not predictive of actual performance at the Facility. Facility-specific breakthrough characteristics and removal efficiencies should be examined at a later stage of evaluation.

Observed PFBA (Group 1 PFAS) removal efficiencies for existing GAC systems at the Facility after approximately 5,000 bed volumes were about 20% to 30% for Phase 1/2 treatment and ranged from -150% to 50% for Phase 3 treatment, likely due to the large variations in influent PFAS. Other PFAS were not measured in the GAC effluent past the first 2,500 bed volumes.

Table 5-1 Estimated Removal Efficiencies of Primary Treatment Technologies by PFAS Group

Technology	Group 1 PFAS (including PFBA)	Group 2 PFAS (including PFBS, PFHxS, and PFOA)	Group 3 PFAS (including PFOS)	References
GAC (5,000 bed volumes)	0–60%(1)	40–75%	60–90%	(Franke 2019) (Woodard 2017)
AIX (5,000 bed volumes)	40–90%	65–99%	90–99%	(Franke 2019) (Woodard 2017)
RO	80-99%	75-99%	95–99%	(Appleman 2014) (ITRC 2020) (Soriano 2019)
NF(2)	25-90%	50-95%	80-95%	(Appleman 2013) (ITRC 2020) (Franke 2019) (Soriano 2019)

(1) PFBA removal across the Facility's existing Wastewater Carbon System is about 38% at 5,000 bed volumes for Phase 1/2 GAC treatment.
(2) Publicly available data for NF rejections of PFAS are limited, especially for group 1 PFAS. Ranges shown are based on available literature data and engineering judgment.

Using these estimated removal efficiencies and the influent PFAS concentrations, the technical feasibility of each alternative was ranked and scored in Large Table 3. Generally, RO scored slightly better than NF while AIX scored better than GAC, with the differences in removal efficiencies for Group 1 PFAS, providing the primary differentiator for technical effectiveness between the alternatives.

5.2 Economic Feasibility

Barr developed Class 5 capital and operating costs with an accuracy range of –50% to +100% to support technology screening. To size the conceptual GAC and AIX treatment systems for Alternatives 1–5, assumptions listed in Table 5-2 were made. In all cases, we assumed that vessels would operate in a lead/lag configuration. Note that the throughputs presented are meant only to facilitate conceptual treatment alternative equipment sizing and operational costs; they should not be interpreted as actual throughput values for the Facility. Note that Barr sized all treatment alternatives assuming they would follow the existing Wastewater Carbon System, which provides 40–45 minutes of GAC EBCT at the maximum flow rate through the existing system of 2.8 MGD.

Table 5-2 Conceptual Design Assumptions for GAC and AIX Sizing

Assumed Parameter	Units	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Primary treatment technology	--	GAC	AIX	NF	Two-stage RO	One-stage RO	Two-stage RO
Media type	--	GAC	AIX	GAC	None	AIX	AIX
Media vessel sizing to support capital costs							
Maximum flow to primary treatment	MGD	8.3	8.3	11.9(1)	10.0(1)	8.3	10.0(1)
Overall membrane recovery	%	--	--	70%	95%	85%	95%
Maximum flow to media	MGD	8.3	8.3	3.6	0.4 to TE/C	1.2	0.4
Total EBCT at the maximum flow(2)	minutes	20(5)	10(6)	40(7)	--	20(8)	45(9)
Breakthrough estimates to support operating costs							
Average flow to media(1)	MGD	5.4	5.4	2.3	0.4 to TE/C	0.8	0.3
Throughput at the average flow(3)	m^3/kg	8(5)	9.8(6)	4.8(7)	--	4.4(8)	2.0(9)
Time to lead vessel change-out(4)	days	49	37	58	--	66	66
Media use rate	lb of media per month	170,000	140,000	120,000	--	47,000	35,000
Media use rate	m^3 of media per month	137	91	98	--	30	23

(1) Membrane separation feed flows for Alternatives 3, 4, and 6 consider total flows routed to membranes. For Alternative 3, this reflects steady-state flows including recycle of GAC effluent. For Alternatives 4 and 6, this includes feed to first-pass membranes as well as to second-pass membranes.

(2) Total EBCT is the EBCT of both the lead and lag vessels (divide by two for the EBCT per vessel). The EBCT is used to estimate the number of vessels needed.

(3) The throughput is an estimate of the volume of water that can be passed through media before PFBA (proxy for Group 1 PFAS) breakthrough occurs. The value used for Alternative 1 is based on an EPA review study (Burckhart et al., 2019), and calculation of subsequent values are described below in separate table footnotes. These values were used to estimate relative media use rates for the different alternatives to support operating cost comparisons, and should be updated when water treatment targets are established. Treatability testing should be conducted to establish site-specific throughput values prior to detailed project planning.

(4) The time to lead vessel change-out is based on the estimated throughput.

(5) For Alternative 1, Barr estimated the total EBCT from the industry standard (10 minutes per vessel) and the throughput from Burckhart et al. (2019) for PFBA breakthrough.

(6) For Alternative 2, Barr estimated the total EBCT for AIX to be one-half the EBCT required for vessels in Alternative 1 (based on data presented in Woodard et al. (2017)) and the throughput to be 50% longer (a factor of 1.5) for a given volume of media. We assumed a bulk media density of 0.57 kg/L for GAC and 0.7 kg/L for AIX, so the throughput increased by a factor of 1.5×0.57/0.7.

(7) For Alternative 3, Barr estimated the total EBCT to be two times the EBCT for vessels in Alternative 1 to maximize PFAS sorption. The mass of PFAS removed per mass of media is estimated to be twice that of Alternative 1 (Franke 2019). However, the same PFAS mass is distributed in 30% as much water as in Alternative 1 (i.e., the PFAS is concentrated up, assuming 70% water recovery from NF). Thus, the throughput of water (m^3 of water per kg of media) for Alternative 3 changes by a factor of 2×0.3.

(8) For Alternative 5, Barr estimated the total EBCT to be two times the EBCT of vessels in Alternative 2 to maximize PFAS sorption. We estimated the mass of PFAS removed per mass of media to be three times that of Alternative 2 (Franke 2019). However, the same PFAS mass is distributed in 15% as much water as in Alternative 2 (i.e., the PFAS is concentrated up assuming 85% water recovery from RO). Thus, the throughput of water (m^3 of water per kg of media) changes by a factor of 3×0.15.

(9) For Alternative 6, Barr estimated the total EBCT to be four and a half times the EBCT of vessels in Alternative 2 to maximize PFAS sorption. We estimated the mass of PFAS removed per mass of media to be four times that of Alternative 2. However, the same PFAS mass is distributed in 5% as much water as in Alternative 2 (i.e., the PFAS is concentrated up assuming 95% overall water recovery from RO). Thus, the throughput of water (m^3 of water per kg of media) changes by a factor of 4×0.05.

The reduction of PFAS into a smaller volume using NF or RO in Alternatives 3 through 6 reduces the volume of flow to the secondary treatment processes, but assumptions of increased residence time requirements offset the effect of this reduction on equipment sizing. Similarly, the increased PFAS concentrations in the flows to secondary treatment processes were assumed to decrease the relative media usage rates (i.e., increased mass of PFAS adsorbed per mass of media) based on recent studies reporting increases in mass loading to GAC and AIX from NF concentrate (Franke, 2019; Franke, 2021). These studies were conducted at lower PFAS concentrations and a smaller range of concentration ratios; actual media usage rates should be determined during piloting.

Costs for each alternative are scored in Large Table 3 using separately weighted scales for both capital and operating costs. Capital costs are weighted higher than operating costs because they occur immediately, while operating costs can potentially be optimized or improved over the life of a project. The bases for capital and operating costs for the alternatives are described separately in the following paragraphs.

5.2.1 Capital Cost Estimates

Barr developed capital cost estimates for the six alternatives using the conceptual design flows indicated in Table 5-2. Costs are Class 5 ranges based on previous project experience. Cost estimating focused on the treatment systems and related buildings and control systems. For this evaluation, Barr did not include ancillary items needed to complete installation of an alternative but deemed similar for all scenarios and would not affect the relative costs of alternatives.

NF recovery for Alternative 3 was assumed to be 70%, RO recovery for Alternatives 4 and 6 was assumed to be 95%, and RO recovery for Alternative 5 was assumed to be 85%. While NF recovery is typically higher than RO recovery, the NF application in Alternative 3 will have more salt in the feed water than the RO application in Alternative 4 due to concentrate recycling. In Alternative 3, Barr sized the NF membrane separation for a total flow rate of 11.9 MGD, the calculated steady-state conceptual design flow rate, assuming 30% of the flow recycles to the front of the process after passing through GAC treatment.

For Alternatives 1-5, Barr estimated costs for GAC and AIX treatment equipment based on recent vendor quotes for similar systems using 20,000-pound GAC vessels and 420-cubic-foot AIX vessels. We also based cost estimates for RO, NF, and crystallization on previous vendor quotes for similar systems. Table 5-3 provides the capital cost estimate summary.

Table 5-3 Capital Cost Estimate Summary[(1)]

Alternative Number	1	2	3	4	5	6
Description	GAC	AIX (single use)	NF with GAC	Two-stage RO with TE/C	RO with AIX (single use)	Two-stage RO with AIX (single use)
Estimated capital cost range[(1)]	$14.8 - $59.2 MM	$12.9 - $51.4 MM	$27.4 - $109.6 MM	$53.6 - $214.4 MM	$17.2- $68.8 MM	$17.1-68.2 MM

TE/C = thermal evaporation/crystallization

(1) Capital costs are considered Class 5 estimates with an accuracy range of –50% to +100%. Costs are to design and construct each alternative.

5.2.2 Operating Cost Estimates

Barr developed operations and maintenance cost estimates for the six alternatives using the conceptual design flows indicated in Table 5-2. Costs are presented as Class 5 ranges based on previous project experience. We also assumed that media change-out would occur for lead vessels in a lead-lag arrangement, with lag vessels moved to lead position at the frequency indicated in Table 5-2. Table 5-4 provides the O&M cost estimate summary. These costs include building and equipment electricity, consumables such as RO chemicals, media replacement and disposal, salt residuals management, supply of RO membranes, and O&M labor, including operations and shift maintenance staff.

Table 5-4 Operations and Maintenance Cost Summary[(1)]

Alternative Number	1	2	3	4	5	6
Description	GAC	AIX (single use)	NF with GAC	Two-stage RO with TE/C	RO with AIX (single use)	Two-stage RO with AIX (single use)
Estimated annual O&M cost range[(1)]	$3.8 – $15.0 MM	$5.6 – $22.2 MM	$4.2 – $16.6 MM	$6.1 - $24.4 MM	$2.9 – $11.6 MM	$2.7-10.6 MM
O&M unit cost ($/1,000 gallons treated)	$2.48	$3.67	$2.75	$4.04	$1.92	$1.46

TE/C = thermal evaporation/crystallization

(1) O&M costs are considered Class 5 estimates with an accuracy range of –50% to +100%.

5.2.3 Cost Estimate Assumptions

The opinions of probable capital and O&M costs provided in this report are made based on Barr's experience and qualifications and represent our best judgment as experienced and qualified professionals familiar with the Facility. The cost opinions are based on Facility-related information available to Barr at this time and include a conceptual-level design of the alternatives. The opinions of cost may change as 3M completes further design. In addition, since we have no control over the cost of labor, materials, equipment, or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from the opinions of probable capital and O&M costs prepared by Barr. Barr can provide further accuracy in the opinions of probable capital and O&M cost with further design.

Barr has based this feasibility-level (Class 5, 0–2% design completion per ASTM E 2516-06) cost estimate on 1% designs, alignments, quantities, and unit prices. Costs will change with further design. We have not included time value-of-money escalation costs. Contingency is an allowance for the net sum of costs that will be in the final total cost for each alternative at the time of design completion but not included at this level of alternatives definition. The estimated accuracy range for the opinions of cost provided as the alternatives are defined is -50% to +100%. Barr has based the accuracy range on professional judgment considering the level of design completed, the complexity, and the uncertainties associated with each alternative. The accuracy range does not include costs for future scope changes that are not part of the conceptualized alternatives or risk contingency costs.

5.3 Energy Consumption

Table 5-5 outlines estimates for relative energy use for each alternative. The thermal evaporation and crystallization process requires the highest energy, whereas energy requirements for GAC and AIX should be considerably lower. The energy requirement for nanofiltration and reverse osmosis is higher when compared to GAC and AIX; however, lower than thermal evaporation and crystallization.

Table 5-5 Estimated Energy Consumption by Alternative

Alternative Number	1	2	3	4	5	6
Description	GAC	AIX (single use)	NF with GAC	Two-Stage RO with TE/C	RO with AIX (single use)	Two-Stage RO with AIX (single use)
Major energy uses	GAC incineration(1)	AIX resin incineration or regeneration(1)	NF high-pressure pumping, GAC incineration	RO high-pressure pumping, evaporation	RO high-pressure pumping, AIX resin incineration, or regeneration	RO high-pressure pumping, AIX resin incineration, or regeneration
Estimated annual total energy use (MWh)	100-400	100-200	3,000-12,000	23,000-89,000	2,000-8,000	3,000-10,000

(1) Alternatives 1 and 2 require pumping, although energy is assumed to be negligible compared to the cost of media management and the high-pressure pumping required for NF and RO.

5.4 Media Shifting of Pollutants

Barr considered the final fate of PFAS in each alternative to evaluate potential "media shifting" of PFAS, in which PFAS in the water phase shifts to another media. As shown in Table 5-6, PFAS in all alternatives are ultimately incinerated at temperatures high enough to be thermally destroyed.

Table 5-6 PFAS Fate and Media Shifting Potential by Alternative

Alternative Number	1	2	3	4	5	6
Description	GAC	AIX (single use)	NF with GAC	Two-Stage RO with TE/C	RO with AIX (single use)	Two-Stage RO with AIX (single use)
Final phase of PFAS	Spent GAC	Spent AIX resin	Spent GAC	Crystallizer salts	Spent AIX resin	Spent AIX resin
Media use rate (lbs per month)	170,000	140,000	120,000	--	47,000	35,000
Media use rate (m^3 per month)	137	91	98	--	30	23
Final fate of PFAS-containing residuals	Incineration or reactivation with incineration of gas (same as current GAC)	Incineration or landfilling	Incineration or reactivation with incineration of gas (same as current GAC)	Incineration or landfilling	Incineration or landfilling	Incineration or landfilling

6 PFAS Treatability Alternatives Summary

Screening efforts identified three primary treatment technologies that may effectively remove PFAS from water at the Facility based on demonstrated efficacy, scalability, and commercial availability. These technologies include:

- Granular activated carbon adsorption
- Anion exchange resin sorption
- Membrane separation (including both NF and RO)

Barr assembled six potential alternatives using these treatment technologies, alone or in combination, along with two secondary technologies (thermal evaporation/crystallization and incineration) that may be applicable for treating concentrated or residual streams generated by one or more of the primary technologies. Screening of the six potential treatment alternatives based on weighted criteria or effectiveness, cost, energy consumption, and media shifting revealed that while each alternative had unique advantages and disadvantages, the AIX-based alternatives may offer a better potential for success. These include Alternative 2 (single-use AIX), Alternative 5 (RO with single-use AIX for concentrate management), and Alternative 6 (two-pass RO with single-use AIX). Selection of AIX over GAC, with or without the addition of a membrane separation step, is predicated on better AIX performance for removal of the Group 1 PFAS, particularly PFBA, which is reported in recent literature (citation) and confirmed by ongoing testing performed by 3M.

When comparing Alternative 2 against Alternatives 5 and 6, the membrane separation process provides better separation of the PFAS from the treated effluent, while preconcentration of PFAS using membranes helps reduce the volume of AIX media needed for adsorption, based on the improved mass transfer onto the media at higher influent concentrations. The increased TDS loading to the sorptive media in the concentrate along with increased PFAS does not appear to reduce PFAS loading. Increased capital costs for RO separation ahead of AIX appear to be offset by decreased disposal and media replacement costs in less than 20 years.

When comparing Alternatives 5 and 6, the estimated capital and operating costs as well as scores for other project criteria are all the same. However, Alternative 6 has more remaining uncertainties, including uncertainties around the ability of RO to achieve 95% overall recovery, the achievable PFAS rejection at that higher recovery, and the degree of increased AIX performance achievable when treating concentrate.

3M will need to address several Facility-specific factors before followed by on-site pilot testing of AIX-based treatment, including the following steps:

- Assessing site-specific flows within the Facility to optimize treatment effectiveness and performance for existing and new treatment processes.

- Verifying the most appropriate location within the Facility for advanced PFAS water treatment based on water quality characteristics and PFAS loading.

- Performing pilot testing in collaboration with AIX vendor ECT2, per the workplan attached as Appendix A. Pilot testing should confirm the following design parameters and submitting the results of the study to the MPCA, pursuant to paragraph no. 18 of the NOV:

    - Flux rate and PFAS rejection performance to evaluate potential design loading rates for membrane separation from multiple membranes to evaluate site-specific performance

    - AIX design parameters:

        - Empty bed contact times
        - Hydraulic loading rates
        - Time to breakthrough for PFBA and other PFAS of interest

    - Performance of regenerable and non-regenerable ion exchange media

    - Impacts of site-specific general water quality characteristics (non-PFAS) on technology performance

3M will develop a schedule for addressing these uncertainties per the other complementary elements of the NOV and the existing NPDES/SDS Permit requirements for the Facility pending approval of this PFAS Treatability Alternatives Identification Plan. A proposed schedule and milestones for piloting, developed by 3M and ECT2, is outlined below, with submission of the Pilot Test Report on December 1, 2021.

	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
PFAS Treatability Plan Submission	■						
Pilot Work Plan Submission	■						
Pilot Fabrication/Installation	■						
Pilot Operation		■	■	■			
Pilot Analysis and Report			■	■	■	■	
Pilot Test Report Submission							■

7 References

Appleman, T.D.; Dickenson, E.R.V.; Bellona, C. Nanofiltration and granular activated carbon treatment of perfluoroalkyl acids. *J. Haz, Mat.*, 2013, 260, 740-746.

Appleman, T.D.; Higgins, C.P.; Quiñones, O.; Vanderford, B.J.; Kolstad, C.; Zeigler-Holady, J.C.; Dickenson, E.R.V. Treatment of poly- and perfluoroalkyl substances in U.S. full-scale water treatment systems. *Wat. Res.*, 2014, 51, 246-255.

Barpaga, D.; Zheng, J.; Han, K.S.; Soltis, J.A.; Shutthanandan, V.; Basuray, S.; McGrail, B.P.; Chatterjee, S. Probing the Sorption of Perfluorooctanesulfonate Using Mesoporous Metal–Organic Frameworks from Aqueous Solutions. *Inorg. Chem.*, 2019, 58, 8339-8346.

Burckhardt, J; et al. Modeling Pilot-Scale GAC PFAS Adsorption for the Simulation of Full-Scale Performance and Costs. Presented at *AWWA Water Quality Technology Conference*. November 2019.

Cui, J.; Gao, P.; Deng, Y. Destruction of Per- and Polyfluoroalkyl Substances (PFAS) with Advanced Reduction Processes (ARPs): A Critical Review. *Environ. Sci. Technol.*, 2020, 54, 7, 3752–3766.

Franke, V.; McCleaf, P.; Lindegren, K.; Ahrens, L. Efficient removal of per- and polyfluoroalkyl substances (PFASs) in drinking water treatment: nanofiltration combined with active carbon or anion exchange. *Environ. Sci.: Water Res. Technol.*, 2019, 5, 1836-1843.

Franke, V.; Ullberg, M.; McLeaf, P.; Wålinder, M.; Köhler, S.; Ahrens, L. The Price of Really Clean Water: Combining Nanofiltration with Granular Activated Carbon and Anion Exchange Resins for the Removal of Per- And Polyfluoralkyl Substances (PFASs) in Drinking Water Production. *ACS EST Water*, 2021.

Huang, P.J.; Hwangbo, M.; Chen, Z.; Liu, Y.; Kameoka, J.; Chu, K.H. Reusable Functionalized Hydrogel Sorbents for Removing Longand Short-Chain Perfluoroalkyl Acids (PFAAs) and GenX from Aqueous Solution. *ACS Omega*, 2018, 3, 17447-17455.

ITRC. PFAS – Per- and Polyfluoroalkyl Substance: Treatment Technologies. September 2020. https://pfas-1.itrcweb.org/12-treatment-technologies/

Kim, S.; Chen, J.; Cheng, T.; Gindulyte, A.; He, J.; He, S.; Li, Q.; Shoemaker, B.A.; Thiessen, P.A.; Yu, B.; Zaslavsky L.; Zhang, J.; Bolton, E.E. PubChem in 2021: new data content and improved web interfaces. *Nucleic Acids Res.*, 2021, 47, D1388-D1395. DOI: 10.1093/nar/gkaa971.

Kumarasamy, E.; Manning, I.M.; Collins, L.B.; Coronell, O.; Leibfarth, F.A. Ionic Fluorogels for Remediation of Per- and Polyfluorinated Alkyl Substances from Water. *ACS Central Science*, 2020, 6, 487-492.

Murray, C.C.; Vatankhah, H.; McDonough, C.A.; Nickerson, A.; Hedtke, T.T.; Tzahi, Y.C.; Higgins, C.P.; Bellona, C.L. Removal of Per- and Polyfluoroalkyl Substances Using Super-Fine Powder Activated Carbon and Ceramic Membrane Filtration. *J. Haz. Mat.*, 2019, 366, 160-168.

Nau-Hix, C.; Multari, N.; Singh, R.K.; Richardson, S.; Kulkarni, P.; Anderson, R.H.; Holsen, T.M.; Thagard, S.M. Field Demonstration of a Pilot-Scale Plasma Reactor for the Rapid Removal of Poly- and Perfluoroalkyl Substances in Groundwater. *ACS EST Water*, 2021, 1, 680-687.

Ross, I.; McDonough, J.; Miles, J.; Storch, P.; Kochunarayanan, P.T.; Kalve, E.; Hurst, J.; Dasgupta, S.S.; Burdick, J. A review of emerging technologies for remediation of PFASs. *Remediation*, 2018, 28, 101-126.

SERDP ESTCP. Plasma Based Treatment Processes for PFAS Investigation Derived Waste. ER18-1624. 2020A. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1624

SERDP ESTCP. Supercritical Water Oxidation (SCWO) for Complete PFAS Destruction. ER20-5350. 2020B. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER20-5350/(language)/eng-US

Soriano, Á.; Gorri, D.; Urtiaga, A. Selection of High Flux Membrane for the Effective Removal of Short-Chain Perfluorocarboxylic Acids. *Ind. Eng. Chem. Res.*, 2019, 58, 3329-3338.

US EPA. Cement Kiln and Waste to Energy Incineration of Spent Media. Presentation. February 2020A. https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=539978&Lab=CESER

US EPA. Estimation Programs Interface Suite, v 4.11. 2012, United States Environmental Protection Agency, Washington, DC, USA.

US EPA. Per- and Polyfluoroalkyl Substances (PFAS): Incineration to Manage PFAS Waste Streams. Technical Brief. February 2020B.

US EPA. Potential PFAS Destruction Technology: Electrochemical Oxidation. Research Brief. January 2021A.

US EPA. Potential PFAS Destruction Technology: Supercritical Water Oxidation. Research Brief. January 2021B.

US EPA. Thermal Treatment of PFAS in Environmental Media: A review of the state-of-the-science. Presentation. February 2020C.
https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=539973&Lab=CESER

Woodard, S.; Berry, J.; Newman, B. Ion exchange resin for PFAS removal and pilot test comparison to GAC. *Remediation*, 2017, 27, 19–27.

Zeng, C.; Atkinson, A.; Sharma, N.; Ashani, H.; Hjelmstad, A.; Venkatesh, K.; Westerhoff, P. Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns. *AWWA Water Science*, 2020. DOI: 10.1002/aws2.1172

Large Tables

Large Table 1 PFAS Groupings for Removal Efficiencies Determination

No.	Abbreviation	Name	CAS Number	Total No. C atoms	Number of fluorinated C atoms	MW	log K_{ow} [1,2]	BP_{exp} (deg. C)[1,3]	BP_{calc} (deg. C)[1]
Group 1 (C: 1-5; CF: 1-4, MW: 114-281, logK_{ow}: -2.6-2.8)									
1	TFA	Trifluoroacetic acid	76-05-1	2	1	114	0.5	72	106
2	TFMS	Trifluoromethane sulfonate	1493-13-6	1	1	150	-0.49	166	203
3	TFMS lithium salt	Trifluoromethane sulfonate lithium salt	33454-82-9	1	1	156	-2.63	na	441
4	2,2,3,3-TFPA	2,2,3,3-tetrafluoropropionic acid	756-09-2 (71592-16-0 potassium salt)	3	2	146	0.86	134	117
5	2,3,3,3-TFPA	2,3,3,3-tetrafluoropropionic acid	359-49-9	3	2	146	0.86	na	117
6	PFPA	Perfluoropropionic acid	422-64-0	3	2	164	1.47	97	110
7	PFES	Perfluoroethanesulfonate	354-88-1	2	2	200	0.48	178	207
8	HQ-115	Bis(trifluoromethylsulfonyl)amine	98837-98-0 (90076-65-6 lithium salt)	2	2	281	2.07	na	287
9	PFBA	Perfluorobutanoic acid	375-22-4	4	3	214	2.14	121	123
10	PIBA	Perfluoroisobutyl amide	662-20-4	4	3	213	0.81	na	178
11	PFPeA	Perfluoropentanoic acid	2706-90-3	5	4	264	2.81	na	145
Group 2 (C: 4-9; CF: 4-7, MW: 284-414, logK_{ow}: 1.8-4.8)									
12	PFBSi	Perfluorobutanesulfinic acid[4]	34642-43-8	4	4	284	1.82	212	201
13	PFBSi	Nonafluorobutane-1-sulfinic acid[4]	34642-43-8	4	4	284	1.82	212	201
14	FBSA	Perfluorobutanesulfonamide	30334-69-1	4	4	299	3.13	115	178
15	PFBS	Perfluorobutane sulfonate	375-73-5	4	4	300	1.82 (0.25)	200	214
16	FBSE	Nonafluoro-N-(2-hydroxyethyl)butane-1-sulfonamide	34454-99-4	6	4	343	2.62	251	270.31
17	MeFBSAA	Perfluorobutyl-methyl sulfonamide glycine acid	159381-10-9	7	4	371	na	na	na
18	PBSA	N-[3-(dimethylamino)propyl]-1,1,2,2,3,3,4,4,4-nonafluoro-butane-1-sulfonamide	68555-77-1	9	4	384	3.78	na	274.01
19	FBSEE Diol	Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide	34455-00-0	8	4	387	2.26	na	339.24
20	FBSEE-DA	[(Nonafluorobutane-1-sulfonyl)-carboxymethylamino] acetic acid	1268835-43-3	8	4	415	na	na	na
21	FBSAA	Perfluorobutyl sulfonamide glycine acid	1910057-70-3	6	4	357	na	na	na
22	PFHxA	Perfluorohexanoic acid	307-24-4	6	5	314	3.48 (0.18)	157	165.08
23	HFPO-DA	Hexafluoropropylene oxide dimer acid	13252-13-6	6	5	330	3.36	na	186.86
24	PFHpA	Perfluoroheptanoic acid	375-85-9	7	6	364	4.15 (0.88)	177	184.82
25	PFHxS	Perfluorohexane sulfonate	355-46-4	6	6	400	3.16 (1.65)	239	221.92
26	PFOA	Perfluorooctanoic acid	335-67-1	8	7	414	4.81 (1.58)	189	203.77
Group 3 (C:8-13; CF: 8-12, MW: 464-664, logK_{ow}: 4.5-8.2)									
27	PFNA	Perfluorononanoic acid	375-95-1	9	8	464	5.48 (2.28)	na	221.92
28	PFOSA	Perfluorooctane sulfonamide	754-91-6	8	8	499	5.8	na	193.87
29	PFOS	Perfluorooctane sulfonate	1763-23-1	8	8	500	4.49 (3.05)	249	229.28
30	PFDA	Perfluorodecanoic acid	335-76-2	10	9	514	6.15	218	239.28
31	PFUnA	Perfluoroundecanoic acid	2058-94-8	11	10	564	6.82	na	255.83
32	PFDoA	Perfluorododecanoic acid	307-55-1	12	11	614	7.49	249	271.58
33	PFTrDA	Perfluorotridecanonic acid	72629-94-8	13	12	664	8.16	na	286.54

(1) US EPA. Estimation Programs Interface Suite, v 4.11. 2012, United States Environmental Protection Agency, Washington, DC, USA.
(2) LogD values are shown in parentheses for select PFAS at pH 7.4. LogD values are n-octanol-water partition coefficients that account for the acid dissciation constant of the PFAS for a given pH of the water phase. From: Zeng, C.; Atkinson, A.; Sharma, N.; Ashani, H.; Hjelmstad, A.; Venkatesh, K.; Westerhoff, P. Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns. *AWWA Water Science*, 2020. DOI: 10.1002/aws2.1172
(3) Kim, S.; Chen, J.; Cheng, T.; Gindulyte, A.; He, J.; He, S.; Li, Q.; Shoemaker, B.A.; Thiessen, P.A.; Yu, B.; Zaslavsky L.; Zhang, J.; Bolton, E.E. PubChem in 2021: new data content and improved web interfaces. *Nucleic Acids Res.* 2021, 47, D1388-D1395. doi: 10.1093/nar/gkaa971.
(4) Two chemical names were provided by MPCA for the abbreviation PFBSi. Based on publically available information, these two chemical names refer to the same PFAS structure.
CF=number of fluorinated carbon atoms; MW=molecular weight in g/mol; logK_{ow}=logarithmic transformation of the n-octanol-water partion coefficient; BP=boiling point in degrees Celcius (experimental and calculated values are shown where available).
na=not available; publically available information was not identified.

Large Table 2 PFAS Treatment Technologies Threshold Screening

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Sorption Technologies							
Granular Activated Carbon (GAC)	PFAS sorbs to hydrophobic GAC surface in a fixed-bed pressure vessel.	Yes	Yes	Yes (baseline)	Primary or Secondary	GAC is a mature technology for PFAS water treatment. It is retained in the analysis as the baseline for comparison of other retained technologies.	(ITRC 2020)
Powdered Activated Carbon (PAC)	Similar to GAC, PFAS are removed via sorption to the hydrophobic surface of PAC. PAC is added directly in process or tank (not fixed bed). Spent PAC is wasted and separated by settling or with low-pressure membrane filtration.	Yes	Yes	No	--	PAC is a mature treatment technology and is able to remove PFAS. PAC is not being retained, however, because its application is more logistically complex than GAC due to the need to continually replenish and waste media.	(Ross 2018)
Super-Fine Powdered Activated Carbon (S-PAC)	PFAS sorbs to PAC that has been ground to a super-fine powder and added in the process (e.g., within a tank). S-PAC is removed via membrane filtration.	Yes	No	No	--	Technology is not commercially available. Would require a near continuous supply of fresh super-fine PAC.	(Murray 2019)
Anion Exchange Resin (single use media)	PFAS attaches to resin via electrostatic interactions with charged functional groups and via hydrophobic interactions with resin support material in a fixed bed pressure vessel. Once exhausted, media is removed and disposed.	Yes	Yes	Yes	Primary or Secondary	Technology is effective for PFAS treatment and commercially available. Equipment is typically smaller than GAC equipment. Modestly higher efficacy than GAC for treatment of short-chain PFAS.	(ITRC 2020)
Anion Exchange Resin (regenerable media)	PFAS attaches to resin via electrostatic interactions with charged functional groups and via hydrophobic interactions with resin support material in a fixed-bed pressure vessel. Once exhausted, media is regenerated on-site using a brine/solvent mixture and returned to service.	Yes	No	No[1]	--	Technology is effective for PFAS treatment, however, regeneration equipment at the required scale is not commercially available.	(ITRC 2020)
Synthesized Gel Polymeric Absorbents	PFAS sorbs to synthetic polymer materials with tunable functional groups and various support materials meant to optimize PFAS removal from water.	Yes	No	No	--	Technology is effective for PFAS treatment, but is not commercially available. These technologies are currently only on the laboratory-scale.	(Huang 2019) (Kumarasamy 2020)
Modified Adsorbents	PFAS sorbs to modified adsorbent media, which can include modified natural materials: polymer-coated sand, modified cyclodextrin, or modified cellulose.	Limited	No	No	--	Technologies can be effective. While commercial products are under development, they are not available at the scale required.	(ITRC 2020) (Ross 2018)
Metal-Organic Frameworks (MOF)	PFAS sorbs to an organic coordination network (repeating structures) with complexed metal ions tuned for PFAS sorption.	No	No	No	--	MOF technologies are not commercially available for PFAS treatment. Technologies are currently only on the laboratory scale.	(Ross 2018) (Barpaga 2019)
Separation Technologies							
Reverse Osmosis (RO) or Nanofiltration (NF)	PFAS are separated into a concentrate stream by physical separation via high-pressure membranes. NF membranes typically have higher water recovery than RO due to larger membrane pore sizes.	Yes	Yes	Yes	Primary	RO and NF have demonstrated efficacy for PFAS treatment and equipment is commercially available. NF may have slightly lower removal efficiencies than RO, but has higher water recovery.	(ITRC 2020) (Franke 2019)
Thermal Evaporation with Crystallizer	Water is evaporated, with most PFAS and other dissolved constituents remaining in a slurry requiring management (for example, dewatering and disposal in a landfill or via incineration). Some short-chain PFAS may evaporate with water.	No	Yes	Yes	Secondary	Thermal evaporation with crystallizer is being retained as an option for concentrate management from RO, not as primary PFAS treatment option.	--

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Foam Fractionation	PFAS are stripped from liquid phase as foam using fine air or ozone bubbles. This technology takes advantage of the surfactant properties of PFAS at high concentrations.	Limited	Limited	No	--	Foam fractionation is an emerging technology for PFAS treatment. It is not commercially available at the scale needed. This technology may be most applicable for concentrating up high concentration PFAS streams.	(ITRC 2020) (Ross 2018)
Precipitation/ Coagulation/ Flocculation	PFAS are removed via sorption to or incorporation with coagulated and flocculated solids and removed via settling with other solids. Treatment is similar to conventional coagulation and flocculation.	Limited	Yes	No	--	Treatment efficacy of precipitation is limited. Partial removal of PFAS is possible, but typically limited to longer chain PFAS.	(ITRC 2020)
Destructive Technologies (on-site)							
Plasma	Plasma reactors use charged gases, such as argon, to degrade PFAS via reactions with reactive intermediates (electrons and radicals).	Limited	No	No[(1)]	--	Plasma reactors are an emerging technology for PFAS treatment and degradation. Reactors specifically for PFAS treatment are not commercially available.	(ITRC 2020) (SERDP 2020A) (Nau-Hix 2021)
Super Critical Water Oxidation (SCWO)	PFAS is degraded by water heated and pressurized to a super critical state (above a temperature of 374°C and pressure of 221 bar).	Limited	Limited	No	--	SCWO is an emerging technology for PFAS treatment and degradation. There are commercial applications of SCWO, but few specifically for PFAS treatment.	(US EPA 2021B) (SERDP 2020B)
Advanced Oxidation Processes (AOP)	AOP use oxidants, such as ozone, peroxide, persulfate, UV light, and/or combinations thereof to degrade PFAS via reaction with reactive intermediates such as hydroxyl radicals.	Limited	Yes	No	--	While AOP technologies are available on commercial scales, they have relatively low efficacy for PFAS treatment and result in incomplete PFAS degradation.	(ITRC 2020)
Electrochemical Oxidation	Electrochemical oxidation uses electrical currents passed through water to degrade PFAS. PFAS are oxidized at the anode of the electrochemical cell.	Yes	Limited	No	--	Electrochemical oxidation of PFAS has been demonstrated to be effective, but is still an active area of research. Electrochemical reactors specifically for PFAS water treatment are not commercially available.	(ITRC 2020) (US EPA 2021A)
Advanced Reduction Processes (ARPs)	ARPs generate hydrated electrons and hydrogen radicals by application of reductants (such as iodide or sulfite) with a source of activating energy (such as ultrasound or UV light). The hydrated electrons and hydrogen radicals have the potential to cleave C-F bonds.	Limited	No	No	--	ARP technologies are emerging as potential options for PFAS water treatment. ARPs have the potential to degrade PFAS, but efficacy is still an active area of research. Technologies are not commercially available.	(ITRC 2020) (Cui 2020)
Biological Treatment	PFAS are (partially) degraded via microbial degradation under aerobic or anaerobic conditions.	No	Yes	No	--	Partial microbial degradation of PFAS is possible for select classes of PFAS (for example, fluorotelomers and PFAS precursors). To date, microbial degradation of PFAS is incomplete and results in formation of shorter chain, stable perfluoroalkyl acids.	(ITRC 2020)
Sonolysis	Sonolysis (or sonochemical oxidation) uses ultrasound waves in water to cause cavitation. Cavitation generates radicals that can degrade PFAS.	Yes	No	No	--	Sonolysis has been shown to be effective for PFAS treatment in the laboratory and pilot scales, but reactors are not commercially available. Treatment efficacy is an active area of research.	(ITRC 2020)

Technology	Description	Demonstrated treatment effectiveness for representative PFAS from Groups 1, 2, and 3 at any scale (bench, pilot, or full-scale)	Application of the PFAS treatment technology at the design flow is feasible and the equipment can be procured through commercial vendors/manufacturers	Selected for Further Evaluation?	Primary or Secondary Treatment?	Reason for Retaining or Removing	References
Destructive Technologies (offsite)							
Incineration	PFAS (sorbed to media or in a concentrated stream) are thermally degraded at high temperature.	Yes	Yes	Yes	Secondary	This technology is mature, but is not viable as a primary treatment technology for PFAS due to scale constraints. It is being retained as a secondary technology for management of residuals. Efficacy of PFAS destruction in incinerators is an active area of investigation.	(ITRC 2020) (US EPA 2020B)
Cement Kiln	Similar to incineration, PFAS (sorbed to media or in a concentrated stream) are thermally degraded at high temperature.	Limited	Yes	No	--	This technology is not viable as a primary treatment option due to scale constraints. It may be appropriate for management of spent media and other residuals. Efficacy of PFAS destruction in cement kilns is an active area of investigation.	(USEPA 2020A) (US EPA 2020C)

(1) While these experimental technologies have not yet been demonstrated at full-scale and/or commercially available, 3M plans to proceed with testing regenerable AIX and plasma reactors at one or more facilities.

Large Table 3 PFAS Treatment Alternatives Screening

Category	Criteria Weight	Ranking Key	**Alternative 1** Modified Granular Activated Carbon	**Alternative 2** Anion Exchange (Single Use)	**Alternative 3** Nanofiltration with Granular Activated Carbon	**Alternative 4** Two-Stage Reverse Osmosis with Thermal Evaporation/ Crystallization	**Alternative 5** Reverse Osmosis with Anion Exchange (Single Use)	**Alternative 6** Two-Stage Reverse Osmosis with Anion Exchange (Single Use)
Technical Feasibility			***21***	***30***	***19***	***31***	***34***	***34***
Group 1 PFAS removal efficiency(1)	3	1 - <50% removal efficiency 2 - >50% and <75% removal efficiency 3 - >75% removal efficiency	1	2	1	3	3	3
Group 2 PFAS removal efficiency(1)	3	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	1	2	1	3	3	3
Group 3 PFAS removal efficiency(1)	3	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	2	3	2	3	3	3
General complexity of operation/maintenance of primary technology	2	1 - most complex 3 - most simple	3	3	2	1	2	2
Operator and public health risks	1	1 - significant additional health risk 3 - no additional health risk	3	3	3	2	3	3
Economic Feasibility			***15***	***15***	***9***	***9***	***15***	***15***
Capital costs for primary technology (and secondary technology, where applicable)	3	1 - high relative capital cost 3 - low relative capital cost	3	3	2	1	2	2
O&M costs for primary technology (and secondary technology, where applicable)	3	1 - high relative O&M cost 3 - low relative O&M cost	2	2	1	2	3	3
Energy Consumption			***6***	***6***	***4***	***2***	***4***	***4***
Energy consumption of primary technology (and secondary technology, where applicable)	2	1 - high energy consumption 3 - low energy consumption	3	3	2	1	2	2
Potential for Media Shifting of Pollutants			***2***	***2***	***2***	***6***	***4***	***4***
Relative quantity of residuals generated	2	1 - high 2 - average 3 - low	1	1	1	3	2	2
		Total Score	**44**	**53**	**34**	**48**	**57**	**57**

(1) Removal efficiency ratings for media technologies reflect anticipated removal at 5,000 bed volumes.

Appendix A

Pilot Testing Workplan, 5/12/2021

Pilot Test Workplan

3M

Cottage Grove, MN Facility

Submission Date: 5/27/2021

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1.0 ECT2 Understanding of the Project Objectives

Based on a technical review meeting between 3M and ECT2, we understand that 3M already operates four separate granular activated carbon (GAC) treatment systems to treat PFAS-impacted water at the site:

Source	Description	Current Treatment
Potable Supply Wells Avg Flow = 1.4 MGD	These wells supply water for domestic and manufacturing use	Currently treated with 3 pairs of Calgon Model 10 systems
Non-Potable Supply Wells Avg Flow = 4.9 MGD	These wells supply water for non-contact cooling water, manufacturing, and scrubber makeup for the on-site incinerator	Currently treated with 6 pairs of Calgon Model 10 systems
Phase 3 Wastewater Avg Flow = 0.7 MGD	Phase 3 wastewater includes scrubber blowdown from the on-site incinerator	Currently treated with 4 pairs of Norit Model 10 systems
Phase 1 & 2 Wastewater Avg Flow = 2.1 MGD	Phase 1 & 2 wastewater includes all other wastewater from the facility from inorganic manufacturing ("Phase 1") and domestic/organic manufacturing ("Phase 2") sources.	Currently treated with 9 pairs of Norit Model 10 systems

ECT2 further understands that 3M is required by the Minnesota Pollution Control Agency (MPCA) to perform a pilot test to demonstrate treatment technologies to remove PFAS from the facility prior to discharge to the Mississippi. A pilot test workplan is due to the MPCA by June 1, 2021 and the pilot test must be completed and report submitted no later than 180 days from MPCA approval of the pilot test workplan.

3M has expressed a desire to pilot test the PFAS treatment technologies currently being designed and/or tested at other 3M facilities. These technologies include Reverse Osmosis coupled with ECT2's regenerable ion-exchange (IX) resin. Major pretreatment technologies for these processes include ultrafiltration (UF) (to pretreat incoming water to the RO membranes) and LGAC (to treat RO reject for TOC, iron and long-chain PFAS compounds prior to ECT2's regenerable IX resin treatment).

The pilot test work at the Cottage Grove plant will focus on evaluating the performance of RO and regenerable IX (along with LGAC and single-use IX for comparison purposes) to evaluate PFAS removal capacities and develop breakthrough curves. On-site regeneration, multi-cycling, and subsequent PFAS destruction of the regenerant still bottoms are not planned for this pilot test, as 3M is already pilot testing these parameters and technologies at other sites. However, regeneration of each column will be performed off-site at ECT2's laboratory to demonstrate that the regenerant formula used by ECT2 can remove the site-specific PFAS loaded onto the media.

ECT2 plans to pilot test 3M's proprietary Liquid-Liquid PFAS extraction technology on one of the RO reject trains to evaluate its potential for full-scale application. Currently, the plan is to test this technology on the RO Reject from the Phase 3 WWTP test.

In addition to PFAS treatment testing, ECT2 also plans to evaluate how well the UF performs at zinc removal during the Phase 3 WWTP test.

2.0 Pilot Testing Description

The proposed overall scope of the pilot test is to:

- Demonstrate the PFAS removal capacity of RO membranes
- Develop breakthrough curves of RO reject water for LGAC, single-use AIX and regenerable AIX resins in three main process trains:
    - NCCW Stormwater (Outfall SD002)
    - Phase 1 & 2 WWTP effluent
    - Phase 3 WWTP effluent
- Demonstrate the ability to remove PFAS compounds from the regenerable AIX media using ECT2's proprietary blend of solvent and brine solution at ECT2's lab in Rochester, NY.
- Evaluate the effectiveness of UF membranes to sufficiently pre-treat the water for use in RO membranes
- Evaluate 3Ms proprietary Liquid-Liquid extraction technology for PFAS removal. The scope of this effort will be developed in collaboration with 3M.
- Evaluate zinc removal efficiency of the UF for the Phase 3 WW.

Pilot testing of all 3 areas of the plant will not be performed simultaneously, but rather in series, in order to reduce the amount of equipment needed to be deployed to the site. We envision testing the cleanest water first (NCCW Stormwater Pond) and the Phase 3 WW last.

ECT2 plans to deploy the PFAS pilot testing equipment in one or more Conex boxes. The equipment includes:

- Influent equalization tank
- Feed pumps and break tanks for the UF and RO influent, permeate and reject flows
- UF membrane skid
- RO membrane skid with integral pump, controls, instrumentation
- 9 trains of single-use or regenerable AIX columns in lead-lag configuration (2 columns per train). Each train will have its own dedicated peristaltic pump.
- Piping, valves, instrumentation, flow meters, sample ports and appurtenances for the above major units.

Additional details for the pilot testing can be found in the following attachments:

- Figure 1 – Pilot Test Block Flow Diagrams
- Table 1 – Pilot Test Setup
- Table 2 – Sampling and Analysis Plan

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Pilot Test Program Description

ECT2 anticipates that the pilot test equipment will operate for approximately 7 weeks in order to complete the scope of work described above. 4 additional weeks will be staffed onsite for mobilization, relocation of the equipment around the site, and demobilization.

- ECT2 will be onsite to set up the pilot skids and tanks; load the media in each column; hydrate the media, install filter membranes, and pressure test the system.
- ECT2 will staff the operations of the pilot test for the duration of the test. Core ECT2 responsibilities onsite will include:
    - Record process instrument data in a log book (pressures, temperatures, flow rates and flow totals);
    - Collect samples according to the sampling plan;
    - Collect and analyze field parameters;
    - Label, package and ship samples to Enthalpy Analytical for laboratory analysis of PFAS and background chemistry compounds.
- During the first week of operations, ECT2 will focus our efforts on optimizing the UF and RO skids without operating any treatment columns. Once ECT2 has confirmed the UF and RO units are operating according to design, treatment of RO Reject and RO permeate through the different trains of media will begin.

The sampling plan is provided in Table 2, which incorporates PFAS as well as background chemistry testing. The SAP is designed to provide an adequate number of samples to evaluate RO treatment capacity as well as capture break through curves of each media treating RO Reject. The SAP calls for collection and analysis of approximately 293 PFAS samples during forward flow operations and off-site regeneration and 126 for background water chemistry. Hold samples will be collected and sent in if needed to fill in data gaps where needed.

	Forward Flow	**Off-Site Regen**	**Liquid-Liquid Extraction**	**Total**
PFAS Samples	263	30	TBD	293
Background Chemistry	126	0	TBD	126

We have assumed 12 samples will be collected from the Phase 3 WW pilot and submitted to an off-site laboratory for analysis for zinc.

Montrose Environmental Group
125 Industrial Way
Portland, ME 04103
Phone: (207) 274-3700

3.0 Project Schedule

ECT2 will immediately begin procurement of equipment upon PO acceptance. The estimated project schedule is provided below:

Date	Scope Description
June 1, 2021	No later than June 1, 2021, 3M submits pilot test workplan to MPCA
May/June 2021	Pilot System Fabrication/Installation on site, pending workplan approval
July – Sept 2021	Pilot System Operation, pending workplan approval
Dec 1, 2021	3M Submits Pilot Test Report to MPCA

This schedule assumes pilot testing will start on site in July of 2021 and concluding in September of 2021, based on acceptance of PO in May 2021. ECT2 has budgeted for 11 weeks of onsite labor to compete the install, startup, pilot testing & demobilization described in this workplan.

ECT2 will provide a Pilot Testing Report that includes our conclusions and recommendations within 2-4 weeks of receipt of all analytical data (from 3M and/or commercial lab).

ECT2 is aware that the pilot test report must be submitted within 180 days of MPCA approval of the pilot test workplan.

TABLE 2 - SAMPLING AND ANALYSIS PLAN - FORWARD FLOW

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

Flow Rate - RO Influent	mL/min	2,361
	gpd	898
	gpm	0.62
Flow Rate - RO Permeate	mL/min	2,053
	gpd	781
Flow Rate - RO Reject	mL/min	308
	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

NCCW & STORMWATER POND

Start Date/Time: 7/12/21 8:00

Date	Day	Time	Date/Time	Daily Flows RO Influent (gal)	Daily Flows RO Permeate (gal)	Daily Flows RO Reject (gal)	Cumulative Flows RO Influent (gal)	Cumulative Flows RO Permeate (gal)	Cumulative Flows RO Reject (gal)
7/11/2021	SUN								
7/12/2021	MON	12:00	7/12/21 12:00	150	130	20	150	130	20
7/13/2021	TUE	12:00	7/13/21 12:00	898	781	117	1,048	911	137
7/14/2021	WED	12:00	7/14/21 12:00	898	781	117	1,946	1,692	254
7/15/2021	THU	12:00	7/15/21 12:00	898	781	117	2,844	2,473	371
7/16/2021	FRI	12:00	7/16/21 12:00	898	781	117	3,742	3,254	488
7/17/2021	SAT	12:00	7/17/21 12:00	898	781	117	4,641	4,035	605
7/18/2021	SUN	12:00	7/18/21 12:00	898	781	117	5,539	4,816	722
7/19/2021	MON	12:00	7/19/21 12:00	898	781	117	6,437	5,597	840
7/20/2021	TUE	12:00	7/20/21 12:00	898	781	117	7,335	6,378	957
7/21/2021	WED	12:00	7/21/21 12:00	898	781	117	8,233	7,159	1,074
7/22/2021	THU	12:00	7/22/21 12:00	898	781	117	9,131	7,940	1,191
7/23/2021	FRI	12:00	7/23/21 12:00	898	781	117	10,030	8,721	1,308
7/24/2021	SAT	12:00	7/24/21 12:00	898	781	117	10,928	9,502	1,425
7/25/2021	SUN	12:00	7/25/21 12:00	898	781	117	11,826	10,283	1,543
7/26/2021	MON	12:00	7/26/21 12:00	898	781	117	12,724	11,064	1,660
7/27/2021	TUE	12:00	7/27/21 12:00						
7/28/2021	WED	12:00	7/28/21 12:00						
7/29/2021	THU	12:00	7/29/21 12:00						
7/30/2021	FRI	12:00	7/30/21 12:00						
7/31/2021	SAT	12:00	7/31/21 12:00						

Setup pilot system for Phase 1/2 WW

Date	RO STREAMS INFLUENT	RO STREAMS UF EFFLUENT	RO STREAMS RO PERMEATE	RO STREAMS RO REJECT
7/11/2021				
7/12/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/13/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/14/2021	PFAS	PFAS	PFAS	PFAS
7/15/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/16/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/17/2021				
7/18/2021				
7/19/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/20/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/21/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/22/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/23/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/24/2021				
7/25/2021				
7/26/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/27/2021				
7/28/2021				
7/29/2021				
7/30/2021				
7/31/2021				

Date	Cumulative Flows (Trains A & B) To TRAINS A & B (gal)	GAC1 (BVs)	GAC2 (BVs)	IX1 (BVs)	IX2 (BVs)
7/11/2021					
7/12/2021	10	16	8	16	8
7/13/2021	68	112	56	112	56
7/14/2021	127	208	104	208	104
7/15/2021	185	304	152	304	152
7/16/2021	244	400	200	400	200
7/17/2021	303	496	248	496	248
7/18/2021	361	592	296	592	296
7/19/2021	420	688	344	688	344
7/20/2021	478	784	392	784	392
7/21/2021	537	880	440	880	440
7/22/2021	596	976	488	976	488
7/23/2021	654	1,072	536	1,072	536
7/24/2021	713	1,168	584	1,168	584
7/25/2021	771	1,264	632	1,264	632
7/26/2021	830	1,360	680	1,360	680
7/27/2021					
7/28/2021					
7/29/2021					
7/30/2021					
7/31/2021					

Date	TRAIN A GAC1-A (PRETREATMENT)	TRAIN A GAC2-A (PRETREATMENT)	TRAIN A IX1-A (SINGLE-USE IX)	TRAIN A IX2-A (SINGLE-USE IX)	TRAIN B GAC1-B (PRETREATMENT)	TRAIN B GAC2-B (PRETREATMENT)	TRAIN B IXR1-B (REGENERABLE IX)	TRAIN B IXR2-B (REGENERABLE IX)
7/11/2021								
7/12/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
7/13/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/14/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/15/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/16/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
7/17/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/18/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/19/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/20/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/21/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/22/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/23/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/24/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS
7/25/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
7/26/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
7/27/2021								
7/28/2021								
7/29/2021								
7/30/2021								
7/31/2021								

Date	Cumulative Flows (Train C) To TRAIN C (gal)	IX1 (BVs)	IX2 (BVs)	TRAIN C IX1-C (SINGLE-USE IX)	TRAIN C IX2-C (SINGLE-USE IX)
7/11/2021					
7/12/2021	49	80	40	PFAS	PFAS
7/13/2021	342	560	280	PFAS (H)	PFAS (H)
7/14/2021	635	1,040	520	PFAS+BC	PFAS+BC
7/15/2021	927	1,520	760	PFAS (H)	PFAS (H)
7/16/2021	1,220	2,000	1,000	PFAS	PFAS
7/17/2021	1,513	2,480	1,240	PFAS (H)	PFAS (H)
7/18/2021	1,806	2,960	1,480	PFAS (H)	PFAS (H)
7/19/2021	2,099	3,440	1,720	PFAS (H)	PFAS (H)
7/20/2021	2,392	3,920	1,960	PFAS+BC	PFAS+BC
7/21/2021	2,685	4,400	2,200	PFAS (H)	PFAS (H)
7/22/2021	2,978	4,880	2,440	PFAS (H)	PFAS (H)
7/23/2021	3,271	5,360	2,680	PFAS (H)	PFAS (H)
7/24/2021	3,563	5,840	2,920	PFAS	PFAS
7/25/2021	3,856	6,320	3,160	PFAS (H)	PFAS (H)
7/26/2021	4,149	6,800	3,400	PFAS+BC	PFAS+BC
7/27/2021					
7/28/2021					
7/29/2021					
7/30/2021					
7/31/2021					

TABLE 2 - SAMPLING AND ANALYSIS PLAN - FORWARD FLOW

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

Flow Rate - RO Influent	mL/min	2,361
	gpd	898
	gpm	0.62
Flow Rate - RO Permeate	mL/min	2,053
	gpd	781
Flow Rate - RO Reject	mL/min	308
	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

PHASE 1 & 2 WASTEWATER (PRE-LGAC)

Start Date/Time: 8/2/21 8:00

				Daily Flows			Cumulative Flows			*RO STREAMS*			
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject	INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT
				gal	gal	gal	gal	gal	gal				
8/1/2021	SUN												
8/2/2021	MON	12:00	8/2/21 12:00	150	130	20	150	130	20	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/3/2021	TUE	12:00	8/3/21 12:00	898	781	117	1,048	911	137	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/4/2021	WED	12:00	8/4/21 12:00	898	781	117	1,946	1,692	254	PFAS	PFAS	PFAS	PFAS
8/5/2021	THU	12:00	8/5/21 12:00	898	781	117	2,844	2,473	371	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/6/2021	FRI	12:00	8/6/21 12:00	898	781	117	3,742	3,254	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/7/2021	SAT	12:00	8/7/21 12:00	898	781	117	4,641	4,035	605				
8/8/2021	SUN	12:00	8/8/21 12:00	898	781	117	5,539	4,816	722				
8/9/2021	MON	12:00	8/9/21 12:00	898	781	117	6,437	5,597	840	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/10/2021	TUE	12:00	8/10/21 12:00	898	781	117	7,335	6,378	957	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/11/2021	WED	12:00	8/11/21 12:00	898	781	117	8,233	7,159	1,074	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/12/2021	THU	12:00	8/12/21 12:00	898	781	117	9,131	7,940	1,191	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/13/2021	FRI	12:00	8/13/21 12:00	898	781	117	10,030	8,721	1,308	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/14/2021	SAT	12:00	8/14/21 12:00	898	781	117	10,928	9,502	1,425				
8/15/2021	SUN	12:00	8/15/21 12:00	898	781	117	11,826	10,283	1,543				
8/16/2021	MON	12:00	8/16/21 12:00	898	781	117	12,724	11,064	1,660	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/17/2021	TUE	12:00	8/17/21 12:00	Setup pilot system for Phase 3 WW									
8/18/2021	WED	12:00	8/18/21 12:00										
8/19/2021	THU	12:00	8/19/21 12:00										
8/20/2021	FRI	12:00	8/20/21 12:00										
8/21/2021	SAT	12:00	8/21/21 12:00										

	Cumulative Flows (Trains D & E)					TRAIN D			
Date	To TRAINS D & E	GAC1	GAC2	IX1	IX2	GAC1-D	GAC2-D	IX1-D	IX2-D
	gal	BVs	BVs	BVs	BVs	(PRETREATMENT)		(SINGLE-USE IX)	
8/1/2021									
8/2/2021	10	16	8	16	8	PFAS	PFAS	PFAS	PFAS
8/3/2021	68	112	56	112	56	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/4/2021	127	208	104	208	104	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/5/2021	185	304	152	304	152	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/6/2021	244	400	200	400	200	PFAS	PFAS	PFAS	PFAS
8/7/2021	303	496	248	496	248	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/8/2021	361	592	296	592	296	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/9/2021	420	688	344	688	344	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/10/2021	478	784	392	784	392	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/11/2021	537	880	440	880	440	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/12/2021	596	976	488	976	488	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/13/2021	654	1,072	536	1,072	536	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/14/2021	713	1,168	584	1,168	584	PFAS	PFAS	PFAS	PFAS
8/15/2021	771	1,264	632	1,264	632	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)
8/16/2021	830	1,360	680	1,360	680	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC
8/17/2021									
8/18/2021									
8/19/2021									
8/20/2021									
8/21/2021									

	TRAIN E				Cumulative Flows (Train F)			TRAIN F	
Date	GAC1-E	GAC2-E	IXR1-E	IXR2-E	To TRAIN F	IX1	IX2	IX1-F	IX2-F
	(PRETREATMENT)		(REGENERABLE IX)		gal	BVs	BVs	(SINGLE-USE IX)	
8/1/2021									
8/2/2021	PFAS	PFAS	PFAS	PFAS	49	80	40	PFAS	PFAS
8/3/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	342	560	280	PFAS (H)	PFAS (H)
8/4/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	635	1,040	520	PFAS+BC	PFAS+BC
8/5/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	927	1,520	760	PFAS (H)	PFAS (H)
8/6/2021	PFAS	PFAS	PFAS	PFAS	1,220	2,000	1,000	PFAS	PFAS
8/7/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,513	2,480	1,240	PFAS (H)	PFAS (H)
8/8/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,806	2,960	1,480	PFAS (H)	PFAS (H)
8/9/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,099	3,440	1,720	PFAS (H)	PFAS (H)
8/10/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	2,392	3,920	1,960	PFAS+BC	PFAS+BC
8/11/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,685	4,400	2,200	PFAS (H)	PFAS (H)
8/12/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,978	4,880	2,440	PFAS (H)	PFAS (H)
8/13/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,271	5,360	2,680	PFAS (H)	PFAS (H)
8/14/2021	PFAS	PFAS	PFAS	PFAS	3,563	5,840	2,920	PFAS	PFAS
8/15/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,856	6,320	3,160	PFAS (H)	PFAS (H)
8/16/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	4,149	6,800	3,400	PFAS+BC	PFAS+BC
8/17/2021									
8/18/2021									
8/19/2021									
8/20/2021									
8/21/2021									

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	gpd	117

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

PHASE 3 WASTEWATER (PRE-LGAC)

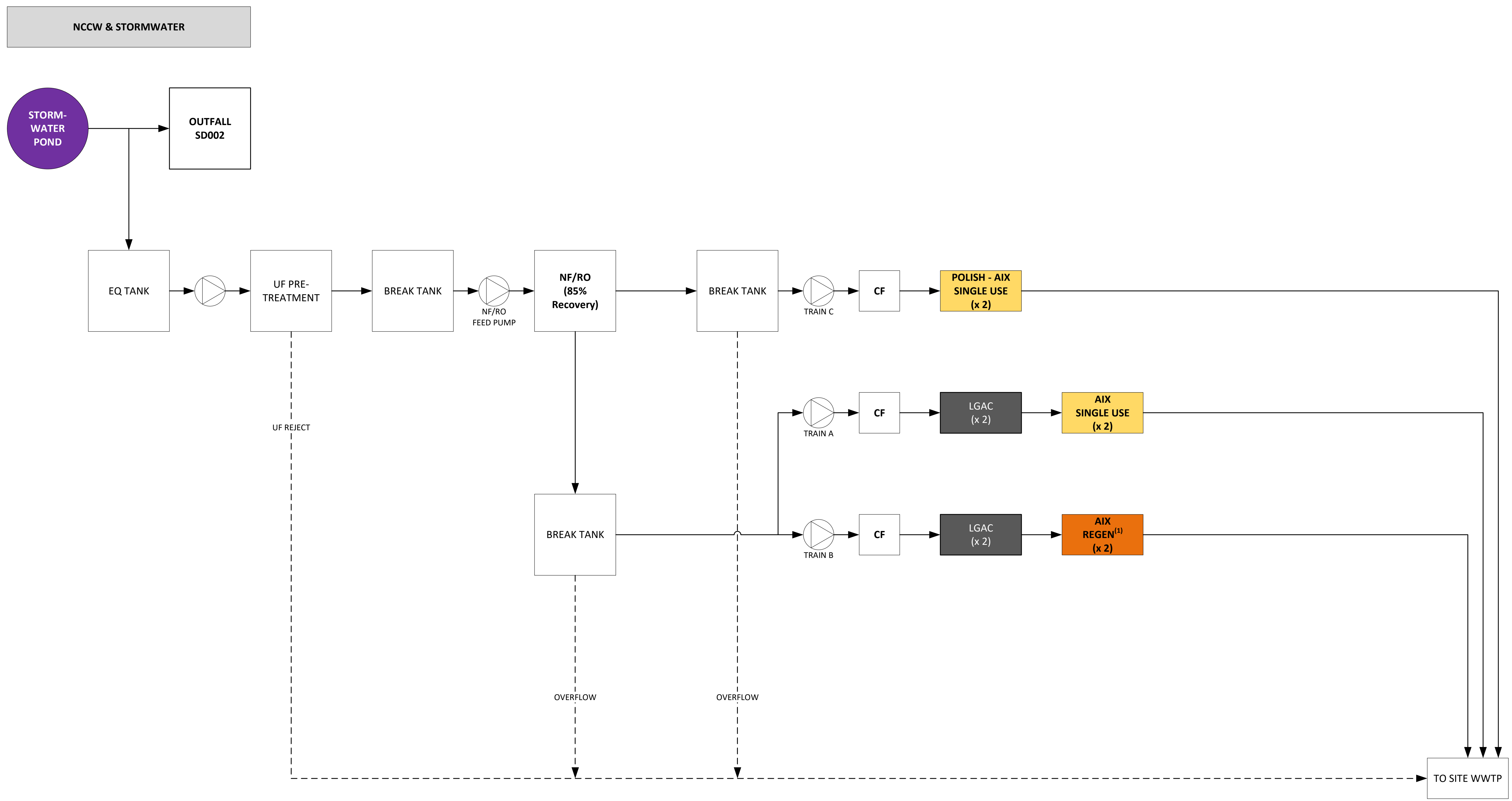
Start Date/Time: 8/23/21 8:00

				Daily Flows			Cumulative Flows		
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject
				gal	gal	gal	gal	gal	gal
8/22/2021	SUN								
8/23/2021	MON	12:00	8/23/21 12:00	150	130	20	150	130	20
8/24/2021	TUE	12:00	8/24/21 12:00	898	781	117	1,048	911	137
8/25/2021	WED	12:00	8/25/21 12:00	898	781	117	1,946	1,692	254
8/26/2021	THU	12:00	8/26/21 12:00	898	781	117	2,844	2,473	371
8/27/2021	FRI	12:00	8/27/21 12:00	898	781	117	3,742	3,254	488
8/28/2021	SAT	12:00	8/28/21 12:00	898	781	117	4,641	4,035	605
8/29/2021	SUN	12:00	8/29/21 12:00	898	781	117	5,539	4,816	722
8/30/2021	MON	12:00	8/30/21 12:00	898	781	117	6,437	5,597	840
8/31/2021	TUE	12:00	8/31/21 12:00	898	781	117	7,335	6,378	957
9/1/2021	WED	12:00	9/1/21 12:00	898	781	117	8,233	7,159	1,074
9/2/2021	THU	12:00	9/2/21 12:00	898	781	117	9,131	7,940	1,191
9/3/2021	FRI	12:00	9/3/21 12:00	898	781	117	10,030	8,721	1,308
9/4/2021	SAT	12:00	9/4/21 12:00	898	781	117	10,928	9,502	1,425
9/5/2021	SUN	12:00	9/5/21 12:00	898	781	117	11,826	10,283	1,543
9/6/2021	MON	12:00	9/6/21 12:00	898	781	117	12,724	11,064	1,660
9/7/2021	TUE	12:00	9/7/21 12:00						
9/8/2021	WED	12:00	9/8/21 12:00						
9/9/2021	THU	12:00	9/9/21 12:00						
9/10/2021	FRI	12:00	9/10/21 12:00						
9/11/2021	SAT	12:00	9/11/21 12:00						

End of test or extend to perform additional testing.

	RO STREAMS				Cumulative Flows (Trains G & H)				
Date	INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT	To TRAINS G & H	GAC1	GAC2	IX1	IX2
					gal	BVs	BVs	BVs	BVs
8/22/2021									
8/23/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	10	16	8	16	8
8/24/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	68	112	56	112	56
8/25/2021	PFAS	PFAS	PFAS	PFAS	127	208	104	208	104
8/26/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	185	304	152	304	152
8/27/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	244	400	200	400	200
8/28/2021					303	496	248	496	248
8/29/2021					361	592	296	592	296
8/30/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	420	688	344	688	344
8/31/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	478	784	392	784	392
9/1/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	537	880	440	880	440
9/2/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	596	976	488	976	488
9/3/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	654	1,072	536	1,072	536
9/4/2021					713	1,168	584	1,168	584
9/5/2021					771	1,264	632	1,264	632
9/6/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	830	1,360	680	1,360	680
9/7/2021									
9/8/2021									
9/9/2021									
9/10/2021									
9/11/2021									

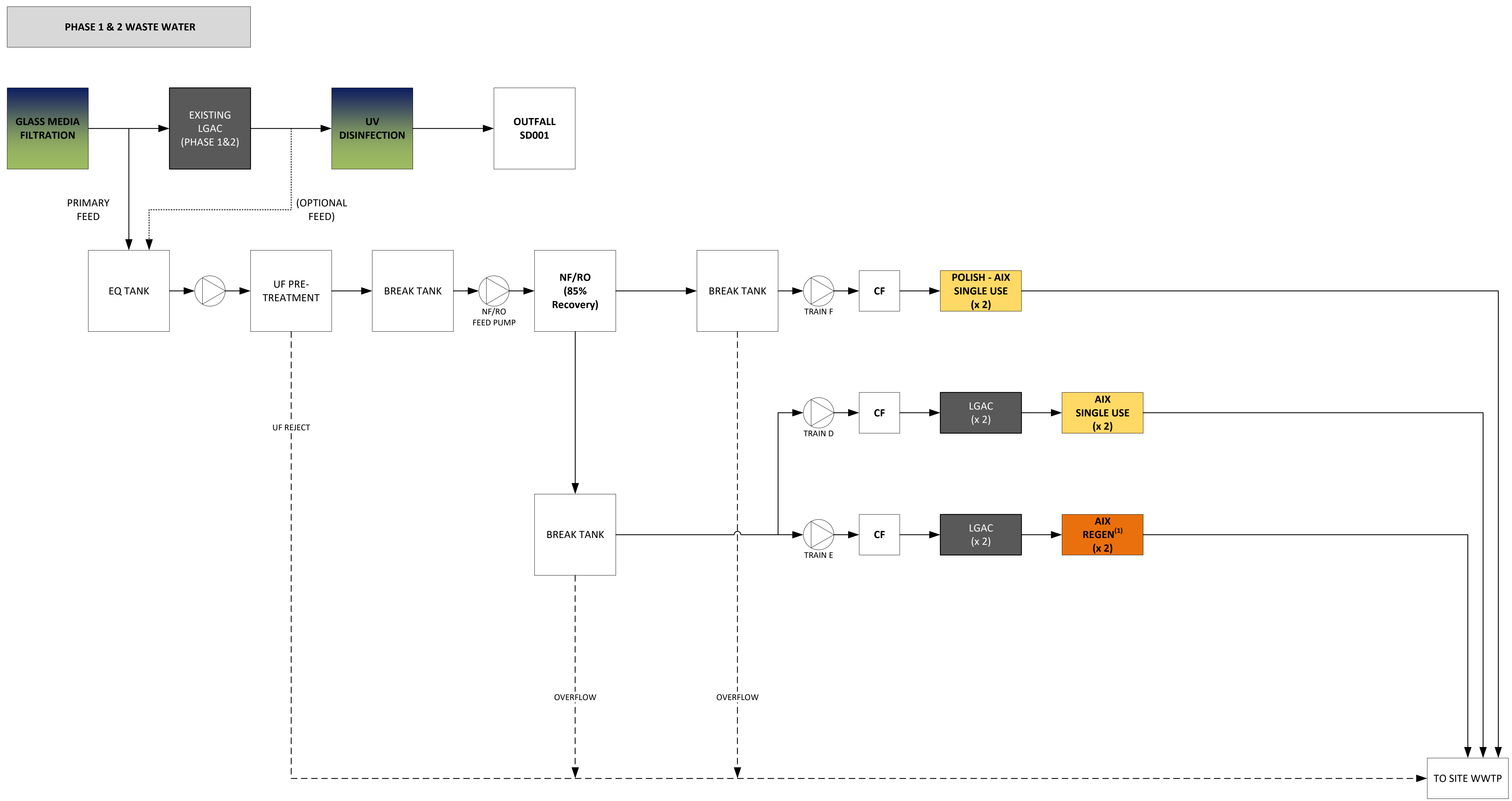
	TRAIN G				TRAIN H				Cumulative Flows (Train I)			TRAIN I	
Date	GAC1-G	GAC2-G	IX1-G	IX2-G	GAC1-H	GAC2-H	IXR1-H	IXR2-H	To TRAIN I	IX1	IX2	IX1-I	IX2-I
	(PRETREATMENT)		(SINGLE-USE IX)		(PRETREATMENT)		(REGENERABLE IX)		gal	BVs	BVs	(SINGLE-USE IX)	
8/22/2021													
8/23/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	49	80	40	PFAS	PFAS
8/24/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	342	560	280	PFAS (H)	PFAS (H)
8/25/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	635	1,040	520	PFAS+BC	PFAS+BC
8/26/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	927	1,520	760	PFAS (H)	PFAS (H)
8/27/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	1,220	2,000	1,000	PFAS	PFAS
8/28/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,513	2,480	1,240	PFAS (H)	PFAS (H)
8/29/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	1,806	2,960	1,480	PFAS (H)	PFAS (H)
8/30/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,099	3,440	1,720	PFAS (H)	PFAS (H)
8/31/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	2,392	3,920	1,960	PFAS+BC	PFAS+BC
9/1/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,685	4,400	2,200	PFAS (H)	PFAS (H)
9/2/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	2,978	4,880	2,440	PFAS (H)	PFAS (H)
9/3/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,271	5,360	2,680	PFAS (H)	PFAS (H)
9/4/2021	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	PFAS	3,563	5,840	2,920	PFAS	PFAS
9/5/2021	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	3,856	6,320	3,160	PFAS (H)	PFAS (H)
9/6/2021	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	PFAS+BC	4,149	6,800	3,400	PFAS+BC	PFAS+BC
9/7/2021													
9/8/2021													
9/9/2021													
9/10/2021													
9/11/2021													



NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration

FIGURE 1A: PILOT TESTING BLOCK FLOW DIAGRAM – NCCW & STORMWATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

ECT2
www.ect2.com

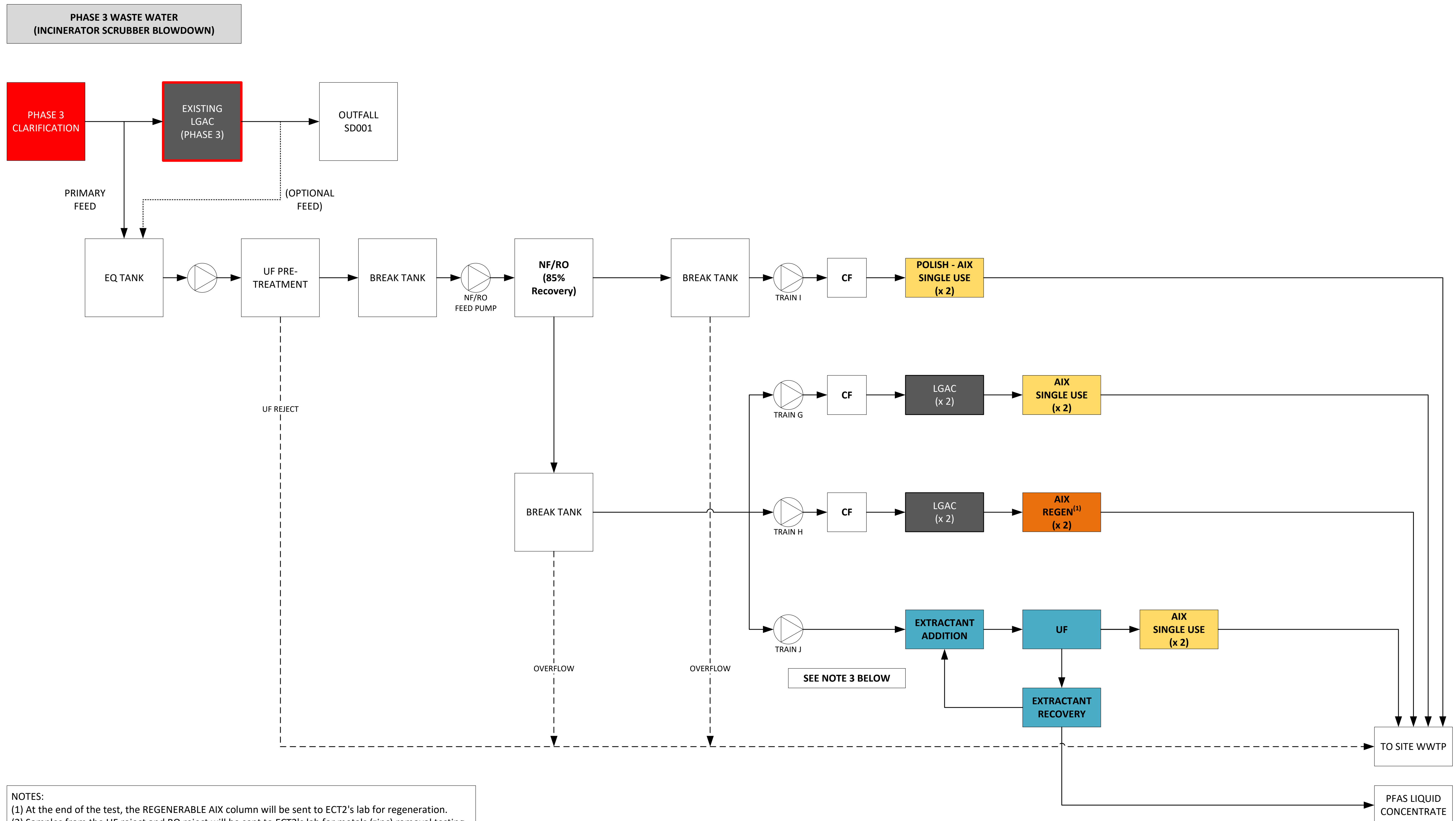


NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration

FIGURE 1B: PILOT TESTING BLOCK FLOW DIAGRAM – PHASE 1 & 2 WASTE WATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

ECT2
www.ect2.com

Montrose Environmental Group



NOTES:
(1) At the end of the test, the REGENERABLE AIX column will be sent to ECT2's lab for regeneration.
(2) Samples from the UF reject and RO reject will be sent to ECT2's lab for metals (zinc) removal testing.
(3) Details/scope of Train J to be developed at a later date.

FIGURE 1C: PILOT TESTING BLOCK FLOW DIAGRAM – PHASE 3 WASTEWATER
3M COTTAGE GROVE PLANT
UPDATED 5/27/21

ECT2
www.ect2.com

Montrose Environmental Group

EXHIBIT B

Pilot Study

Note: This is a complete copy of the study. Due to size restrictions the electronic version does not include the Tables, Figures and Appendices.

PFAS Treatability Study

3M Cottage Grove, MN Facility

December 22, 2021

Montrose Environmental Group

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Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for Sections 1, 3.3, 3.5; Large Tables 2, 7, 8; Appendices D, E, H

Kathryn M. Wolohan PE #: 54881	December 22, 2021 Date

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for Sections 3.1 and 3.2

Don E. Richard PE #: 21193	December 22, 2021 Date

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota.

Responsible for Sections 2, 3.4, 3.6, 4; Large Tables 1, 3, 4, 5, 6, 9; all Large Figures; Appendices A, B, C, F, G

Michael J. Sims PE #: 59838	December 22, 2021 Date

Abbreviations

2,2,3,3-TFPA	2,2,3,3-Tetrafluoropropionic acid
AIX	anion exchange
BV	bed volume
CIP	clean in place
DI	deionized
EBCT	empty bed contact time
ECT2	Emerging Compounds Treatment Technologies Inc.
FBSA	1,1,2,2,3,3,4,4,4-Nonafluorobutane-1-sulfonamide
FBSAA	perfluorobutyl sulfonamido acetic acid
FBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-1-butanesulfonamide
FBSEE Diol	1,1,2,2,3,3,4,4,4-Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide
FBSEE-DA	[(nonafluorobutane-1-sulfonyl)-carboxymethylamino]acetic acid
FOSA	Perfluorooctanesulfonamide
GAC	granular activated carbon
GFD	measurement of flux–units of gallons per square foot per day
gpm	gallon(s) per minute
HLR	hydraulic loading rate
HQ-115	lithium bis-trifluoromethanesulfonimide
IXR	regenerable ion exchange resin
LOD	limit of detection
MeFBSA	1,1,2,2,3,3,4,4,4-Nonafluoro-N-methylbutane-1-sulfonamide
MeFBSAA	perfluorobutyl-methyl sulfonamido acetic acid
MeFBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methylbutane-1-sulfonamide
mg/L	milligram(s) per liter
mL	milliliter(s)
MPCA	Minnesota Pollution Control Agency
NaCl	sodium chloride
NCCW	non-contact cooling water
ng/L	nanogram(s) per liter
NTU	nephelometric turbidity units
PBSA	2-Propenoic acid, reaction products with N-[3-(dimethylamino)propyl]-1,1,2,2,3,3,4,4,4-nonafluoro-1-butanesulfonamide OR N-[3-(Dimethylamino)propyl]-N-(1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonyl)-beta-alanine
PBSA-DC	3-((3-((N-(2-carboxyethyl)-perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate
PECHS	perfluoro-4-ethylcyclohexanesulfonate
PFAS	per- and polyfluoroalkyl substance
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFBSi	nonafluorobutane-1-sulfinic acid

PFES	perfluoroethanesulfonate
PFHpA	perfluoroheptanoic acid
PFHpS	perfluoroheptanesulfonate
PFHS	perfluorohexane sulfonate
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonate
PFOSA	perfluorooctanesulfonamide
PFPA	perfluoropropanoic acid
PFPeA	perfluoropentanoic acid
PFPeS	perfluoropentanesulfonate
pH	scale used to specify the acidity or basicity of an aqueous solution
PHSA-C	PHSA-C refers to the combined concentration of isomers PHSA-C1 and PHSA-C2. The individual concentration of each isomer could not be chromatographically resolved by the analytical method.
PHSA-C1	3-((N-(3-(dimethylamino)propyl)-perfluorohexyl)sulfonamido) propanoic acid
PHSA-C2	2-carboxyethyl-dimethyl-[3-(1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluorohexylsulfonylamino) propyl] ammonium
PIBA	perfluoisobutyl amide
ppt	part(s) per trillion
psi	pound(s) per square inch
PSId	differential pressure
RO	reverse osmosis
SW	stormwater
TDS	total dissolved solids
TFA	trifluoroacetic acid
TFMS	trifluoromethane sulfonic acid
TFPA	tetrafluoropropionic acid
TMP	trans-membrane pressure
TOC	total organic carbon
TSS	total suspended solids
UF	ultrafiltration
WW	wastewater
WWTF	wastewater treatment facility

Executive Summary

3M conducted a per- and polyfluoroalkyl substances (PFAS) Treatability Study using a combination of ultrafiltration (UF) and reverse osmosis (RO) membrane separation, with RO concentrate treated by granular activated carbon (GAC) and anionic exchange (AIX) media. The PFAS Treatability Study activities also included evaluation of AIX regeneration, which was determined to be technically feasible and economically favorable. Multiple test phases were completed, including treatment of non-contact cooling water combined with stormwater (NCCW/SW) combined and Phase 1/2 wastewater (WW).

The results of this PFAS Treatability Study show that a combination of UF and RO membranes, coupled with GAC and AIX resin for treatment of the RO concentrate can remove PFAS to below analytical limits of detection ([LODs], typically between 100 to 5,000 nanograms per liter [ng/L] for this study). Key results from the Treatability Study are summarized below:

- UF and RO membrane separation:
  - The UF achieved 96% water recovery.
  - The RO achieved between 85% and 95% water recovery. However, operating at water recoveries greater than 85% resulted in inefficiencies in the membrane separation processes due to fouling.
  - The combined total pilot membrane water recovery was 82% (96% UF recovery × 85% RO recovery).
  - Total PFAS concentrations measured in the RO permeate ranged from below LODs to 5,050 ng/L across all five pilot test phases.
- RO concentrate treatment:
  - GAC
    - During the NCCW test phases, GAC removed Group 2 PFAS to below LODs for more than 2,000 bed volumes (BVs) across the lead GAC column. Shorter-chain Group 1 PFAS, including perfluoropropanoic acid (PFPA), perfluorobutanoic acid (PFBA), and trifluoromethane sulfonic acid (TFMS), broke through the lag column in 300 BVs or less.
    - For the Phase 1/2 WW test phase, GAC achieved similar treatment performance to the NCCW test phases, although 3M observed intermittent detections of Group 2 PFAS across the lead GAC column.

- AIX
    - During the NCCW test phases, 3M observed that four Group 1 PFAS broke through the lead CalRes resin column: 2,3,3,3-tetrafluoropropionic acid (TFPA), PFPA, PFBA, and trifluoroacetic acid (TFA). 3M observed three PFAS following the lag column: 2,3,3,3-TFPA, PFPA, and TFA. No consistent breakthrough curves of Group 2 or Group 3 PFAS were observed after the CalRes resin columns. Similar observations were made with the SORBIX resin, although 3M did not observe TFA breakthrough.
    - For the Phase 1/2 WW test phase, the CalRes resin did not show a clear breakthrough curve for any of the 16 PFAS analyzed across the lag column for up to approximately 250 BVs. For the SORBIX resin, PFPA broke through the lag column after 200 BVs. 3M also observed intermittent detections of lithium bis-trifluoromethanesulfonimide (HQ-115) and TFMS after the lag SORBIX resin.

- AIX regeneration:
    - Lead AIX columns were regenerated after being fed with GAC-treated RO concentrate from Phase 1/2 WW using an alcohol-brine solution.
    - CalRes 2301 resin exhibited a higher capacity for sorbing and desorbing PFAS than SORBIX A3F resin.
    - The fraction of sorbed PFAS estimated to have desorbed during AIX regeneration varied by compound, with only about 20% of TFMS recovered during regeneration.

Lessons learned from the pilot regarding membrane fouling, membrane recovery, PFAS breakthrough in media columns, and other water quality observations will inform the final full-scale design. The proposed full-scale design mimics the pilot-scale process flow, with separate treatment trains for the NCCW/SW and Phase 1/2 WW flows to manage the different influent water quality. RO membrane separation will have three stages, which enable higher recovery without extensive fouling. 3M expects these stages to operate near 85% recovery. GAC will generally remove long-chain PFAS from RO concentrate, while AIX will remove PFPA, PFBA, and TFMS. AIX columns will include SORBIX A3F and another media. 3M will regenerate the columns using on-site infrastructure built with the treatment process.

The remaining risks and uncertainties include selected pretreatment needs, UF recovery and cleaning requirements, long-term RO membrane resiliency, GAC media duration to breakthrough and changeout, AIX run times before regeneration, loss of AIX treatment capacity following repeated regenerations, and management of AIX regeneration wastes.

1 Introduction

This PFAS Treatability Study Report (report) has been prepared pursuant to corrective action no. 18 of the Notice of Violation issued by the Minnesota Pollution Control Agency (MPCA) to the 3M Cottage Grove Center (Facility) dated January 22, 2021. This report summarizes the testing of selected treatment alternatives identified in the *PFAS Treatability Alternatives Identification Plan* (Treatability Plan) prepared by Barr Engineering Co. (revised July 7, 2021, to include Alternative 6).[1]

1.1 Alternatives Evaluated from PFAS Treatability Plan

The Treatability Plan evaluated six different treatment alternatives for PFAS management in Facility wastewaters (WWs). These included direct treatment using GAC or anion exchange resin (AIX) as well as reverse osmosis (RO) treatment followed by concentrate treatment using GAC or AIX.

Based on the evaluation summarized in the Treatability Plan, 3M identified Alternatives 5 and 6, RO membrane separation followed by AIX treatment of RO concentrate, as the selected alternatives for pilot testing in the Treatability Study. These alternatives assumed an overall RO recovery of 85% and 95%, respectively, meaning that 3M would route only 15% or 5% of the influent flow to AIX for concentrate treatment. Figure 1.1 shows simplified block flow diagrams of Alternatives 5 and 6 as described in the Treatability Plan.

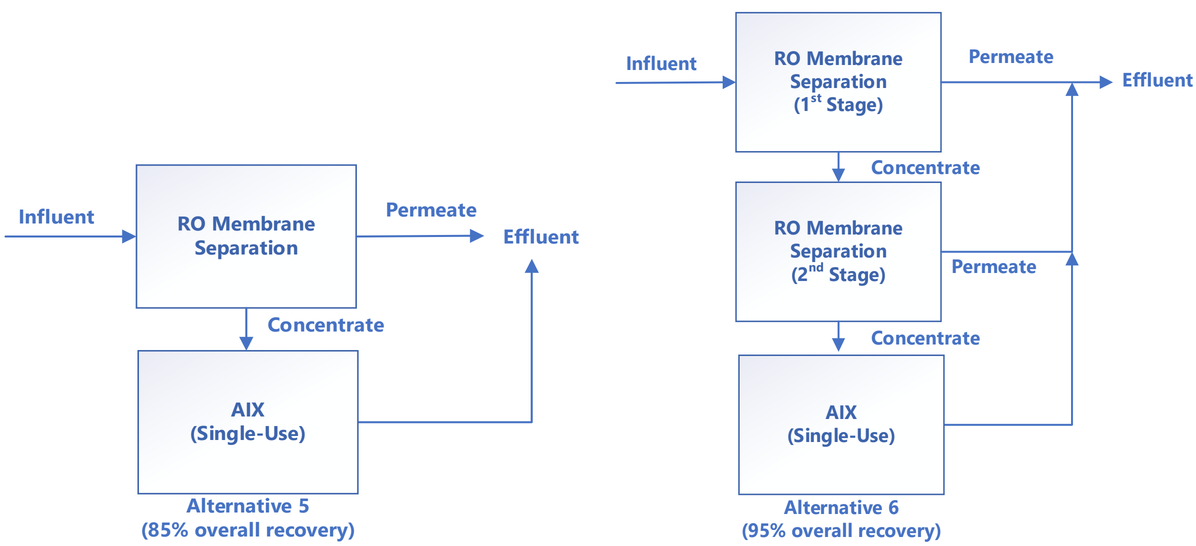

Figure 1.1 Block flow diagram for Alternatives 5 and 6 – RO with AIX

The treatment technology configuration used during the Treatability Study was an adaptation of Alternatives 5 and 6, further described in Section 2 of this report. Adaptations tested in this pilot

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[1] Barr Engineering Co. PFAS Treatability Alternatives Identification Plan. Prepared for 3M Cottage Grove Facility. July 2021.

included UF for pretreatment of the WW ahead of the RO, different combinations of media treatments for the RO concentrate, and regeneration of the AIX resin.

1.2 Treatability Study Objectives

The objectives of the Treatability Study were to evaluate removal efficiencies and operational considerations of the individual technologies included in the selected treatment alternatives using different potential feed-water streams, informing the basis for a full-scale treatment system design. As outlined in the Treatability Plan, the design parameters to be evaluated during this Treatability Study included:

- RO membrane flux rate and PFAS rejection efficiencies.
- AIX empty bed contact times (EBCT), hydraulic loading rates (HLRs), and time to breakthrough for PFBA and other PFAS of interest.

In addition to RO rejection demonstrations and AIX capacity testing, 3M evaluated a potential liquid-liquid extraction technology to remove PFAS from the NCCW/SW and Phase 1/2 WW RO concentrate streams concurrently with the pilot test activities. Section 3.4.2 discusses these efforts.

The Pilot Test Workplan (included as an appendix to the Treatability Plan) outlined specific test objectives, including testing WW generated from the on-site incinerator (identified as Phase 3 WW). However, on August 4, 2021, 3M announced that it would discontinue the incineration process used at the Facility by the end of 2021. Because the Facility will not generate Phase 3 WW after 2021, the scope of work included in this Treatability Study does not include test objectives specific to Phase 3 WW.

1.3 Report Organization

Section 2 of this report summarizes pilot test methods, including the pilot test process flow diagram and equipment, sampling and analysis methods, and pilot operating phases.

Section 3 summarizes the results from the pilot test work, focusing on achievable RO recovery and PFAS removal from RO concentrate using AIX technology for each water source, and compares the PFAS analytical results from the two laboratories used during the Treatability Study.

Section 4 summarizes the pilot test results compared to the preliminary evaluation of treatment alternatives presented in the Treatability Plan. This comparison highlights any significant modifications that 3M may need for the full-scale implementation of the selected alternative. Section 4 also includes a description of the preliminary design basis for the treatment processes selected by 3M for full-scale implementation. This includes updates to the preliminary capital and operating cost estimates previously provided in the Treatability Plan.

1.4 Definitions

Definitions are provided below for several parameters used in this Treatability Study to describe the pilot-test methods and results:

- Flux: For UF and RO membrane filtration, flux describes the volume of permeate produced per unit of membrane surface and per unit time. Flux is typically expressed in gallons per square foot per day (GFD).

- Recovery: Recovery is the ratio of the permeate water flow to the filter feed-water flow for UF and RO membrane filtration, typically expressed as a percentage.

- Trans-membrane pressure (TMP): TMP is the difference in water pressure between the filter feed and the permeate for UF and RO membrane filtration. TMP is the driving force for permeate generation; typically, increasing the TMP increases membrane flux.

- Rejection efficiency (PFAS-specific): Rejection efficiency describes the mass of PFAS eliminated from the RO permeate by the RO membrane. Eqn. 1, below, calculates rejection efficiency.

  $$\text{Rejection Efficiency (as \%)} = \frac{(\text{RO Influent Concen. - RO Permeate Concen.})}{\text{RO Influent Concen.}} \times 100\% \qquad \text{Eqn. 1}$$

  In this report, if the RO permeate PFAS concentration was below the LOD, the rejection efficiency was calculated using the nominal LOD value. For these instances, the rejection efficiency is shown as greater than (>) the calculated rejection efficiency to signify that the actual rejection efficiency is likely greater than the calculated value using the LOD.

- Breakthrough: In this report, we define breakthrough as the timepoint or volume of water treated when a specific PFAS is first detected above the LOD following a GAC or AIX resin (media) vessel. Subsequent detections indicate a consistent breakthrough curve.

- EBCT: EBCT measures the amount of time water is in contact with a filtration media. It is calculated as the total media (BV) (the total media BV includes both the physical media volume and the pore space volume) divided by the forward water flow rate (refer to Eqn. 2). EBCT is expressed in units of time (e.g., minutes).

  $$\text{EBCT} = \frac{\text{Total Media Bed Volume}}{\text{Forward Water Flow Rate}} \qquad \text{Eqn. 2}$$

- BVs: BVs are a unitless measure of the volume of water treated through GAC and AIX media. Because BVs are a unitless measure, they apply to different sizes of water treatment vessels (i.e., pilot- vs. full-scale). BVs are calculated as the total volume of water treated divided by the total volume of the media bed (refer to Eqn. 3).

  $$\text{Bed volumes} = \frac{\text{Total Volume of Water Treated}}{\text{Total Media Bed Volume}} \qquad \text{Eqn. 3}$$

For vessels in series (lead-lag configuration), the BVs of water treated through the lead vessel are calculated using only the total BV of the lead vessel, whereas the BVs of water treated through the lag vessel are calculated using the total BV of both the lead and lag vessels. For example, if 1,000 liters (L) of water are treated through lead-lag vessels each filled with 2 L of media, the BVs treated through the lead vessel are 500 (1000 L/2 L), and the BVs treated through the lag vessel are 250 (1000 L/[2 L + 2 L]).

Using this convention, comparing the BVs treated to PFAS breakthrough between the lead and lag vessels provides a way to assess whether additional contact time with the media benefits PFAS removal. If the number of BVs to breakthrough from the lag vessel (lead + lag BVs) is greater than the number of BVs to breakthrough across the lead vessel, this indicates that a longer EBCT provides additional removal capacity. Typically, a longer EBCT is beneficial for GAC media because the removal of PFAS by GAC can be kinetically limited by the rate of surface-diffusion processes on the GAC surface. In contrast, the same benefit is not typically observed for AIX resin with a longer EBCT because the rates of the ion exchange and sorption onto AIX resin surfaces are relatively rapid such that additional EBCT does not provide additional removal capacity. Thus, for AIX resin, it is expected that the number of BVs to breakthrough from the lead vessel will be similar or equivalent to the BVs to breakthrough from the lag vessel.

Under this convention, it is also possible for the BVs breaking through from the lag vessel to be less than the BVs breaking through from the lead vessel. This phenomenon indicates that breakthrough from the lag vessel occurs effectively at the same time or soon after breakthrough from the lead vessel.

The observed number of BVs to breakthrough is dependent on the LODs of the specific analytical method used. Thus, the observed number of BVs to breakthrough is susceptible to variability based on analytical method limitations (e.g., elevated LODs from matrix interferences).

2 Methods

3M performed pilot testing for this Treatability Study following the Pilot Test Workplan as further described in this section.

2.1 Pilot Test Treatment Processes

Figure 2.1 shows the treatment processes used during the pilot test. These processes were used to simulate Alternatives 5 and 6, the selected alternatives from the Treatability Plan. Pilot test treatment also included UF pretreatment ahead of RO membrane separation, GAC adsorption of RO concentrate before AIX treatment, and regeneration of the AIX resin. Large Figure 1 includes a general layout of the pilot location relative to the site.

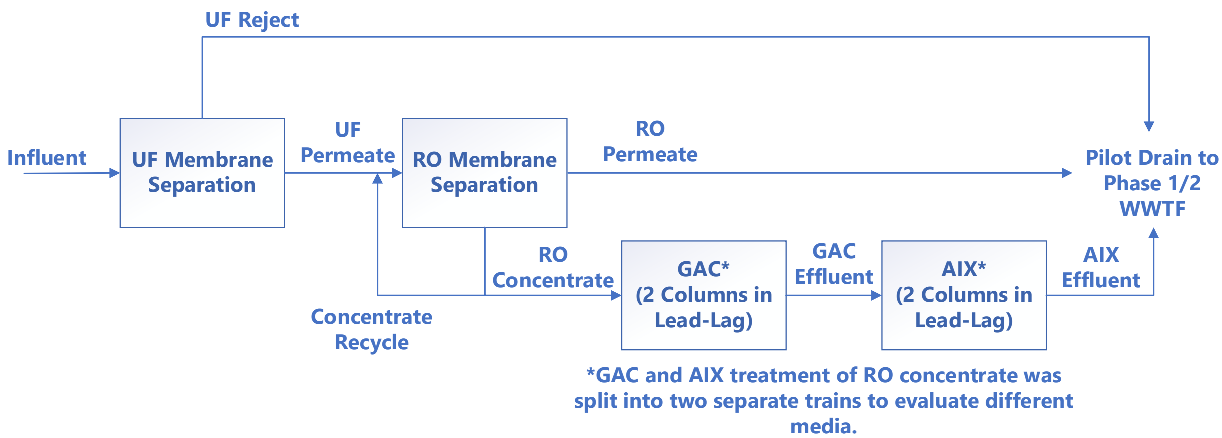


Figure 2.1 Pilot test treatment process configuration

The following section provides additional details on the equipment used for each treatment process. Large Figure 2 and Large Figure 3 provide detailed process flow diagrams for the NCCW/SW and WW test phases, respectively.

2.2 Equipment Summary

Pilot equipment sizing was based on full-scale treatment plant design factors, with a particular focus on the GAC and AIX column configurations, sizing, and HLRs. These configurations were scaled down to a size 3M could use on-site. The pilot test column configurations, in turn, dictated a minimum sizing for the UF/RO system. Table 2.1 outlines key design parameters and the rationale for sizing the pilot test equipment.

Table 2.1 Summary of pilot test equipment design and rationale

Process	Design Parameter	Pilot Test Value	Typical Full-Scale Value	Reason for Difference (if applicable)
UF	Flux (NCCW/SW)	85 GFD	32 GFD	Pilot test equipment limitation—full-scale rate is lower
	Flux (Phase 1/2 WW)	85 GFD	22 GFD	Pilot test equipment limitation—full-scale rate is lower
RO	Flux (NCCW/SW)	14 GFD	16 GFD	Within acceptable range—Brackish well source with UF pretreatment allows permeate flux between 14 and 18 GFD
	Flux (Phase 1/2 WW)	12 GFD	12 GFD	--
	Recovery	85%	85%	--
GAC[1]	EBCT	15 to 30 min	10 to 30 min	High PFAS concentrations require longer EBCT
	HLR	0.9 to 1.8 gpm/SF	2 to 6 gpm/SF	Low HLR due to longer EBCT
AIX[1]	EBCT	15 to 30 min	2 to 5 min	High PFAS concentrations require longer EBCT
	HLR	0.9 to 1.8 gpm/SF	6 to 12 gpm/SF	Low HLR due to longer EBCT

GFD=gallons per square foot per day, EBCT=empty bed contact time, HLR=hydraulic loading rate, gpm/SF = gallons per minute per square foot
[1] Typical design values listed reflect higher EBCT for high-concentration, short-chain PFAS treatment than for more conventional PFAS applications to decrease required GAC changeout and AIX regeneration frequencies.

2.2.1 UF/RO Membrane Separation Equipment

Zeeweed 1500 Junior UF modules and AK4040TM AK Series RO membranes, both provided by SUEZ Water Technologies (SUEZ), were selected for use in pilot testing. Appendix A includes product fact sheets for these membranes. These membranes were selected to maintain a consistent design basis with similar treatment systems currently in development at other 3M facilities.

3M considered both low energy and high rejection RO elements. Membranes with low energy requirements were selected. While low-energy membranes also have lower rejection than higher energy membranes, 3M considered operation at a lower specific energy consumption more beneficial for long-term full-scale sustainability than higher rejection. The AK Series membranes have a standard sodium chloride (NaCl) test solution rejection of 99.0%. 3M expects these membranes to have similar or higher rejection for PFAS due to their comparatively larger size.

The RO unit used during the pilot test was a single-stage array of three RO elements. “Multiple stages” refers to the number of membrane units treating concentrate from the previous stage, useful in increasing overall recovery and constituent concentration in the final concentrate. “Multiple passes” refers to the number of membrane units treating permeate from the previous pass, which is useful in producing very high-purity water. A single-pass, multi-stage system will likely be used for full-scale treatment to facilitate high recovery by subjecting membrane concentrate to additional membrane separation steps within the same RO unit. However, the low flow rate needed for the pilot test made the continuous operation of a multi-stage system inefficient. To achieve the target recovery range of between 85% (Alternative 5) and 95% (Alternative 6), 3M employed a semi-closed-circuit operation in conjunction with the single-stage system. In this configuration, a defined portion of the concentrate (between 5% and 15% of the incoming feed flow) was continuously removed from the system and sent forward for treatment through the GAC and AIX systems. The remaining concentrate was returned as feed to the RO system.

2.2.2 GAC and AIX Equipment and Media

3M selected two different regenerable AIX resins for pilot testing to provide a side-by-side comparison of different products by comparing removal and regeneration performance for PFAS of differing chain lengths. The selected resins included:

- SORBIX A3F resin was selected as it is currently the only commercially available regenerable AIX resin.
- CalRes 2301 was selected based on bench testing work performed by 3M's Film and Materials Science Research and Development Lab. This work indicated that CalRes 2301 may have a higher capacity than A3F resin and may be regenerated with the same alcohol/brine regenerant used to regenerate A3F resin.

Table 2.2 summarizes the GAC and AIX media configurations used during the pilot test.

Table 2.2 GAC and AIX media treatment train configurations

Media Treatment Train	Column	Media Type Product Name Purpose
CalRes Concentrate Train	Columns GAC1 (lead) and GAC2 (lag)	GAC Calgon F400 Total organic carbon (TOC) removal, long-chain PFAS removal
	Columns IX1 (lead) and IX2 (lag)	Macroporous AIX Resin CalRes 2301 Short-chain PFAS removal (PFCAs only)
SORBIX Concentrate Train[1]	Columns GAC1 (lead) and GAC2 (lag)[1]	GAC Calgon F400 TOC removal, long-chain PFAS removal
	Columns regenerable ion exchange resin (IXR)1 (lead) and IXR2 (lag)	Macroporous AIX Resin SORBIX A3F Short-chain PFAS removal (PFCAs and PFSAs)
CalRes Permeate Train	Columns IX1 (lead) and IX2 (lag)	Macroporous AIX Resin CalRes 2301 PFAS removal (All PFAS)

[1] No PFAS samples were collected from the GAC columns of the SORBIX Concentrate Train. It was operated the same way as the GAC Train for the CalRes Concentrate Train and assumed to have equal performance.

2.3 Source Waters

The WW collection system at the Facility receives WW from multiple processes for one of two main phases of treatment:

- Phase 1, the inorganic treatment system, adjusts the pH and removes suspended solids from the process WW.
- Phase 2, the organic treatment system, treats organic material and nutrients in process WW and sanitary WW from across the Facility.

Effluent from the combined Phase 1/2 WW treatment systems currently receives final treatment through GAC for polishing, followed by ultraviolet (UV) disinfection. After GAC treatment and UV disinfection, the Phase 1/2 effluent flows to Outfall SD001 (SD001).

Combined NCCW and SW from a portion of the site flows to Outfall SD002 (SD002). Effluent from SD001 and SD002 combines at Outfall SD003 (SD003) before discharging from the Facility to the Mississippi River via an unnamed creek.

3M used two different source waters during the pilot testing:

- NCCW/SW effluent (SD002)
- Phase 1/2 GAC influent

Figure 2.2 shows where 3M obtained these source waters for the pilot test.

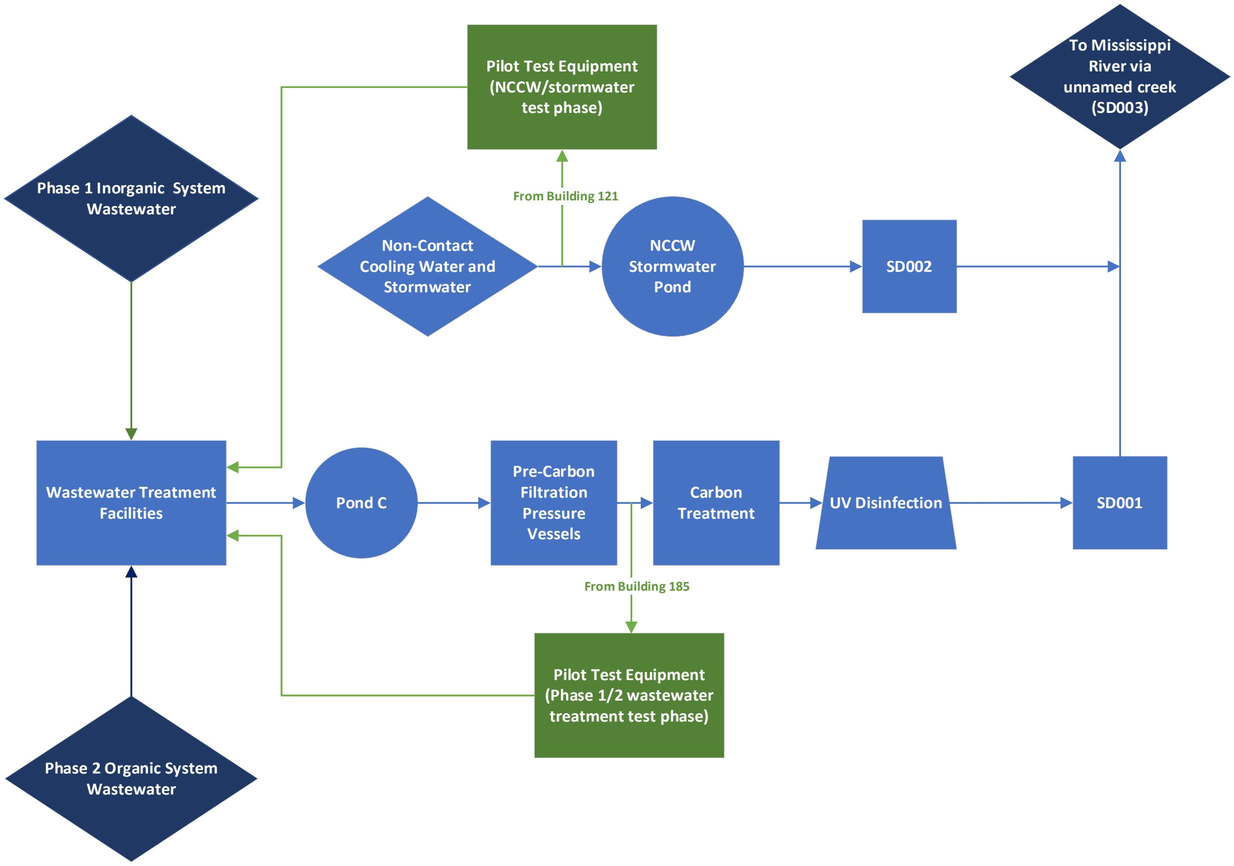


Figure 2.2 Pilot test source water locations

NCCW/SW source water consisted of groundwater collected from a series of on- and off-site wells along with SW upstream of the Facility's NCCW Stormwater Pond. All NCCW and SW from across the site are combined in the NCCW Stormwater Pond, and 3M recycles a portion of the pond water to Building 121 for use in the solids dewatering process. 3M routed source water for NCCW/SW pilot testing from Building 121 to the equalization (EQ) tank for the pilot system, near Building 185. This source water was allowed to overflow continuously while the UF system was online, ensuring that the feed water to the pilot test equipment was always representative. 3M routed the overflow with pilot test effluent to the head of the Phase 1/2 WW treatment facilities (WWTFs).

The Phase 1/2 GAC influent source water consisted of treated WW from the combined Phase 1/2 systems. This source water was obtained downstream of pre-carbon filtration with glass media filters in Building 185 and upstream of existing GAC treatment and UV disinfection.

2.4 Pilot Test Phases

3M completed pilot testing in five different phases. Table 2.3 outlines the five pilot test phases, operational conditions, and the dates associated with each phase.

Table 2.3 Pilot test phases

Test Phase	Source Water	RO Recovery	GAC and AIX EBCT (min)	Start Date	End Date	Duration (days)
NCCW_A	NCCW/SW	85%	15	7/30/2021	8/16/2021	17
NCCW_B	NCCW/SW	85%	30	8/23/2021	9/13/2021	21
WW	Phase 1/2 WW	85%	30	9/14/2021	9/30/2021	16
NCCW_C	NCCW/SW	92%	30	10/1/2021	10/2/2021	1
NCCW_D	NCCW/SW	95%	30	10/3/2021	10/29/2021	26

After using a 15-minute EBCT during the NCCW_A test phase, 3M operated the subsequent test phases with an EBCT of 30 minutes per column and collected samples at a higher frequency to develop higher resolution and more complete breakthrough curves. The 30 minutes per column EBCT rate was maintained throughout the remainder of the study.

3M executed the NCCW_C and NCCW_D test phases to quantify both RO and downstream media performance at higher RO recovery per Alternative 6. The higher RO recovery was expected to produce concentrate with higher total dissolved solids (TDS) and PFAS concentrations, which could affect the AIX resin capacity and run times before a regeneration was needed. However, RO performance degraded in less than a day during the NCCW_C test phase. In response, pH adjustment and a lower permeate flux rate were implemented during NCCW_D to reduce scaling.

2.5 Sampling and Monitoring

3M collected water samples throughout the pilot test per the sampling plan included in Appendix B. Additional detail on the sampling and monitoring activities performed during the pilot test are described below.

2.5.1 Field Parameters

3M monitored the following field parameters throughout the pilot testing program.

- Flow rates and totalizer volumes
- Water levels in equalization (EQ) tanks
- System pressures around the UF and RO processes, as well as at the influent of each GAC/AIX resin column
- Specific conductivity
- TDS concentrations
- Turbidity
- Oxidation reduction potential
- pH
- Chemical tank levels (UF and RO pretreatment chemicals)

Field parameter data were collected daily. Section 3.1.1 and 3.2.1 discuss the results obtained from monitoring these field parameters.

2.5.2 Water Sample Collection and Analysis

During each of the pilot test phases described in Section 2.4, 3M collected water samples at the following locations:

- Pilot Influent (UF Feed)
- UF Permeate (RO Feed)
- RO Permeate
- RO Concentrate
- Lead GAC Column Effluent (GAC1 from the CalRes Concentrate Train)
- Lag GAC Column Effluent (GAC2 from the CalRes Concentrate Train)
- Lead CalRes Column Effluent (IX1)
- Lag CalRes Column Effluent (IX2)
- Lead SORBIX Column Effluent (regenerable ion exchange resin [IXR]1)
- Lag SORBIX Column Effluent (IXR2)

3M collected all water samples using the procedures described in the Workplan and submitted them with chain-of-custody documentation to analytical laboratories for analysis of PFAS and other water chemistry constituents. Three laboratories completed water quality analyses during the pilot test:

- Enthalpy Analytical analyzed a list of 16 PFAS (included in Table 2.4 below). 3M submitted most samples to Enthalpy with a requested 5-day turnaround time to facilitate pilot adjustments in response to the data.
- 3M Global EHS Laboratory analyzed a list of 32 PFAS and achieved generally lower detection limits than Enthalpy.
- Pace Analytical (Minneapolis) analyzed general (non-PFAS) water chemistry constituents.

Appendices C, D, and E provide laboratory data and additional detail on laboratory methods.

2.5.3 PFAS Analytes and Method Selection

The 16 PFAS analyzed by Enthalpy Analytical (provided in Table 2.4) include a range of chemical and physical properties and act as a surrogate for the broader list of PFAS included in the Treatability Plan. 3M selected the subset of 16 PFAS because:

1. A review of the PFAS data in the Treatability Plan showed that greater than 90% of PFAS mass in the NCCW/SW and Phase 1/2 WW streams comprises five PFAS: TFA, TFMS, PFPA, HQ-115, and PFBA.
2. Enthalpy Analytical could readily analyze the list of 16 PFAS on an expedited timeline.

The sum of concentrations of these 16 PFAS are presented throughout this report and referred to as the "Sum of 16 Analyzed PFAS."

Enthalpy Analytical used direct injection analytical methods, both with and without isotopic dilution. 3M selected direct injection methods to receive results in an expedited timeframe to inform pilot test operational decisions and quantify the relative order of magnitude of PFAS concentrations throughout the pilot test streams. The LODs achieved by Enthalpy using direct injection methods were variable depending on the specific PFAS analyte and the sample matrix, typically ranging between 100 and 5,000 ng/L (full range from 0.1–233,000 ng/L). LODs generally improved as the water was treated through the pilot test treatment system (e.g., LODs were lower for samples collected in the RO permeate streams than the influent and RO concentrate streams).

A subset of samples was also analyzed by the 3M Global EHS Laboratory for a larger suite of 32 PFAS. 3M used these data to verify results from Enthalpy Analytical and assess the treatability of a broader list of PFAS. The 3M Global EHS Laboratory also used a direct injection analytical method.

Table 2.4 Summary of the 16 PFAS analyzed by Enthalpy Analytical

Group No.[1]	Abbreviation	Full Name
Group 1		
1	TFA	Trifluoroacetic acid
2	TFMS	Perifluoromethanesulfonate
3	2,2,3,3-TFPA	2,2,3,3-Tetrafluoropropionic acid
4	2,3,3,3-TFPA	2,3,3,3-Tetrafluoropropionic acid
5	PFPA	Perfluoropropionic acid
6	HQ-115	Methanesulfonamide, 1,1,1-trifluoro-N-[(trifluoromethyl)sulfonyl-
7	PFBA	Perfluorobutyric acid
8	PFPeA	Perfluoropentanoic Acid
Group 2		
9	PFBS	Perfluorobutanesulfonate
10	PFPeS	Perfluoropentanesulfonate
11	PFHxA	Perfluorohexanoic acid
12	PFHpA	Perfluoroheptanoic acid
13	PFHxS	Perfluorohexanesulfonate
14	PFHpS	Perfluoroheptanesulfonate
15	PFOA	Perfluorooctanoic acid
Group 3		
16	PFOS	Perfluorooctanesulfonate

[1] Groups 1, 2, and 3 were established in the Treatability Plan based on the number of carbon atoms, the number of fluorinated carbons, and the physical characteristics of the PFAS. These groups were established to estimate the treatability of specific PFAS for which publicly available treatability information is not available.

2.6 Pilot Test Startup and Operation

The pilot test treatment system was developed to meet the requirements of the Treatability Study and was assembled and tested by Emerging Compounds Treatment Technologies Inc. (ECT2) before delivery.

The pilot test equipment was delivered to the Facility on July 11, 2021. Commissioning continued over the rest of the week, including safety and quality checks. Various construction activities to prepare the site for pilot testing included the installation of secondary containment basins, equalization tanks, and interconnecting piping and electrical utility connections.

Tanks and the pilot test equipment were located on top of spill-containment basins, which provided secondary containment in the event of a spill or other inadvertent discharge of test water. Since the secondary containment basins were outdoors, rainwater was also captured and regularly forwarded to the common drain line. 3M routed water treated through the pilot test system, residual cleaning solutions, and excess WW to the influent of the existing WWTF.

The following sections describe operational details for individual components of the pilot test system.

2.6.1 UF/RO Membrane Separation Operations

The UF and RO systems were operated in series. The process goal of the UF membranes is to remove suspended solids prior to RO membrane separation, while the process goal of the RO membranes is to separate dissolved solids and contaminants into a concentrated stream, resulting in two streams. Water passing through RO membranes is RO permeate, and the remaining stream containing separated dissolved solids is RO concentrate. As described in Section 2.6.2, RO concentrate containing elevated concentrations of PFAS was sent to GAC and AIX resin trains for further treatment.

3M collected flow readings according to the Sampling and Analysis Plan. As described in the Workplan, 3M monitored field parameters and collected water samples for analysis at the UF influent, UF effluent (RO influent), RO permeate, and RO concentrate. Additional details on the operation and cleaning of the UF and RO treatment units are described below.

The UF system was operated with fixed time setpoints, stepping through the sequences shown in Table 2.5 and summarized below.

- Forward flow: UF operated in dead-end filtration.
- Backwash: UF used filtrate to backwash the hollow fiber UF, pressurizing the filtrate side. This step served to lift the accumulated solid cake layer formed from forward flow off the fiber surface for disposal.
- Backwash/air scour: This step served to agitate the hollow fibers and any remaining solids inside the UF module before the flush step.
- Flush: The UF module was drained completely, removing any remaining solids.
- Fill: Feed water was reintroduced to the UF module inlet. Water at the top port was directed to drain, flushing any remaining solids not drained from the module during the flush step. Once the module was filled, the cycle returned to forward flow and repeated in a continuous loop.

Table 2.5 UF operational sequence durations

	Minutes
Total cycle time	60
Forward flow	57.66
Backwash	0.5
Backwash/air scour	0.5
Flush	0.5
Fill	0.83
Sum offline	2.33
Percent recovery	96%

Percent recovery for the UF was established by dividing the duration of forward flow by the total cycle time. Since the flow rate was constant across all steps, no correction was needed for differing instantaneous flux rates during the various sequence steps.

Following successful safety and quality checks, the RO system was loaded with membranes and operated with UF permeate for 2 hours. After this flush was complete, operators brought the RO system to the test-operating point; RO permeate and concentrate production for analysis and testing began on July 26, 2021. Due to the low concentrate flow rate, filling the approximately 600-gallon EQ tank took several days. By July 30, 2021, the minimum RO concentrate and permeate volumes required were available, and the first column test commenced.

3M operated UF/RO equipment only during normal business hours with operators present. The small scale of the UF and RO systems required operator oversight at regular intervals to verify the system was operating at the indicated setpoints. These units were specified to produce a surplus volume of water during normal business hours to allow for continuous (24/7) operation of the GAC and AIX media test columns (see below) using stored process water volume during UF/RO downtime. To allow the pilot test columns to run continuously, RO permeate and concentrate were collected in break tanks used to feed downstream resin trains continuously at the specified rates.

3M performed clean-in-place (CIP) operations on UF and RO processes to ensure confidence in the proposed cleaning regime. CIP procedures involved removing the treatment train from service and recirculating a cleaning solution across the membrane surface. The cleaning solutions removed compounds such as suspended solids, sparingly soluble salts, and other compounds accumulated on the membranes during normal operations. For CIP of the UF membranes, 3M used sodium hypochlorite, a disinfectant, and sodium hydroxide, a high pH source, to remove organic substances and suspended solids. For CIP of the RO membranes, 3M used an acidic solution of citric acid and sulfuric acid to remove chemical precipitation and other foulants. The CIP solution consisted of 250 milligrams per liter (mg/L) of citric acid, further acidified to pH 2 using sulfuric acid for the NCCW_D test phase. CIP cleaning events were conducted at the end of NCCW_B and WW test phases and daily during the NCCW_D test phase

2.6.2 GAC and AIX Media Treatment Operations

GAC and AIX media columns operated 24 hours a day. 3M collected analytical samples, field parameters, and flow readings for the GAC and AIX operations according to the Sampling and Analysis Plan.

GAC and AIX columns were filled with the selected media as described below. First, operators rinsed and filled each empty column with deionized (DI) water. Next, the GAC or AIX resin was wetted with DI water and slowly added to the column, allowing it to settle to the bottom. Operators then removed displaced DI water from the top of the column. After filling, operators backwashed each GAC column with DI water at a rate of approximately 330 milliliters(mL)/minute (3.7 gpm/SF), targeting 25% bed expansion and allowing fines and any other material to rise to the top of the bed and be removed. The column was then allowed to settle before being placed into service. The backwash water was routed along with the rest of the tank overflow points and other drain streams to the head of the existing WWTF. During operations, hen air bubbles or voids were observed based on changes in flow or pressure readings, agitation or backwashing with DI water was performed to maintain a uniform BV.

Spent lead AIX columns from the WW phase were flushed with DI water before being prepared for shipment off-site for alcohol/brine regeneration. 3M selected these columns because they had the highest PFAS loading of the AIX pilot columns and were expected to have the highest mass of PFAS sorbed. ECT2 collected samples of spent regenerant at every 1.25 BVs to evaluate its effectiveness in removing the different PFAS compounds loaded onto the resin media. Section 2.6.4 describes the specifics of the regeneration procedure and sampling.

Operators changed out media in all four columns between test phases, except NCCW_A and NCCW_B. During this phase change, the CalRes and SORBIX AIX media in RO concentrate treatment trains were changed out, but GAC media in these trains were not. Operators did not change out the AIX media in the RO permeate treatment train during the NCCW_A and NCCW_B test phases, trying to maximize the BVs treated through this column train.

Between NCCW_A and NCCW_B, RO operation remained at 85% recovery, but the column loading rate was decreased to increase EBCT per column to 30 minutes instead of 15. 3M made this change in EBCT and collected samples twice as frequently to increase data resolution by an overall factor of four, enabling breakthrough observation.

2.6.3 Pilot Test Phase Changeover

When switching source waters between test phases, flow from the initial source was stopped. Operators then flushed and thoroughly rinsed the EQ and break tanks with RO permeate water to remove any remaining source water from the previous test. Next, the new source was introduced by connecting the inlet to the EQ tank. With the new source connected, 3M operated the EQ tank in overflow mode for a minimum of 2 days and operated the inlet lines between the pilot equipment and the feed tanks for 20 times the theoretical residence times using the new feed water before the next column test was started.

2.6.4 AIX Regeneration

As noted previously, 3M selected the lead columns from the RO concentrate AIX trains used during the WW test phase for regeneration testing. These columns included:

- IX1-A: Train A, lead CalRes 2301 column
- IX1-B: Train B, lead SORBIX A3F column

One column containing each type of resin, subjected to similar loading, was selected to provide comparable desorption curves.

After flushing with DI water, the lead RO concentrate columns from the WW phase of the pilot test were drained, sealed, wrapped in appropriate packaging, and then shipped to the ECT2 research and development laboratory in Fuquay-Varina, North Carolina.

The solution used to regenerate the media was made by mixing 80 volume % SDA-3C alcohol (95 volume % Ethanol/5 volume % Isopropanol) with 20 volume % water and 1 weight % salt (NaCl) into a 5-gallon carboy. To regenerate the AIX resin, operators pumped the regenerant solution through the media in the opposite direction of the forward flow at a rate of 2 BVs/hour (30 minutes EBCT, ~77 mL/min) for a total of 5 BVs or 2.5 hours. Operators collected spent regenerant grab samples every 7.5 minutes (0.25 BV). Excess spent regenerant was collected in a separate 15-gallon drum. After operators pumped 5 BVs (12.5 L) of regenerant through the media bed, the residual regenerant was flushed with potable water at a rate of 2 BVs/hour (~77 mL/min) for 2 BVs. After 2 BVs were pumped through the media, an additional 10 BVs of rinse water were pumped through the media bed at a flow rate of 6.7 BVs/hour (~280 mL/min). Large Table 6 lists regeneration volumes, times, and BVs, as well as resulting PFAS concentrations.

3 Pilot Test Results

This section describes pilot test results for UF and RO operation and PFAS treatability through RO, GAC, and AIX media columns for each testing phase. This section also includes the results of additional analytical and treatment technology test work conducted by 3M to further support the design of a full-scale treatment system for the removal of PFAS. The additional work included the following:

- Collection of split samples for comparison of analytical results between the two laboratories used during the Treatability Study
- Treatment of RO permeate using AIX
- Liquid-liquid PFAS extraction
- AIX regeneration

3.1 NCCW/SW

3.1.1 Pilot Operation Summary

NCCW/SW was the influent feed for four of the five test phases. Table 3.1 summarizes operating results from three of the four test phases. It does not include the NCCW_C test phase, which was only operated for 4 hours due to rapid membrane scaling.

Table 3.1 Summary of average UF and RO operational parameters for NCCW/SW test phases

	Test Phase	NCCW_A	NCCW_B	NCCW_D
Operational Parameters	**Units**			
UF Operations (Two trains in parallel)				
Flux	GFD	85	85	85
Trans-membrane pressure	PSId	9.5	9.5	10
Permeability	GFD/PSI	8.7	8.7	8.2
Flow (total)	gpm	1.9	1.9	1.9
Recovery (% to permeate)	%	96%	96%	96%
RO Operations				
Feed pressure	PSI	123	123	216
Pressure drop	PSId	2.9	2.9	2.7
Permeate flux	GFD	14	14	11
Recovery (% to permeate)	%	85%	85%	94%
Observed TDS rejection[1]	%	99%	93%	78%

GFD=gallons per square foot per day, PSId= differential pressure, gpm=gallons per minute, PSI=pounds per square inch

[1] TDS rejection was calculated based on RO permeate TDS concentrations compared to RO feed concentrations for NCCW_A. RO permeate was not sampled for other phases, and RO concentrate was used to estimate TDS rejection.

RO membrane TDS rejection during NCCW_A matched the stated NaCl rejection of the membrane at 99%. However, calculated TDS rejection for NCCW_B and NCCW_D phases were 93% and 78%, respectively. Three potential outcomes could account for the decrease in dissolved constituent mass measured in the concentrate during the NCCW_B and NCCW_D test phases:

- Chemical precipitation of solids in the RO concentrate
- Chemical precipitation of solids on the membrane surface
- Passage of dissolved solids to the RO permeate

Analytical results show increased TSS in the RO concentrate for the NCCW_D test phase. However, the reported concentration of TSS (see Table 3.2) is calculated to account for approximately four percent of potentially additional TDS. 3M experienced operational issues consistent with potential chemical precipitation of solids on the membranes. However, the mass recovered from membranes during cleaning operations cannot be quantified with the available pilot test data. Similarly, the TDS mass in the RO permeate was not measured in the NCCW_D phase. Considerations to address each of the three potential mechanisms for decreased TDS in the RO concentrate will be included in the full-scale system design.

Table 3.2 summarizes water quality data for NCCW test phases. The pH through the treatment train is near neutral, ranging from 5.2 to 8.7. TSS concentrations were below 10 mg/L in the UF feed, RO feed, and RO permeate but increased in the RO concentrate (GAC feed, AIX feed, and AIX effluent) during the NCCW_D test phase. Elevated TSS in the RO concentrate may be due to carbonate or other chemical precipitation in the RO concentrate during the operation of the RO units with higher permeate recovery. 3M observed turbidity values between 1–2 nephelometric turbidity units (NTU) in the RO concentrate (GAC feed and AIX feed). Influent total organic carbon (TOC) was decreased in the RO permeate and increased in the RO concentrate. The GAC feed, AIX feed, and AIX effluent TOC were between 17–23 mg/L, suggesting limited TOC removal through GAC and AIX. Large Table 1 and Large Table 2 provide detailed water quality and field parameter data.

Table 3.2 Summary of average water quality and field parameters for NCCW Tests

	Units	UF Feed	RO Feed	GAC Feed	AIX Feed	RO Permeate	AIX Effluent
Calcium	mg/L	101	100	594	425	0.9	410
Iron+ Manganese	mg/L	<0.055	<0.055	<0.055	<0.055–0.1	<0.055	<0.055–0.1
TOC	mg/L	4.8	4.9	23	17–20	1.4	15–17
TDS[1]	mg/L	292–570	437–514	3,170–5,680	2,370–5,640	10–87	2,390–5,440
TSS[1]	mg/L	<10	<10	<10–300	<10–470	<10	<10–358
Turbidity[2]	NTU	0.21–0.33	0.05–0.36	1.3–1.4	1.5–1.7	NA	0.2–0.9
pH[2]	Std. Units	7.5–8.1	5.2–8.1	8.1–8.3	8.0–8.7	6.0–8.7	5.6–8.3

[1] Variation in TDS and TSS concentrations reflect differences in recovery between NCCW_A/NCCW_B and NCCW_D, with higher TDS and TSS concentrations observed during NCCW_D.
[2] 3M did not collect field data during the NCCW_D test phase.

UF Operating Performance

The TMP across the UF membranes ranged from 9.5 to 10 PSId during the pilot test. The UF feed and filtrate turbidity levels were consistently below 1.7 NTU and 0.4 NTU, respectively. Appendix F includes results from operational monitoring of the UF system during the NCCW/SW testing phases. 3M observed no significant fouling during the NCCW/SW test phases.

In one specific instance during commissioning, the feed tank was allowed to sit stagnant for 4 days in direct sunlight before being placed into service. This resulted in algae growth in the UF feed tank and elevated TMP trends in the UF system. To resolve this issue, operators cleaned the feed tank using a dilute hypochlorite (100 mg/L) solution before completely draining and refilling it. After this flush, operators covered the tank with a heavy poly barrier to prevent UV light from entering it. 3M also operated the tank with a continuous overflow to maintain representative test conditions through the NCCW inlet line and throughout the tank volume during planned system downtime overnight.

RO Operating Performance

Using UF filtrate from the NCCW/SW source, 3M operated the RO system at design setpoints of 85% recovery and 14 GFD permeate flux rate during test phases NCCW_A and NCCW_B. The TDS in the concentrate were 6.7 times higher than in the feed stream but did not exceed solubility limits for any dissolved constituents. Observed TDS rejection was consistent with reported membrane performance for NaCl. This matched the RO recovery projections conducted before the pilot test, which included predicted membrane rejections using RO modeling software provided by SUEZ. Appendix G includes graphical summaries of the operations monitoring for the RO system.

During test phase NCCW_C, at an operating target of 95% recovery, scale formed within the RO array even when using an antiscalant chemical additive. After 4 hours of operation, the conductivity of the permeate increased by 80%, and the system reached the maximum operating pressure of 300 PSI. At 95% recovery, the TDS in the concentrate were 20 times higher than the feed stream and exceeded the solubility limit for constituents present in the feed, resulting in precipitation of solids on the membrane.

To minimize chemical precipitation during test phase NCCW_D, 3M decreased the pH of the feed stream to 7.05 standard units by adding 30 parts per million H_2SO_4. However, pH adjustment alone did not allow sustainable operations. Feed pressures rose from a baseline of 150 PSI to a system maximum pressure of 300 PSI within a few hours. To regain performance, operators completed daily flush sequences and offline periods of soaking the membranes with RO permeate. Adding citric acid to this soak solution (up to 100 mg/L) also enhanced recovery, allowing daily operation sequences for between 3 and 5 hours while maintaining nominal design permeate flux and recovery. As the test continued, these cleaning steps were not as effective in fully restoring performance and allowing sufficient run time. 3M installed new elements to complete the test phase, continuing the cycle of operations and CIPs. During each daily run, 3M observed increased permeate conductivity consistent with chemical precipitation on the membrane surface.

3.1.2 PFAS Treatment

Table 3.3 summarizes concentrations of PFAS measured at each sampling location during the NCCW/SW pilot test phases. The Sum of 16 Analyzed PFAS in the RO feed ranged from 7,800 ng/L to 99,000 ng/L. All 16 PFAS were below LODs in the RO permeate stream (LODs ranged between <152 and <1,000 ng/L) for the NCCW_A and NCCW_B test phases. During the NCCW_D test phase, TFMS, HQ-115, and PFBA were detected in the RO permeate. Fourteen of the 16 analyzed PFAS were detected in the RO concentrate, suggesting some PFAS present in the influent below the LODs were concentrated to detectable levels through the RO system. 3M observed limited detections of PFAS through the GAC and AIX media, which were used to estimate breakthrough values for full-scale system design, as described below.

Table 3.3 Summary of PFAS concentrations during the NCCW/SW pilot test phases

PFAS	Units	NCCW/SW Concentration Ranges (minimum and maximum)							
		LOD Range	Pilot Influent UF feed	UF Permeate	RO Permeate[1]	RO Concentrate	Lag GAC Effluent (GAC2)	Lag CalRes Effluent (IX2)	Lag SORBIX Effluent (IXR2)
Sum of 16 Analyzed PFAS[2]	ng/L	--	ND–**27,000**	**7,790–99,000**	ND–**6,200**	**47,400–795,000**	ND–**225,000**	ND–**21,900**	ND–**52,000**
Group 1									
TFA	ng/L	<2.29–<69,853	ND	ND	ND	ND–**14,900**	ND–**4,750**	ND–**17,900**	ND
TFMS	ng/L	<346–<10,000	ND–**10,800**	**1,600–11,400**	ND–**1,310**	**14,900–174,000**	ND–**195,000**	ND	ND
2,2,3,3-TFPA	ng/L	<1,000–<17,897	ND	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<752–<14,840	ND	ND	ND	ND	ND	ND–**2,790**	ND–**1,890**
PFPA	ng/L	<8.42–<51,058	ND–**7,520**	**1,390–5,910**	ND	ND–**44,900**	ND–**51,700**	ND–**16,000**	ND–**21,200**
HQ-115	ng/L	<2.61–<10,000	ND–**27,000**	ND–**82,700**	ND–**6,200**	**13,500–480,000**	ND–**8**	ND	ND
PFBA	ng/L	<191–<1,910	ND–**8,060**	**398–8,450**	ND–**70**	**7,890–76,600**	ND–**76,100**	ND	ND–**38,100**
PFPeA	ng/L	<212–<2,120	ND–**561**	ND–**717**	ND	**1,240–10,100**	ND	ND	ND
Group 2									
PFBS	ng/L	<444–<4,440	ND–**12,900**	ND–**17,700**	ND	ND–**17,100**	ND	ND–**19**	ND
PFPeS	ng/L	<31.1–<2,580	ND	ND–**41**	ND	ND–**811**	ND	ND–**36**	ND
PFHxA	ng/L	<241–<2,410	ND	ND–**61**	ND	ND–**2,660**	ND	ND	ND
PFHpA	ng/L	<152–<1,520	ND	ND	ND	ND–**40**	ND	ND	ND
PFHxS	ng/L	<239–<2,390	ND	ND	ND	ND–**5,610**	ND	ND	ND
PFHpS	ng/L	<169–<1,690	ND	ND	ND	ND–**222**	ND	ND	ND
PFOA	ng/L	<221–<2,210	ND	ND	ND	ND–**11,200**	ND	ND	ND
Group 3									
PFOS	ng/L	<200–<2,000	ND	ND	ND	ND–**11,800**	ND	ND	ND

Data are from Enthalpy Analytical.

ng/L = nanograms per liter (equivalent to parts per trillion or ppt), LOD=limit of detection, ND=non-detect or below LOD, **bold** values are concentrations detected above the LOD.

[1] During test phase NCCW_D only (95% RO recovery), TFMS, HQ-115, PFBA were detected in the RO permeate.

[2] The Sum of 16 Analyzed PFAS only includes the PFAS detected above the LOD.

PFAS Treatment Performance: RO Membrane Separation

Table 3.4 summarizes RO membrane PFAS rejections for the eight individual PFAS detected above the LOD in the RO influent (UF permeate) during the three NCCW/SW test phases.

Table 3.4 NCCW/SW RO PFAS rejection efficiencies by test phase

PFAS Rejection Efficiencies[1]	Test Phase		
	NCCW_A (n=7)[2]	NCCW_B (n=5) [2]	NCCW_D (n=1) [2]
PFPA	>49.6%–>75.5%	>50.7%–>74.0%	--[5]
PFBA	>94.4%–>97.7%	>52.0%–>86.9%	99.7%
PFPeA	>24.6% –>70.4%	--[3]	>0%[4]
PFHxA	--[3]	--[3]	--[5]
PFBS	--[4]	>97.5%[4]	--[5]
PFPeS	--[3]	--[3]	--[5]
HQ-115	>64.9%–>98.8%[4]	>35.9%–>91.5%	97.0%
TFMS	>66.6%–>91.2%	>37.5%–86.0%	95.5%

The "-- " symbol indicates not applicable; the rejection efficiency could not be calculated because the RO influent (UF permeate) PFAS concentration was below the LOD. The ">" symbol indicates that the concentration in the RO permeate was below the LOD.

[1] This table summarizes only data reported by Enthalpy Analytical.

[2] The number of samples shown (n) indicates the number of paired samples collected within 4 hours of each other from the RO influent (UF permeate) and the RO permeate.

[3] The rejection efficiency could not be calculated in at least one sample because the RO influent (UF permeate) PFAS concentration was below the LOD.

[4] >0% indicates that the reported concentration in the RO permeate was below the LOD, and the concentration in the RO influent was equivalent to the nominal LOD value.

[5] The PFAS were detected in the RO influent and were below the LOD in the RO permeate, but the PFAS rejection efficiency is not reported because the nominal LOD value in the RO permeate was greater than the detected concentration in the RO influent.

PFAS Treatment Performance: GAC and AIX Treatment of Membrane Concentrate

Table 3.5 summarizes the treated bed BVs through GAC and AIX vessels during the NCCW/SW test phases. These BVs represent the total BVs treated up to the final PFAS sample collected from the respective vessel for each test phase.

Table 3.5 BVs of water treated through GAC and AIX vessels during NCCW/SW test phases

Test Phase	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX A3F (IXR1)	Lag SORBIX A3F (IXR2)
NCCW_A	2,210	1,105	1,639	820	1,639	820
NCCW_B	--[1]	--[1]	471	236	471	236
NCCW_D	384[2]	264	528	264	238	119

[1] 3M did not change out the GAC vessels between the NCCW_A and NCCW_B test phases. The total BVs treated through the GAC vessels during both phases is shown under the NCCW_A test phase.

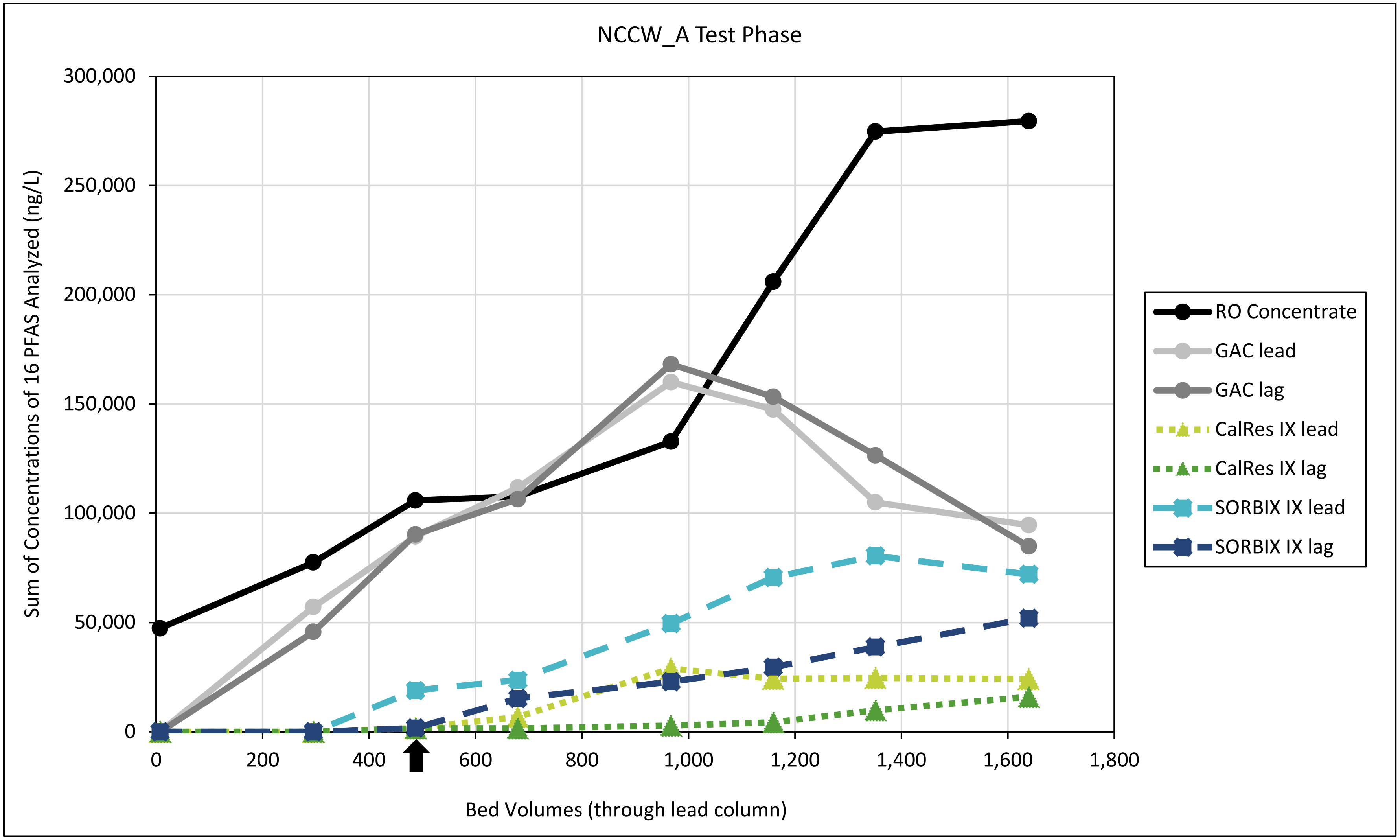
[2] The final PFAS sample was collected from the lead GAC vessel on 10/24/2021 after treating 384 BVs. The final PFAS sample was collected from the lag GAC vessel on 10/27/2021 (3 days later) after treating 264 BVs.

The Sum of 16 Analyzed PFAS in the feed to the GAC and AIX treatment train (RO concentrate) ranged from 47,000 ng/L to 280,000 ng/L throughout the NCCW/SW test phases, with corresponding variations in PFAS loading onto media during those phases. Figure 3.1, Figure 3.2, and Figure 3.3 show breakthrough curves from the three NCCW test phases for the Sum of 16 Analyzed PFAS. Table 3.6 summarizes BVs to the first detection of breakthrough. Large Table 3 includes detailed breakthrough data for individual PFAS.

PFAS treatment performance results from the GAC and AIX column tests are summarized below:

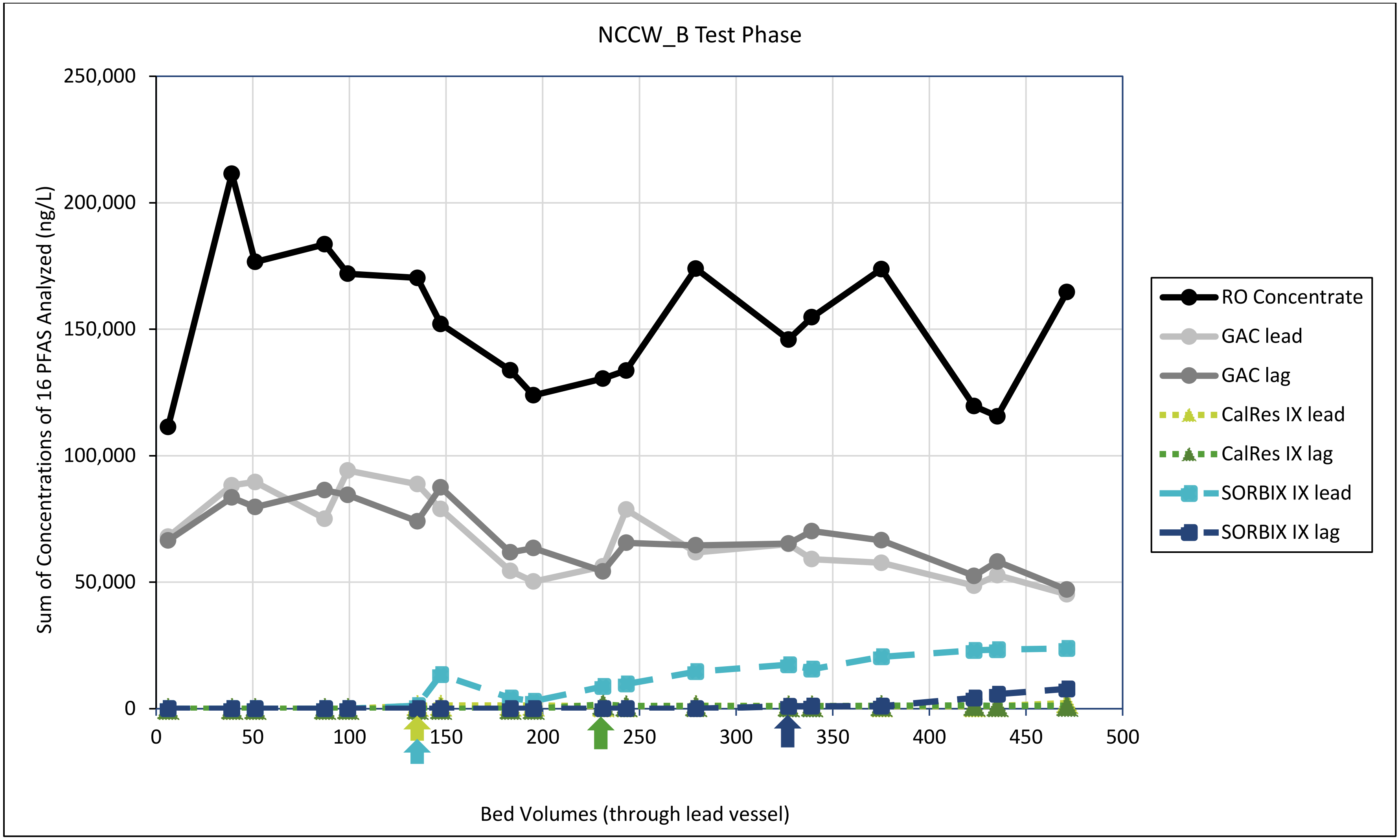
- NCCW/SW GAC treatment summary:
    - During the NCCW_A and NCCW_B combined test phases, PFPeA, PFBS, and HQ-115 were removed through the GAC columns to concentrations below LODs (see Large Table 3). PFBA (up to 76,000 ng/L), PFPA (up to 34,000 ng/L), and TFMS (up to 77,000 ng/L) were observed in GAC effluent and thus loaded onto downstream AIX resin.
    - 3M did not change out GAC media between the NCCW_A and NCCW_B test phases. Between these two test phases, the GAC columns were operated for 2,110 BVs (through the lead vessel). This equates to the treatment of approximately 1,300 gallons.
    - For the NCCW_A and NCCW_D test phases, the mass of PFAS in lag GAC effluent generally increased with time.
    - The BVs to breakthrough from the lag GAC vessel were less than the BVs to breakthrough from the lead GAC vessel for TFMS, PFPA, and PFBA (NCCW_A only). As described in Section 1.4, this breakthrough pattern indicates that these PFAS break through the lag vessel at approximately the same time or soon after breaking through the lead vessel.
- NCCW/SW AIX treatment summary:
    - Figure 3.1 shows breakthrough curves for the Sum of 16 Analyzed PFAS. These curves indicate that the Sum of 16 Analyzed PFAS broke through the SORBIX resin faster than the CalRes resin for both NCCW_A and NCCW_B phases.
    - Both AIX resins removed TFMS to below LOD for the duration of the NCCW/SW test phases.
    - 2,3,3,3-TFPA, PFPA, and PFBA broke through both AIX trains in the order listed for both types of resin used during the testing—except for PFBA, which did not break through the CalRes lag column in any of the three NCCW/SW test phases. TFA was also detected following the lead and lag CalRes columns during the NCCW_D test phase.
    - During the NCCW_A and NCCW_B test phases, the BVs to breakthrough from the lag AIX vessel were less than the BVs to breakthrough from the lead AIX vessel for 2,3,3,3-TFPA, PFPA, and PFBA (NCCW_A SORBIX A3F only). As indicated above for the GAC vessels, this

breakthrough pattern indicates these PFAS break through the lag vessel at approximately the same time or soon after they break through the lead vessel.



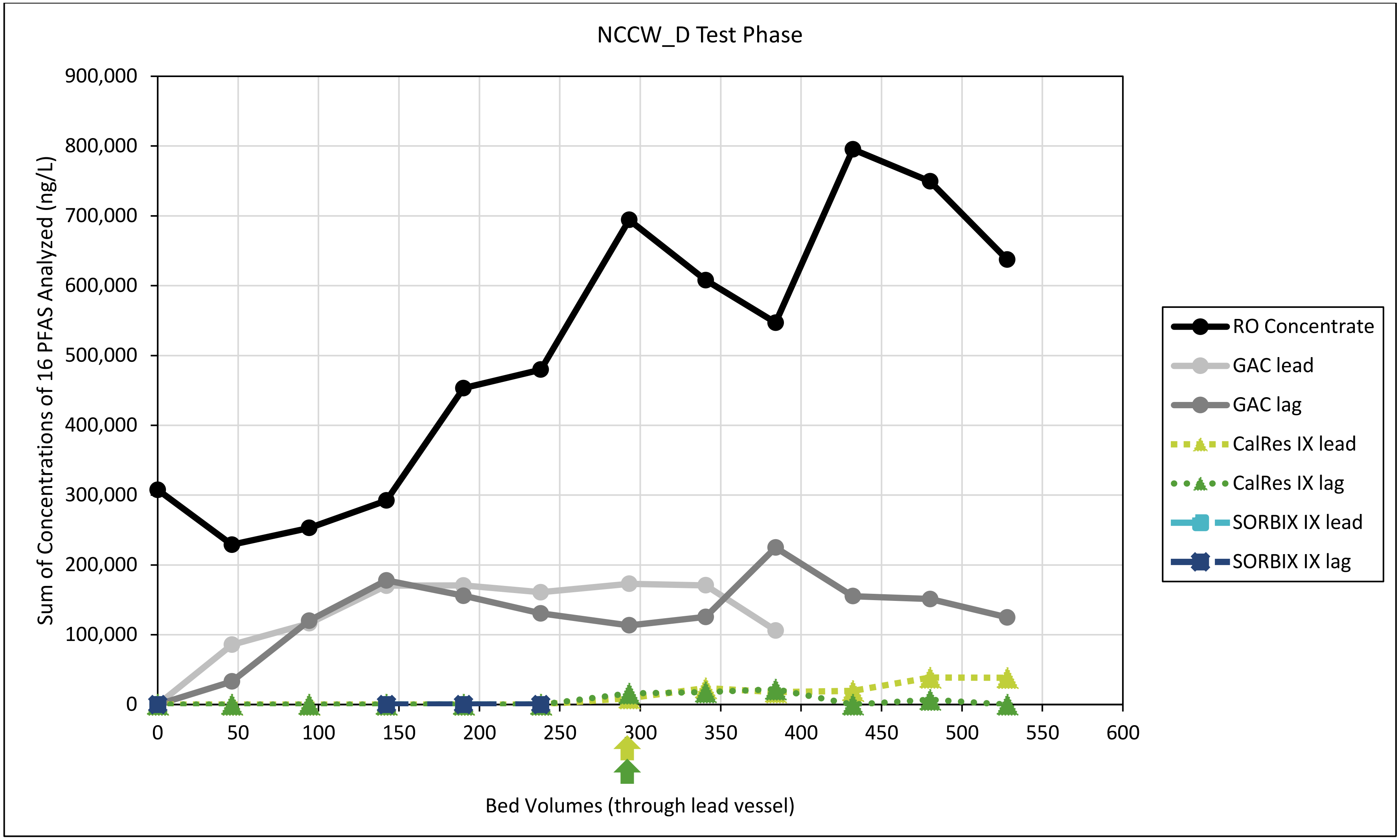
Since each column is the same size, BV calculations are the same for all lead media columns and the same for all lag media columns. The black arrow indicates PFAS breakthrough, which occurred simultaneously for all columns during the NCCW_A phase at 487 BVs treated through the lead column.

Figure 3.1 NCCW_A test phase breakthrough chart (Sum of 16 Analyzed PFAS)



Since each column is the same size, BV calculations are the same for all lead media columns and the same for all lag media columns. The GAC columns were not changed out between the NCCW_A and NCCW_B test phases. So, the GAC BVs for NCCW_B shown above are the values after treating 1,639 BVs during the NCCW_A test phase. The colored arrows indicate PFAS breakthrough, which occurred at 135 BVs for both lead AIX columns and 231 and 327 lead column BVs for the CalRes and SORBIX lag columns, respectively.

Figure 3.2 NCCW_B test phase breakthrough chart (Sum of 16 Analyzed PFAS)



Since each column is the same size, BV calculations are the same for all lead media columns and the same for all lag media columns. The colored arrows indicate PFAS breakthrough, which occurred simultaneously at 293 lead column BVs for both the lead and lag CalRes columns. Samples results were not available from the SORBIX AIX vessels beyond 238 lead column BVs. Thus, breakthrough was not observed for the SORBIX columns during the NCCW_D test phase. PFAS samples were not analyzed for the second half of NCCW_D for SORBIX columns.

Figure 3.3 NCCW_D test phase breakthrough chart (Sum of 16 Analyzed PFAS)

Table 3.6 BVs[1] to first detection of breakthrough[2] for NCCW/SW test phases

PFAS[3]	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX (IXR1)	Lag SORBIX (IXR2)
NCCW_A – BVs to Media Column Breakthrough, up to 1,639 BVs across the Lead Vessel						
Group 1						
TFMS	295	148	not observed	not observed	not observed	not observed
2,3,3,3-TFPA	not observed	not observed	487	244	487	244
PFPA	295	148	679	580	487	340
HQ-115	1,838	not observed	not observed	not observed	not observed	not observed
PFBA	295	148	1,159	not observed	679	484
PFPeA	1,159	not observed	not observed	not observed	not observed	not observed
NCCW_B – BVs to Media Column Breakthrough, up to 471 BVs across the Lead Vessel						
Group 1						
TFA	--[4]	--[4]	not observed	not observed	INT	not observed
2,3,3,3-TFPA	--[4]	--[4]	135	116	135	164
PFPA	--[4]	--[4]	471	not observed	183	212
PFBA	--[4]	--[4]	not observed	not observed	231	not observed
NCCW_D – BVs to Media Column Breakthrough, up to 238 BVs across the Lead Vessel						
Group 1						
TFA	INT	INT	293	INT	not observed	not observed
TFMS	46	23	not observed	not observed	not observed	not observed
HQ-115	94	147	not observed	not observed	not observed	not observed
PFPA	46	23	293	INT	not observed	not observed
PFBA	94	119	not observed	not observed	not observed	not observed
Group 2						
PFBS	not observed	not observed	not observed	INT	not observed	not observed
PFPeS	not observed	not observed	not observed	INT	not observed	not observed

Not observed = breakthrough was not observed up to the BVs tested.
INT = intermittent detections, but a consistent breakthrough curve was not apparent.
[1] BV is a unitless measure of the volume of water treated through a media filter; it is equal to the volume of water treated divided by the volume of the media bed. As a result, BVs shown for lag columns are half those shown for lead columns on a given date because the same flow has gone through twice as much media by the time it reaches lag column effluent compared to lead column effluent. However, BVs shown for AIX do not consider upstream GAC volume.
[2] The first breakthrough is defined as the first detection above LOD, with subsequent measurements consistently as high or higher.
[3] For PFAS not listed in this table, breakthrough was not observed during the test phases.
[4] BVs to breakthrough of the GAC columns are not shown for NCCW_B because the media beds were not changed out between test phases NCCW_A and NCCW_B. If breakthrough was observed during NCCW_B, the BV to breakthrough is shown under NCCW_A to reflect continuous GAC operation through the two phases.

3.2 Phase 1/2 WW

3.2.1 Pilot Operation Summary

3M performed the Phase 1/2 WW test phase using source water collected downstream of pre-carbon filtration with glass media filters and before the existing GAC treatment (refer to Figure 2.2). Table 3.7 summarizes operational parameters from the Phase 1/2 WW test phase.

Table 3.7 Summary of average, minimum, and maximum UF and RO operational parameters for Phase 1/2 WW test phase

Operational Parameters	Units	Average for Phase 1/2 WW Test Phase	Maximum for Phase 1/2 WW Test Phase	Minimum for Phase 1/2 WW Test Phase
UF Operations (Two Trains in Parallel)				
Flux	GFD	85	89	83
Transmembrane Pressure	PSId	10	11	4.6
Permeability	GFD/PSI	8.2	9.3	1.2
Flow (total)	gpm	1.9	2.0	0.89
Recovery	%	96%	96%	96%
RO Operations				
Feed Pressure	PSI	157	184	126
Pressure Drop	PSId	3.2	6.0	3.0
Permeate Flux	GFD	13	13	13
Recovery	%	86%	88%	83%
Observed TDS Recovery[1]	%	96%	NA	NA

[1] TDS rejection calculation based on RO permeate TDS concentrations compared to RO feed concentrations.

Table 3.8 summarizes water quality data for the WW test phase. The pH through the treatment train is near neutral and higher than during NCCW phases, ranging from 6.0–9.1. The TSS concentrations were below 10 mg/L in the UF feed, RO feed, RO permeate, and RO concentrate (GAC feed) but increased to approximately 70 mg/L in the AIX feed and AIX effluent during this test phase. A rise in TSS through the GAC columns was unexpected and may be due to biological growth within the GAC columns or loss of GAC media from the columns. Influent TOC was decreased in the RO permeate and increased in the RO concentrate. The TOC also decreased by approximately 39% through the GAC during this test phase, which is considerably higher reduction of TOC compared to the NCCW test phases, suggesting limited TOC removal through the GAC column. This TOC decrease could be due to adsorption or biological growth in the GAC, potentially producing the higher TSS values observed in the AIX feed. Large Table 1 and Large Table 2 provide detailed water quality and field parameter data.

Table 3.8 Summary of water quality and field parameters for the Phase 1/2 WW test phase

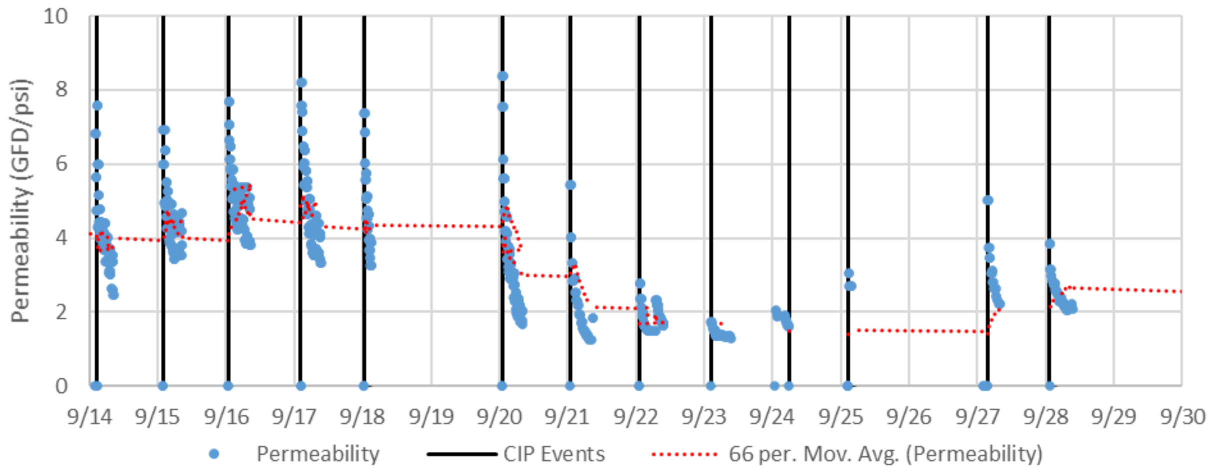
	Units	UF Feed	RO Feed	GAC Feed	AIX Feed	RO Permeate	AIX Effluent
Calcium	mg/L	67	64	478	352	<0.5	358
Iron+ Manganese	mg/L	<0.5	<0.5	<0.5	<0.5	<0.055	0.1
TOC	mg/L	7	6	31	19	1.4	15–16
TDS	mg/L	782	776	6,330	7,020	37	6,980–7,120
TSS	mg/L	<10	<10	<10	73	<10	59-71
Turbidity	NTU	1.2	0.06	NA	NA	NA	NA
pH	Std. Units	7.7	7.7–8.4	8.1–9.1	8.1–9.1	6.0–8.5	7.7–8.9

The paragraphs below provide additional discussion of the operating results from this phase.

UF Operating Performance

Operation of the UF filtration system for the Phase 1/2 WW test phase was more challenging than the previous test phases. While the measured TSS in the influent was still less than 10 mg/L based on samples submitted to the laboratory, the feed turbidity levels measured in the field were between three and five times higher. The higher turbidity observed in the field testing was consistent with the increased rate of fouling on the UF membrane surface during this test phase. Appendix F includes results from operational monitoring of the UF system. As UF fouling accumulated, increasing feed pressures were required to produce the specified filtrate flow.

Operators completed daily CIPs with high pH (8.5 to 12.0 standard units) sodium hypochlorite (NaOCl) solutions to maintain UF membrane permeability during the Phase 1/2 WW test phase. NaOCl concentrations in CIP solutions ranged from 150 mg/L to 750 mg/L. Operators added sodium hydroxide (NaOH) to increase the pH as needed. While CIP procedures were more effective at higher pH, fouling of the UF system continued to be an issue. The daily average membrane permeability during the WW phase was only 1–5 GFD/PSI, with marked increases immediately after CIP events. Figure 3.4 illustrates UF permeability through this test phase. Large Table 4 provides a detailed schedule of UF CIPs conducted.



The moving average shown in the dotted red line reflects the average of 66 time points, which typically reflects about 8 hours of time.

Figure 3.4 UF permeability for WW test phase

RO Operating Performance

Using UF filtrate sourced from the Phase 1/2 WW treatment, 3M operated the RO system at design setpoints of 85% recovery and a 12 GFD permeate flux rate. The system achieved 96% TDS rejection during this phase, suggesting the effective rejection of dissolved constituents into the concentrate stream. Appendix G provides graphical summaries of the operations monitoring for the RO system during this test phase.

3M observed significant variation in the influent TDS concentrations to the RO membranes during the Phase 1/2 WW test phase, based on RO inlet conductivity readings and RO system operating pressures. Higher TDS levels directly affect the osmotic pressure required to produce permeate. For this reason, feed pressures varied in relation to the variability of the inlet TDS over time.

3.2.2 PFAS Treatment

The Phase 1/2 WW had higher PFAS concentrations than the NCCW/SW. Table 3.9 summarizes concentrations of PFAS measured during the Phase 1/2 WW pilot test phase. The Sum of 16 Analyzed PFAS ranged between 98,000 ng/L and 202,000 ng/L in the UF feed and between 75,000 ng/L and 181,000 ng/L in the UF permeate (RO feed), suggesting a loss of between 10% and 20% of PFAS with solids removed through the UF membranes. 3M observed seven of the 16 PFAS in the RO permeate, including HQ-115 and TFMS, which were observed throughout this test phase and PFPA, PFBA, PFPeA, PFBS, and PFPeS, which were detected in the final sample collected from the RO permeate. Thirteen of the 16 analyzed PFAS were detected in the RO concentrate, suggesting some PFAS present in the influent below the LODs were concentrated to detectable levels through the RO system. 3M observed limited detections of PFAS through the GAC and AIX media, which were used to estimate breakthrough values for full-scale system design, as described below.

Table 3.9 Summary of PFAS concentrations during the Phase 1/2 WW pilot test phase

PFAS	Units	Phase 1/2 WW PFAS Concentration Ranges (minimum and maximum)								
		LOD range	Pilot Influent UF Feed	UF Permeate	RO Permeate	RO Concentrate	Lag GAC Effluent (GAC2)	Lag CalRes Effluent (IX2)	Lag SORBIX Effluent (IXR2)
Sum of 16 Analyzed PFAS[1]	ng/L	--	**97,800–202,000**	**74,800–181,000**	**1,420–3,180**	**1,064,000–2,31,000**	**6,500–1,780,000**	ND–**11,000**	ND–**12,400**
Group 1									
TFA	ng/L	<700–<23,461	ND	ND	ND	ND	ND	ND	ND
TFMS	ng/L	<18.4–<1000	**65,900–166,000**	**46,900–145,000**	**1,050–3,090**	**827,000–1,850,000**	ND–**1,770,000**	ND	ND–**290**
2,2,3,3-TFPA	ng/L	<373–<19,129	ND	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<122–<31,656	ND	ND–**1,610**	ND	ND–**7,300**	ND–**7,920**	ND	ND
PFPA	ng/L	<20.8–<63,771	ND–**2,420**	ND–**10,100**	ND–**34**	ND–**44,000**	ND–**105,000**	ND–**11,000**	ND–**12,400**
HQ-115	ng/L	<0.734–<102	**17,000–24,100**	**13,400–20,800**	**92–157**	**128,000–259,000**	ND–**8**	ND–**20**	ND–**21**
PFBA	ng/L	<8.17–<1,053	**1,500–3,160**	**1,740–2,960**	ND–**10**	**12,400–26,500**	ND	ND	ND
PFPeA	ng/L	<12.5–<1,062	ND	ND–**111**	ND–**5**	ND–**680**	ND	ND	ND
Group 2									
PFBS	ng/L	<4.43–<2,219	**2,870–16,200**	**3,570–15,200**	ND–**84**	**34,800–143,000**	ND	ND	ND
PFPeS	ng/L	<1.75–<1,288	ND	ND	ND–**80**	ND–**848**	ND	ND–**37**	ND
PFHxA	ng/L	<0.718–<2,087	ND	ND	ND	ND–**127**	ND	ND	ND
PFHpA	ng/L	<0.612–<1,056	ND	ND	ND	ND	ND	ND	ND
PFHxS	ng/L	<1.93–<1,194	ND	ND–**33**	ND	ND–**5,540**	ND	ND	ND
PFHpS	ng/L	<2.17–<3,375	ND	ND	ND	ND–**102**	ND	ND	ND
PFOA	ng/L	<0.122–<221	ND	ND–**34**	ND	ND–**5,080**	ND	ND	ND
Group 3									
PFOS	ng/L	<1.41–<7,311	ND–**1,360**	ND	ND	ND–**8,940**	ND	ND	ND

Data are from Enthalpy Analytical.

ng/L = nanograms per liter (equivalent to parts per trillion or ppt), LOD=limit of detection, ND = non-detect or below LOD, **bold** values are concentrations detected above the LOD

[1] The Sum of 16 Analyzed PFAS only includes the PFAS detected above the LOD.

PFAS Treatment Performance: RO Membrane Separation

Table 3.10 summarizes PFAS rejections during the Phase 1/2 WW test phase and shows only PFAS detected above the LOD in the RO influent (UF permeate) during the Phase 1/2 WW test phase.

Table 3.10 Phase 1/2 WW RO PFAS rejection efficiencies

PFAS Rejection Efficiencies	Phase 1/2 WW Test Phase (n=3)[1]
2,3,3,3-TFPA	--[2,3]
PFPA	>51.0%–98.2%[2]
PFBA	>84.4%–99.7%[2]
PFPeA	95.5%[2,3]
PFOA	>55.6%[2]
PFBS	>85.4%–99.1%
PFPeS	--[2]
PFHxS	--[2,3]
HQ-115	98.8%–99.4%
TFMS	96.9%–98.1%

The ">" symbol indicates that the concentration in the RO permeate was below the LOD.

[1] The number of samples shown (n) indicates the number of paired samples collected simultaneously from the RO influent (UF permeate) and the RO permeate.

[2] In at least one sample, the rejection efficiency could not be calculated because the RO influent (UF permeate) PFAS concentration was below the LOD.

[3] In at least one sample, the PFAS was detected in the RO influent and was below the LOD in the corresponding RO permeate. The PFAS rejection efficiency is not reported because the nominal LOD value in the RO permeate was greater than the detected concentration in the RO influent.

PFAS Treatment Performance: GAC and AIX Treatment of Membrane Concentrate

Table 3.11 summarizes the treated BVs through GAC and AIX vessels during the Phase 1/2 WW test phase. These BVs represent the total BVs treated up to the final PFAS sample collected from the respective vessel.

Table 3.11 BVs of water treated through GAC and AIX vessels during the Phase 1/2 WW test phase

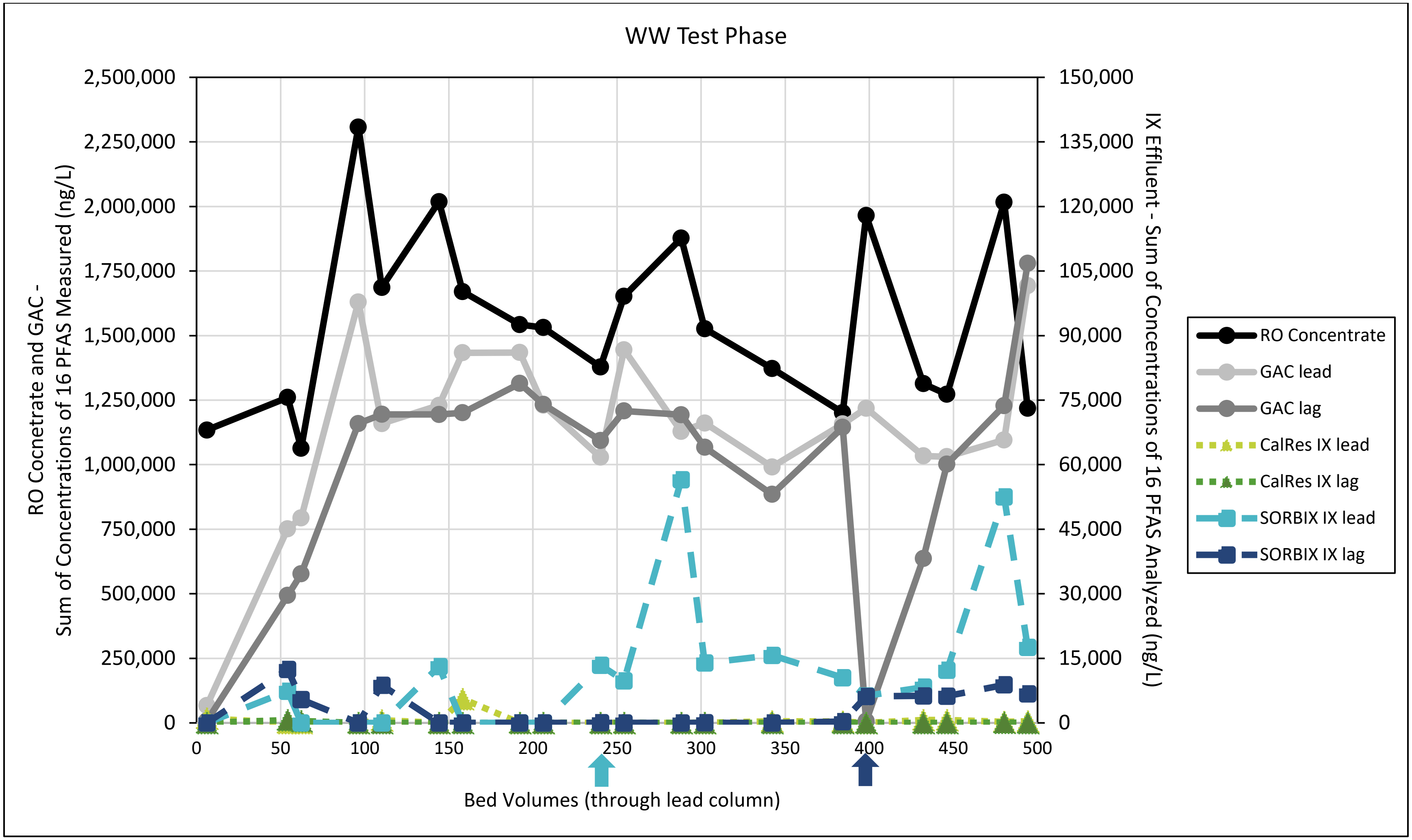
Test Phase	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX A3F (IXR1)	Lag SORBIX A3F (IXR2)
Phase 1/2 WW	496	248	496	248	496	248

3M operated the GAC and AIX columns for 496 BVs (approximately 300 gallons) for this test phase. TFMS, PFPA, HQ-115, PFBA, PFPeA, PFBS, PFHxS, and PFOA were regularly detected in the influent to the GAC and AIX columns (RO concentrate; >50% detections among the samples collected). The Sum of 16 Analyzed PFAS ranged from 1,064,000 ng/L to 2,307,000 ng/L.

Figure 3.5 shows breakthrough curves for the Sum of 16 Analyzed PFAS. Table 3.12 summarizes BVs to the first detection of breakthrough. Large Table 5 summarizes PFAS breakthrough data for individual PFAS.

The paragraphs below summarize observed results from the GAC and AIX column tests:

- Phase 1/2 WW GAC summary:
  - Only TFMS and PFPA broke through the lag GAC columns at concentrations exceeding the LODs.
  - TFMS breakthrough of the lead and lag GAC column was almost immediate.
  - PFPA breakthrough of the lead and lag columns occurred at 112 and 49 BVs, respectively.
  - PFBA broke through the lead column after 194 BVs but was still below the LODs in the lag column after 248 BVs.
  - The lead GAC column removed the remainder of the Sum of 16 Analyzed PFAS analyzed to the LODs for the test duration (approximately 496 BVs through the lead vessel).
- Phase 1/2 WW AIX summary:
  - TFMS broke through the lead SORBIX column after 434 BVs but did not break through the CalRes column.
  - PFPA broke through the lead and lag SORBIX columns after 242 and 200 BVs, respectively.
  - HQ-115 was below LODs in both AIX feeds but was detected intermittently in lead and lag effluent from both trains, likely due to variations in matrix interferences resulting in variable LODs.



Colored arrows indicate PFAS breakthrough for the lead and lag SORBIX columns, which was observed at 242 BVs for the lead column and 400 BVs (lead column BVs) for the lag column. 3M did not observe breakthrough for the CalRes columns during the WW test phase.

Figure 3.5 Phase 1/2 WW test phase breakthrough chart (Sum of 16 Analyzed PFAS)

Table 3.12 BVs[1] to the first detection of breakthrough[2] for the Phase 1/2 WW test phase

PFAS[3]	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX (IXR1)	Lag SORBIX (IXR2)
BVs to Media Column Breakthrough, up to 496 BVs across the Lead Vessel						
Group 1						
TFMS	8	28	not observed	not observed	434	INT
2,3,3,3-TFPA	INT	INT	not observed	not observed	not observed	not observed
PFPA	112	49	INT	INT	242	200
HQ-115	INT	INT	INT	INT	INT	INT
PFBA	194	not observed	not observed[4]	not observed	not observed	not observed
PFPeA	not observed[4]	not observed	not observed[4]	not observed	not observed	not observed
Group 2						
PFBS	not observed	not observed	not observed[4]	not observed	not observed	not observed
PFPeS	not observed	not observed	not observed[4]	INT	INT	not observed
PFHpA	not observed[4]	not observed	not observed[4]	not observed	not observed	not observed
PFHxS	not observed[4]	not observed	not observed[4]	not observed	not observed	not observed
PFHpS	not observed	not observed	not observed[4]	not observed	not observed	not observed
PFOA	not observed[4]	not observed	not observed[4]	not observed	not observed	not observed
Group 3						
PFOS	not observed	not observed	not observed[4]	not observed	not observed	not observed

Not observed = breakthrough was not observed up to the BVs tested.
INT = intermittent detections, but a consistent breakthrough curve was not apparent.
[1] BV is a unitless measure of the volume of water treated through a media filter. It is equal to the volume of water treated divided by the volume of the media bed. As a result, BVs shown for lag columns are half those shown for lead columns on a given date because the same flow has gone through twice as much media by the time it reaches lag column effluent compared to lead column effluent. However, BVs shown for AIX do not consider upstream GAC volume.
[2] The first breakthrough is defined as the first detection above LOD, with subsequent measurements consistently as high or higher.
[3] For PFAS not listed in this table, breakthrough was not observed during the test phase.
[4] One sample had low detections of multiple PFAS, but seven of eight did not have later detections or breakthroughs, suggesting possible sample contamination. As a result, any PFAS only detected in this sample were judged not to have broken through. These samples were from lead GAC column at 56 BVs and lead CalRes column at 386 BVs.

3.3 PFAS Split Sample Comparison

This section summarizes PFAS analytical results from 3M's Global EHS Laboratory. 3M collected 25 split samples: 16 during the NCCW/SW test phase and nine during the Phase 1/2 WW test phase. These split samples were collected to assess data quality, provide an expanded list of PFAS analytes, and evaluate PFAS concentrations down to a lower LOD. Appendix D provides results and a comparison of shared PFAS analytes with the Enthalpy Analytical dataset.

3.3.1 Data Quality Control

Of the 32 PFAS analyzed by 3M and the 16 analyzed by Enthalpy, eight PFAS were detected among the 25 split samples by both laboratories. For these eight PFAS, 3M calculated the relative percent difference (RPD) between the detected values to assess the magnitude of the difference between the two results. Table 3.13 shows a summary of RPD values.

Table 3.13 Summary of relative percent differences between split samples

PFAS detected by both 3M and Enthalpy	Count RPD values	# of comparisons where Enthalpy result is higher	# of comparisons where 3M result is higher	Average RPD	Median RPD	Minimum RPD	Maximum RPD
PFPA	14	6	8	35%	25%	9%	119%
PFBA	11	7	4	16%	13%	1%	36%
PFPeA	5	2	3	36%	11%	2%	131%
PFOA	1	1	0	79%	--	--	--
PFBS	4	4	0	32%	25%	12%	69%
PFHxS/PFHS	1	1	0	59%	--	--	--
HQ-115	9	7	2	38%	48%	2%	63%
TFMS	13	13	0	95%	95%	22%	132%

Key observations from the split sample analysis include:

- Results from Enthalpy tended to be higher than from 3M Global EHS. This pattern was most notable for TFMS. Reasons for the differences are unknown but may be related to the inhomogeneity of the split samples or differences in analytical methods (both in terms of sample preparation and quantification procedures).
- TFMS also showed the highest magnitude of difference between the split samples with an average RPD of 95%.
- For PFPA, PFBA, PFPeA, PFBS, and HQ-115, average RPD values were less than 40%. This is qualitatively considered to be relatively low given the known differences in sampling and analytical protocols between the two laboratories.
- Only one sample report contained shared detections of PFOA and PFHxS. As such, it is difficult to make conclusions about the magnitude of difference between the two laboratories for these two analytes.

In 24 instances, one laboratory detected a specific PFAS, and the other did not. Given the LOD of the laboratory that did not detect the PFAS, if the reported result from the other laboratory was a true detection, the PFAS should have been detected. This was particularly notable for TFA, where in 15 instances, 3M Global EHS detected TFA, but Enthalpy did not. 3M also observed this for other PFAS analytes, including 2,3,3,3-TPFA, PFPA, PFBS, PFPeS, HQ-115, and TFMS. These instances suggest that the reported results could be false-positive values, or the reported non-detect values could be false negatives. Further analysis would be needed to determine the direction of bias between the two results; however, given the expectation of specific PFAS in these waste streams (e.g., TFA, PFPA, and TFMS), a false negative result may be more plausible.

3.3.2 NCCW/SW Test Phase: PFAS Split Samples

Table 3.14 summarizes the split samples collected during the NCCW/SW phase and analyzed by 3M Global EHS laboratory. Results from these data are summarized below.

- RO Permeate (two samples collected)
  - 3M Global EHS Laboratory—Two PFAS were detected separately in the two RO permeate split samples: HQ-115 (111 ng/L) and PFBA (25.2 ng/L).
  - Enthalpy Analytical—No PFAS were detected by Enthalpy in the two split samples. Among all RO permeate samples analyzed by Enthalpy, three PFAS were detected: HQ-115, TFMS, and PFBA.
- RO Concentrate (five split samples collected)
  - 3M Global EHS Laboratory—Eighteen PFAS were detected in the RO concentrate: FBSA, FOSA, HQ-115, PECHS, PFBA, PFBS, PFES, PFHpA, PFHpS, PFHxS, PFHxA, PFOA, PFPA, PFPeA, PFPeS, PIBA, TFA, and TFMS. PFOS was not detected above the LOD (<9.3 ng/L).
  - Enthalpy Analytical
    - Among the five split RO concentrate samples, six PFAS were detected: PFPA, PFBA, PFPeA, PFBS, HQ-115, and TFMS.
    - Among all RO concentrate samples analyzed by Enthalpy, 14 of the 16 PFAS analyzed were observed in at least one sample: HQ-115, PFBA, PFBS, PFHpA, PFHpS, PFHxA, PFHxS, PFOA, PFOS, PFPA, PFPeA, PFPeS, TFA, and TFMS (Enthalpy did not detect 2,2,3,3-TFPA and 2,3,3,3-TFPA above the LOD). Enthalpy did not analyze FBSA, FOSA, PECHS, PFES, or PIBA.
- Lag CalRes (IX2—one split sample collected after 212 BVs through the lag vessel)
  - 3M Global EHS Laboratory—TFA was the only PFAS detected at 19,800 ng/L.
  - Enthalpy Analytical—2,3,3,3-TFPA was the only PFAS detected at 1,270 ng/L in this split sample.
- Lag SORBIX (IXR2—one split sample collected after 212 BVs through the lag vessel)
  - 3M Global EHS Laboratory—Two PFAS were detected: PFPA at 4,320 ng/L and TFA at 19,800 ng/L.
  - Enthalpy Analytical—Two PFAS were detected in this split sample: PFPA at 3,190 ng/L and 2,3,3,3-TFPA at 1,080 ng/L.

Table 3.14 Summary of PFAS concentrations during the NCCW/SW pilot test phases (split samples only)

PFAS	Units	NCCW/SW Concentration Ranges (minimum and maximum)—Split Samples Only						
		LOD Range	Pilot Influent UF Feed (n=1)	UF Permeate (n=4)	RO Permeate (n=2)	RO Concentrate (n=5)	Lag CalRes Effluent (IX2) (n=1)[1]	Lag SORBIX Effluent (IXR2) (n=1)[1]
Group 1								
TFA	ng/L	<200	**3,360**	**3,040–3,320**	ND	**17,000–21,600**	**19,800**	**19,800**
TFMS	ng/L	<25.0	**3,160**	**1,280–3,140**	ND	**8,560–14,600**	ND	ND
2,2,3,3-TFPA	ng/L	<500	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<1,000	**1,210**	ND	ND	ND	ND	ND
PFPA	ng/L	<50.0	**3,180**	**1,800–3,300**	ND	**9,840–16,200**	ND	**4,320**
PFES	ng/L	<25.0	**73.2**	ND–**71**	ND	**74.8–322**	ND	ND
HQ-115	ng/L	<10.0	**236**	**256–4,440**	ND–**111**	**1,430–74,000**	ND	ND
PFBA	ng/L	<10.0	**8,000**	**482–8,120**	ND–**25.2**	**8,700–36,800**	ND	ND
PIBA	ng/L	<100	**123**	ND–**109**	ND	**139–334**	ND	ND
PFPeA	ng/L	<10.0	**502**	ND–**526**	ND	**560–2,140**	ND	ND
Group 2								
PFBSi	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSA	ng/L	<10.1	ND	ND	ND	ND–**13.4**	ND	ND
PFBS	ng/L	<10.0	**142**	ND–**147**	ND	**546–13,800**	ND	ND
PFPeS	ng/L	<9.4	**45**	ND–**44.2**	ND	**96.8–256**	ND	ND
MeFBSA	ng/L	<39.4–<44.0	ND	ND	ND	ND	ND	ND
FBSE	ng/L	<45.6–<51.0	ND	ND	ND	ND	ND	ND
MeFBSAA	ng/L	<44.8–<50.0	ND	ND	ND	ND	ND	ND
MeFBSE	ng/L	<17.9–<20.0	ND	ND	ND	ND	ND	ND
PBSA	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSEE-Diol	ng/L	<44.8–<50.0	ND	ND	ND	ND	ND	ND
FBSEE-DA	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSAA	ng/L	<100	ND	ND	ND	ND	ND	ND
PBSA-DC	ng/L	<10.7–<12.0	ND	ND	ND	ND	ND	ND
PFHxA	ng/L	<10.0	**173**	ND–**182**	ND	**204–740**	ND	ND
PFHpA	ng/L	<10.0	**27.2**	ND–**28**	ND	**34.4–82.2**	ND	ND
PFHxS/PFHS	ng/L	<10.0–<20.0	**54.6**	ND–**35.6**	ND	**94.2–300**	ND	ND
PFHpS	ng/L	<10.0	ND	ND	ND	ND–**23.6**	ND	ND
PHSA-C	ng/L	<89.5–<100	ND	ND	ND	ND	ND	ND
PFOA	ng/L	<9.6–<19.2	**62.8**	ND–**69.4**	ND	**173–324**	ND	ND
Group 3								
FOSA/PFOSA	ng/L	<10.0	ND	ND	ND	ND–**45.2**	ND	ND
PFOS	ng/L	<8.3–<9.3	ND	ND	ND	ND	ND	ND
PECHS	ng/L	<9.2	**14.5**	ND	ND	**31.2–76.2**	ND	ND

Data from 3M Global EHS Laboratory. No data available from GAC effluent. n = the number of split samples collected at the specified location. ND=non-detection.

[1] Sample collected after 212 BVs treated across the lag vessel.

3.3.3 Phase 1/2 WW Test Phase: PFAS Split Samples

Table 3.15 shows a data summary of the split samples collected during the Phase 1/2 WW test phase and analyzed by the 3M Global EHS laboratory. Results from these data are summarized below.

- RO Permeate (two split samples collected)
  - 3M Global EHS Laboratory—Four PFAS were detected in the two split samples: HQ-115, PFBA, PFBS, and TFMS.
  - Enthalpy Analytical—The four PFAS detected by 3M Global EHS (HQ-115, PFBA, PFBS, and TFMS) were also detected by Enthalpy in the split RO permeate samples. Enthalpy also detected PFPA, PFPeA, and PFPeS.
- RO Concentrate (one split sample collected)
  - 3M Global EHS Laboratory—Twenty-seven PFAS were detected in the split sample: FBSA, FBSAA, FBSE, FBSEE-Diol, FBSEE-DA, FOSA, HQ-115, MeFBSA, MeFBSAA, MeFBSE, PBSA, PECHS, PFBA, PFBS, PFBSi, PFHpA, PFHpS, PFHxS, PFHxA, PFOA, PFOS, PFPA, PFPeA, PFPeS, PIBA, TFA, and TFMS.
  - Enthalpy Analytical
    - Eight PFAS were detected by Enthalpy in the split sample analyzed by both Enthalpy and 3M Global EHS: PFPA, PFBA, PFPeA, PFOA, PFBS, PFHxS, HQ-115, and TFMS. Of the 16 PFAS analyzed by Enthalpy, six were not detected by Enthalpy but were detected by 3M Global EHS: TFA, PFHxA, PFHpA, PFPeS, PFHpS, and PFOS.
    - Among all RO concentrate samples analyzed by Enthalpy, 13 of the 16 PFAS were detected: TFMS, 2,3,3,3-TFPA, PFPA, HQ-115, PFBA, PFPeA, PFBS, PFPeS, PFHxA, PFHxS, PFHpS, PFOA, and PFOS. Of these, 3M did not detect 2,3,3,3-TFPA.
- Lag CalRes Vessel (IX2—one split sample collected)
  - 3M Global EHS Laboratory—PFPA and TFA were the only two PFAS detected in the split sample analyzed by 3M at 370 ng/L and 10,700 ng/L, respectively.
  - Enthalpy Analytical—PFPA was the only detected PFAS in the split sample analyzed by Enthalpy at 1,460 ng/L. TFA was not detected above the LOD (<9,604 ng/L).
- Lag SORBIX Vessel (IXR2—one split sample collected)
  - 3M Global EHS Laboratory—PFPA and TFA were the only two PFAS detected in the split sample analyzed by 3M at 6,640 ng/L and 13,200 ng/L, respectively.
  - Enthalpy Analytical: PFPA was the only detected PFAS in the split sample analyzed by Enthalpy at 8,840 ng/L. TFA was not detected above the LOD (<6,914 ng/L).

Table 3.15 Summary of PFAS concentrations during the Phase 1/2 WW test phase (split samples only)

PFAS	Units	Phase 1/2 WW Concentration Ranges (minimum and maximum) – Split Samples only					
		LOD Range	RO Permeate (n=2)	RO Permeate Polishing Lag CalRes (n=2)	RO Concentrate (n=1)	Lag CalRes Effluent (IX2) (n=1)[1]	Lag SORBIX Effluent (IXR2) (n=1)[1]
Group 1							
TFA	ng/L	<200	ND	ND	**11,300**	**10,700**	**13,200**
TFMS	ng/L	<25.0	**582–320**	ND	**414,000**	ND	ND
2,2,3,3-TFPA	ng/L	<500	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<1,000	ND	ND	ND	ND	ND
PFPA	ng/L	<50.0	ND	ND	**8,500**	**370**	**6,640**
PFES	ng/L	<25.0	ND	ND	ND	ND	ND
HQ-115	ng/L	<10.0	**96.2–120**	ND–**22.4**	**91,000**	ND	ND
PFBA	ng/L	<10.0	ND–**11.1**	ND	**13,800**	ND	ND
PIBA	ng/L	<100	ND	ND	**140**	ND	ND
PFPeA	ng/L	<10.0	ND	ND	**706**	ND	ND
Group 2							
PFBSi	ng/L	<10.0	ND	ND	**2,460**	ND	ND
FBSA	ng/L	<10.1	ND	ND	**1,600**	ND	ND
PFBS	ng/L	<10.0	**16.5–41**	ND	**37,000**	ND	ND
PFPeS	ng/L	<9.4	ND	ND	**174**	ND	ND
MeFBSA	ng/L	<44.0	ND	ND	**464**	ND	ND
FBSE	ng/L	<51.0	ND	ND	**234**	ND	ND
MeFBSAA	ng/L	<50.0	ND	ND	**134**	ND	ND
MeFBSE	ng/L	<20.0	ND	ND	**84.6**	**26.0**	**26.2**
PBSA	ng/L	<10.0	ND	ND	**436**	ND	ND
FBSEE-Diol	ng/L	<50.0	ND	ND	**107**	ND	ND
FBSEE-DA	ng/L	<10.0	ND	ND	**212**	ND	ND
FBSAA	ng/L	<100	ND	ND	**141**	ND	ND
PBSA-DC	ng/L	<12.0	ND	ND	ND	ND	ND
PFHxA	ng/L	<10.0	ND	ND	**252**	ND	ND
PFHpA	ng/L	<10.0	ND	ND	**35.8**	ND	ND
PFHxS/PFHS	ng/L	<10.0	ND	ND	**510**	ND	ND
PFHpS	ng/L	<10.0	ND	ND	**110**	ND	ND
PHSA-C	ng/L	<100	ND	ND	ND	ND	ND
PFOA	ng/L	<9.6–<19.2	ND	ND	**488**	ND	ND
Group 3							
FOSA/PFOSA	ng/L	<10.0	ND	ND	**41.8**	ND	ND
PFOS	ng/L	<9.3	ND	ND	**170**	ND	ND
PECHS	ng/L	<9.2	ND	ND	**179**	ND	ND

Data from 3M Global EHS Laboratory. There is no data available from the pilot influent/UF feed, UF permeate, and GAC effluent. n = the number of split samples collected at the specified location.

[1] Sample collected after 241 BVs through the lag vessel.

3.4 Additional Evaluations

In addition to the scope of work outlined in the Workplan, 3M elected to conduct additional testing of potential technologies that could be used in conjunction with the treatment process outlined in Alternatives 5 and 6 to improve overall treatment during full-scale operations. The additional treatment technologies evaluated during the Treatability Study included:

- AIX treatment of RO permeate
- Liquid-liquid extraction of PFAS from water
- AIX regeneration

The following paragraphs summarize the results from these supplemental testing activities.

3.4.1 AIX Treatment of RO Permeate

3M installed lead-lag polishing AIX (CalRes media) columns on the RO permeate stream as a provision to characterize the time to breakthrough for any PFAS that passed through the RO membrane during the five pilot test phases. 3M exchanged the polishing AIX media between each test phase.

As described above in Sections 3.1.2 and 3.2.2, limited PFAS detections were reported for the RO permeate. Thus, there were few PFAS detections through the polishing AIX vessels. Results from the polishing AIX columns are summarized below.

- NCCW Test Phases:
    - During the NCCW_A and NCCW_B test phases, no PFAS were detected above the LODs in the RO permeate.
    - During the NCCW_D test phase, PFBA, HQ-115, and TFMS were detected in the RO permeate. Following the lead polishing AIX column, PFPA was detected in one sample after 1,477 BVs, but no consistent breakthrough pattern was observed. Following the lag AIX, none of the 16 Analyzed PFAS were detected for the duration of the NCCW/SW test phases.
- Phase 1/2 WW Test Phase:
    - During the Phase 1/2 WW test phase, TFMS and HQ-115 were consistently detected in the RO permeate. PFPA, PFBA, PFPeA, PFBS, and PFPeS were also detected in the last sample collected from the RO permeate during this test phase.
    - Following the lead AIX column, single detections of PFPA and TFMS were reported, but no consistent breakthrough pattern was observed (note that samples were only collected at four time points across the AIX columns on the RO permeate stream, so distinct breakthrough patterns were not observed).

- Following the lag polishing AIX column, a single detection of TFMS at 156 ng/L was reported from the final sample collected. For the split sample from the lag polishing AIX column analyzed by 3M, HQ-115 was the only PFAS detected.

3.4.2 Liquid/Liquid PFAS Extraction

3M has developed an approach for removing PFAS from water that forms ionic pairs between PFAS and a protonated tertiary amine material. When combined, this pair is easier to extract from the water phase and can be removed using a liquid/liquid extraction of the PFAS-amine complex into a non-aqueous phase liquid rather than a fixed-bed ion exchange treatment process. In this case, 3M used the long-chain fatty amine alamine as the non-aqueous phase liquid. 3M conducted a concurrent liquid/liquid extraction pilot test using centrifugation and inside-out UF technologies to separate the oil and water phases. In the inside-out operation, the oil-water mixture flows through the interior of UF membrane straws, and water passes out while the membrane rejects the oil phase. Appendix H summarizes these tests. Test feed waters included GAC2 effluent from NCCW_B test phase and RO concentrate from the WW test phase; each acidified to less than pH 4.

Treated waters had no observable oil phase remaining, with concentrations of TFA, PFPA, 2,2,3,3-TFPA, 2,3,3,3-TFPA, PFPeA, PFOA, PFNA, PFDA, PFES, PFHxS, PFOS, and HPDO-DA below detection limits (with LODs between 70 and 2,500 ng/L). PFAS detected in treated effluent included PFBA, TFMS, PFBS, PFBSi, and HQ-115. The test results suggest that the method (using alamine/mesitylene oil) effectively extracts PFAS from acidified water, with lower extraction efficiencies for selected short-chain PFAS.

While 3M will not use this treatment technology for the full-scale design, future work could focus on addressing the following remaining uncertainties:

- Scale-up using a longer trial and larger equipment
- Potential arrangement combining liquid/liquid extraction with GAC and AIX systems
- Optimization of consumable volumes needed
- Evaluation of alternate organoammonia compounds for PFAS extraction

3.4.3 AIX Regeneration

ECT2 and 3M have demonstrated in both lab studies and pilot tests that an alcohol/brine mixture can remove short-chain, carboxylic PFAS compounds (e.g., PFPA, PFBA) loaded onto either CalRes 2301 or SORBIX A3F. These tests have also shown that short- and long-chain sulfonated PFAS compounds (e.g., PFBS, PFOS) cannot be easily removed from CalRes 2301 during regeneration but can be removed from SORBIX A3F. These studies have also shown that, in general, CalRes 2301 exhibits a higher capacity for all PFAS compounds than SORBIX A3F. The data from regenerating the pilot test columns validate these findings. Large Table 6 provides detailed analytical results. Figure 3.6 summarizes PFAS results from the two regenerated columns.

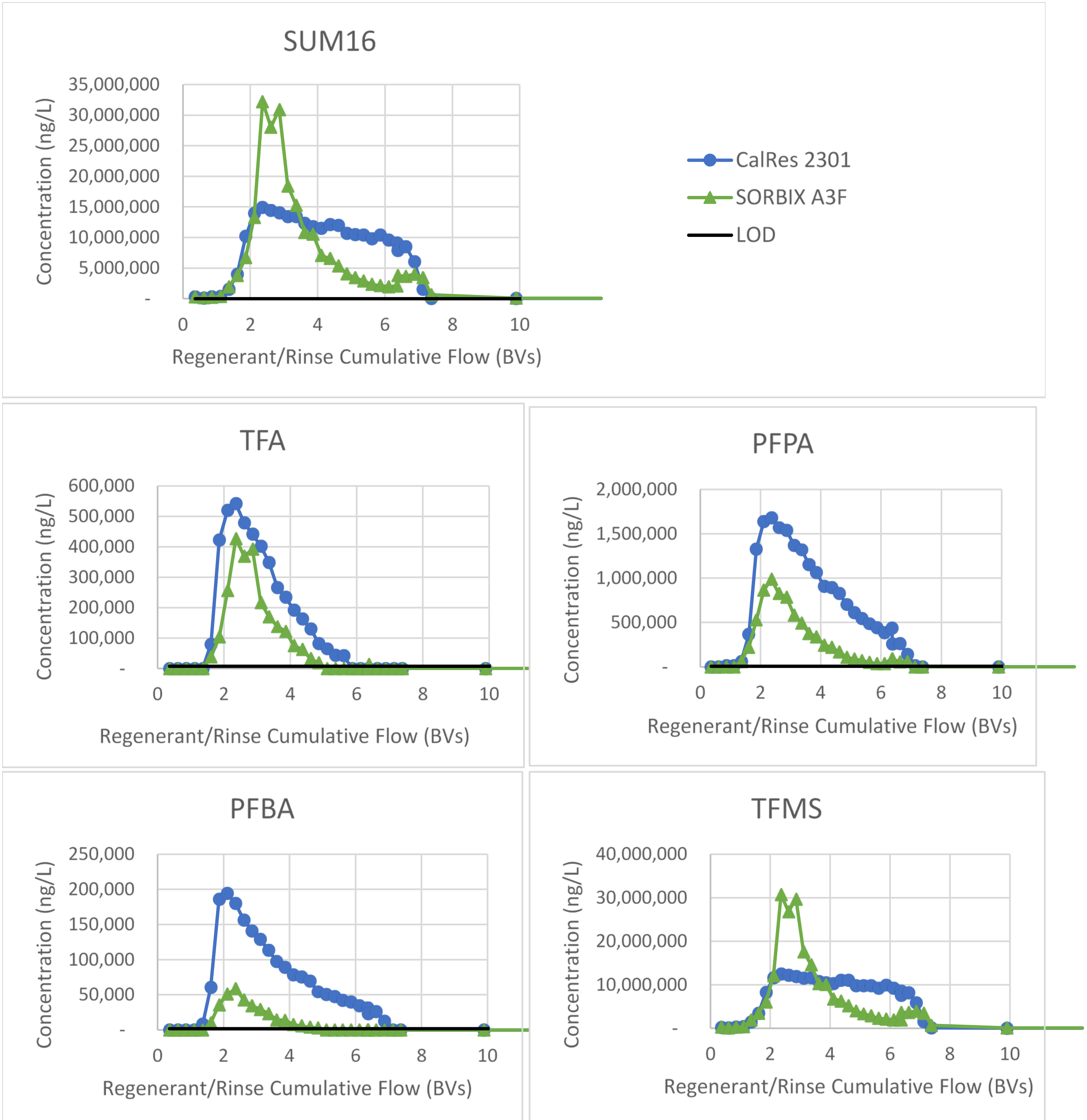


Figure 3.6 Desorption curves for selected PFAS during regeneration

TFMS, which occurred at concentrations that were orders of magnitude higher than other compounds, dominated the desorption curve for the Sum of 16 Analyzed PFAS. Desorption curves for specific PFAS can be aggregated into two main categories.

- TFA, PFPA, and PFBA exhibited typical desorption curves for PFAS regenerable resin, indicating a spike in concentration shortly after initiating regenerant flow to the column, followed by a decline in concentrations as PFAS compounds are desorbed. The data indicate that more of each compound was removed from the CalRes than the SORBIX during regeneration (likely due to the higher capacity of CalRes to capture these compounds). 3M observed more complete regeneration for the SORBIX resin, as the residual PFAS concentrations after 5 BVs were much lower for A3F than CalRes.

- TFMS desorption curves indicate that similar mass amounts were desorbed from both columns but at different speeds. The TFMS appears to have been fully removed from the A3F media after 5 BVs based on the steep desorption curve and low residual TFMS concentration at the end of the regeneration. The TFMS appears to have been only partially removed from the CalRes media after 5 BVs based on the shallow/flat desorption curve, with significant desorption occurring through 7 BVs.

To estimate regeneration efficiency, estimates for sorbed PFAS based on forward flow measurements are compared to the desorbed PFAS measured during regeneration. However, differences in LODs and matrix effects of the regeneration brine made this comparison difficult. 3M and ECT2 are continuing to evaluate this issue to understand the ability of regeneration to effectively remove PFAS from AIX resin and enable ongoing resin reuse.

3.5 Estimated Full-Scale Treatment Effluent Water Quality

Based on the results of the Treatability Study, Table 3.16 presents a preliminary estimate of full-scale treatment system effluent water quality, consisting of 85% RO permeate water and 15% AIX lag vessel effluent.

Table 3.16 Estimated treated effluent water quality based on Treatability Study[1]

Source Water (Test Phase)	NCCW/SW (NCCW_B)			Phase 1/2 WW (WW)		
# of BVs	98	212	212	97	241	241
AIX Resin	SORBIX/CalRes	SORBIX	CalRes	SORBIX/CalRes	SORBIX	CalRes
General Chemistry[1]						
Calcium	62			54		
Iron+ Manganese	<0.055			<0.055		
TOC	3.6			3.5		
TDS	367			1,150[7]		
TSS	<10			14[3]		
pH	5.9–8.6			6.3–8.6		
PFAS[4]						
Sum of 16 Detected PFAS[5]	--	4,218	3,570	1,807	3,385	2,069
Group 1[6]						
TFA	< 700	**< 3,140**[6]	**< 3,140**[6]	< 700	**< 2,150**[6]	**< 1,775**[6]
TFMS	< 1,000	< 498	< 498	**< 1,811**[6]	< 276	< 276
2,2,3,3-TFPA	< 1,000	< 500	< 500	< 2,406	< 500	< 500
2,3,3,3-TFPA	< 752	< 1,000	< 1,000	< 740	< 1,000	< 1,000
PFPA	< 700	**< 691**[6]	< 50	< 700	**< 1,039**[6]	**< 98**[6]
HQ-115	< 1,000	< 83	< 83	**133**[6]	< 104	< 104
PFBA	< 191	**< 11**[6]	**< 11**[6]	< 260	< 10	< 10
PFPeA	< 212	< 10	< 10	< 17	< 10	< 10
Group 2[6]						
PFBS	< 444	**< 16**[6]	**< 16**[6]	< 9	< 36	< 36
PFPeS	< 258	< 9	< 9	< 2	< 9	< 9
PFHxA	< 241	< 10	< 10	< 2	< 10	< 10
PFHpA	< 152	< 10	< 10	< 24	< 10	< 10
PFHxS	< 239	< 10	< 10	< 5	< 10	< 10
PFHpS	< 169	< 10	< 10	< 6	< 10	< 10
PFOA	< 221	< 18	< 18	< 15	< 18	< 18
Group 3[6]						
PFOS	< 200	< 9	< 9	< 4	< 9	< 9

[1] Effluent concentrations are estimated as weighted average of RO permeate concentrations and AIX lag column effluents and not intended to include regeneration waste. BVs indicated are for lag vessels. The early BV is generally before breakthrough and thus similar for both resins, while AIX effluent concentrations varied between resins at higher BVs.

[2] General chemistry is based on water quality sampling events for NCCW_B and WW test phases and is not expected to vary significantly by AIX BV.

[3] Effluent TSS concentration is biased by AIX effluent TSS concentration measured at 59–71 mg/L. That concentration is unlikely to have passed through all four media vessels and may reflect precipitation of minerals between the time of sampling and analysis.

[4] PFAS data for end-of-pilot samples (236 BVs for NCCW phase and 241 BVs for WW phase) reflect 3M data, which typically had lower detection limits than Enthalpy data. The initial sample for each water source is Enthalpy data because 3M did not collect data for these events.

[5] Sum of 16 PFAS detected only includes parameters detected above Enthalpy LOD for that sample.

[6] Values where one of the source readings was above LOD are **bolded**. For weighted averages with a different LOD, the LOD indicated here is the weighted average of LODs. For weighted averages with one sample above LOD, the LOD indicated here is the weighted average of the LOD and the detection.

[7] Estimated TDS for treated Phase 1/2 WW includes 60 mg/L of NaCl added with regeneration waste brine recycled back to Phase 1/2 WW influent.

Large Table 7 shows a comparison of estimated effluent water quality for the two treated water streams against permit limits (at SD001 for Phase 1/2 WW and SD002 for NCCW/SW) for permitted parameters measured during the pilot test. The estimated effluent water quality for the two treated water streams is expected to meet the existing permit limits for parameters measured.

3.6 Full-Scale Design Recommendations

Based on the Treatability Study pilot testing results, 3M and ECT2 recommend a modified version of Alternative 5 for advancement to full-scale design. Figure 3.7 shows the proposed modifications to Alternative 5 as pilot-tested, including the addition of pretreatment steps ahead of each of the primary PFAS treatment technologies (UF upstream of RO and GAC upstream of AIX) and regenerable AIX resin in lieu of single-pass.

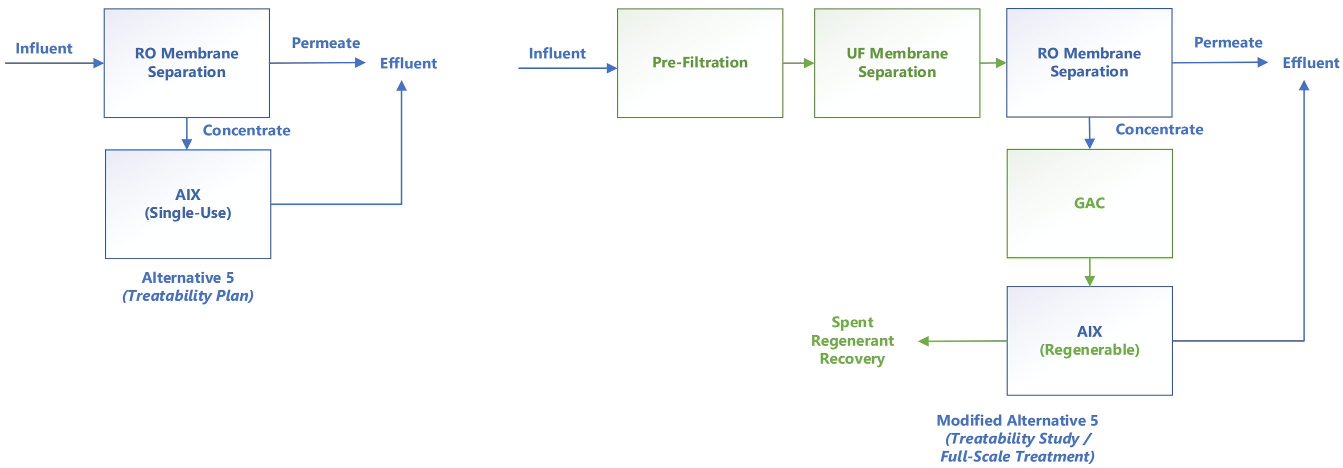


Figure 3.7 Treatability plan Alternative 5 compared to modified Alternative 5

UF as pretreatment allows the RO process to operate at a higher design flux and flow rate, resulting in lower energy usage. UF pretreatment also results in less frequent RO membrane cleaning, meaning lower chemical usage and CIP process WW management. Regenerable AIX instead of single-use provides better flexibility to meet PFAS treatment requirements, even as influent water quality and treatment targets may vary. The regeneration and continued use of the AIX resin result in less solid waste management than single-use AIX. GAC upstream of regenerable AIX provides pretreatment for longer-chain PFAS compounds and extends the time between regeneration events.

3M does not recommend Alternative 6 for further evaluation due to the operational difficulties during pilot testing an RO recovery target of 95% and the resulting PFAS treatability limitations (described in Section 3.1.1). Large Table 8 provides an updated screening for Alternative 5 and Alternative 6 using the same criteria and sub-criteria set forth in the Treatability Plan.

4 Full-scale Treatment System Proposed Design

The full-scale treatment system proposed for design and implementation at the Facility includes the primary treatment technologies from Alternative 5 of the Treatability Plan, with modifications described in Section 3.6 and Table 4.1.

Table 4.1 Comparison of full-scale treatment system process to Alternative 5 of the Treatability Plan

Treatment Process	Alternative 5 Process from Treatability Plan	Proposed Full-scale Treatment Process (Modified Alternative 5)	Comments
Pre-filtration	Not specified	Included	3M will use existing filtration equipment for pretreatment of the Phase 1/2 WW stream and NCCW/SW stream before UF.
UF	Not specified	Included	3M will use UF membranes to protect the RO membranes from excessive fouling. UF backwash stream will be sent to a solids-concentrating system. Concentrated solids will be returned to the existing WWTF.
RO	85% recovery (# of stages not specified)	Three-Stage	Multiple RO stages are included to enable a wider range of recovery setpoints. RO concentrate will be treated using GAC and regenerable AIX. The treated RO concentrate will be combined with the RO permeate, which will be discharged to Outfalls 001 and 002.
GAC	Not specified	Included	GAC adsorption will be used to remove long-chain PFAS from the RO concentrate stream prior to AIX treatment.
AIX	Single-Use	Regenerable (including onsite regeneration system)	AIX will remove short-chain PFAS in the RO concentrate. 3M proposes regenerable AIX resin to reduce total system operating costs. Spent regenerant solution will be distilled to recover solvent and reduce/concentrate the volume of PFAS-containing residuals to be managed offsite.

The Treatability Plan considered a combined treatment system for the NCCW/SW and Phase 1/2 WW streams. 3M proposes two separate treatment trains for full-scale operations: one for treating NCCW/SW that currently discharges to Outfall 002 and one for treating Phase 1/2 WW after treatment through the existing glass media filtration system at the Facility. Separate systems will allow optimum design and operations of both the SW source and the higher organics/TDS load of the WW system effluent. This will also allow separation of the fouling characteristics of each stream to a specific system, allowing more straightforward cleaning and performance monitoring.

Figure 4.1 provides a high-level process flow diagram of the proposed full-scale treatment system, and Figure 4.2 provides a diagram for the proposed three-stage RO membrane separation. A detailed process flow diagram, including routing of CIP WW, regeneration waste, and UF backwash, is included in Large Figure 5.

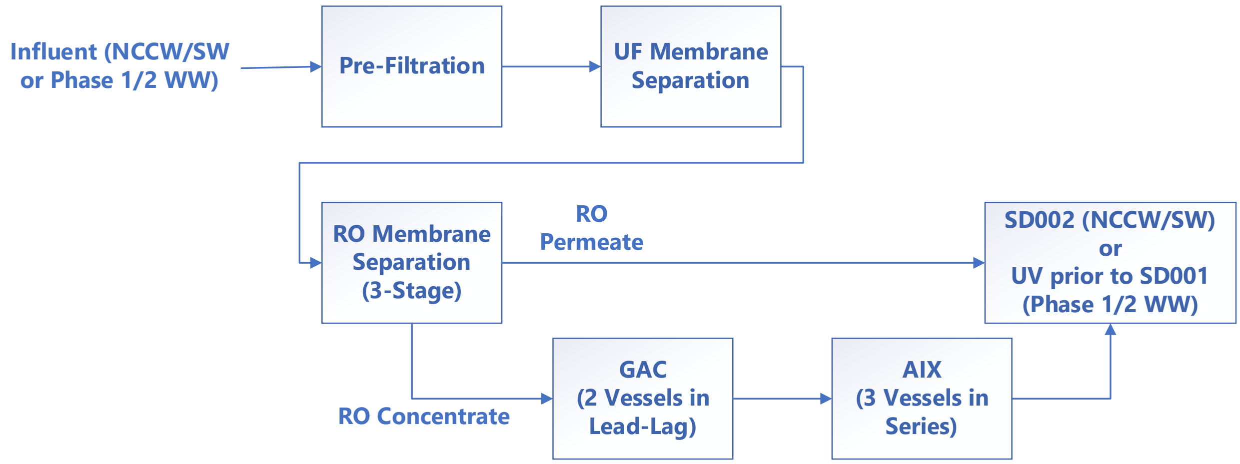


Figure 4.1 Summary of full-scale treatment system process flow

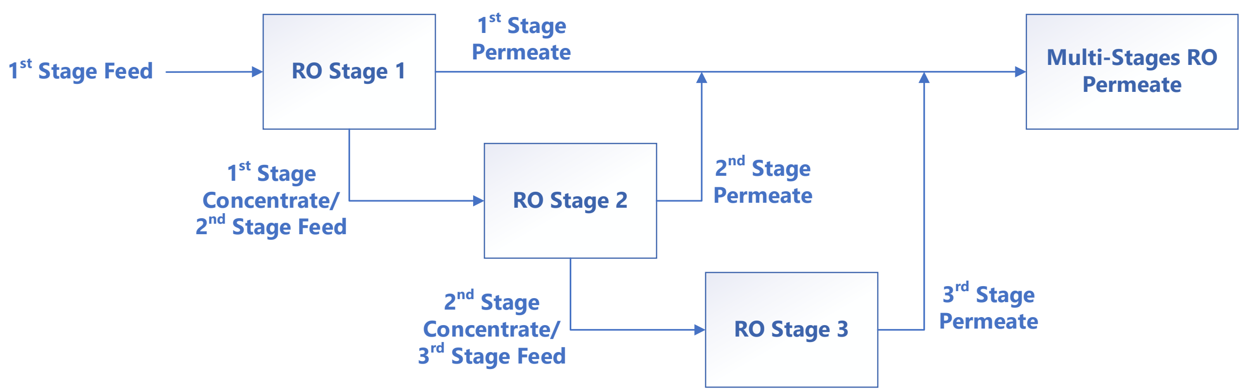


Figure 4.2 Summary of full-scale treatment three-stage RO membrane separation

4.1 Considerations for Full-Scale Treatment System Design

Factors considered during the design of the full-scale treatment system, based on the pilot test results described in this report, are outlined in the following sections for each of the major process units, including UF, RO, GAC, and AIX.

Large Table 9 compares design parameters among the Treatability Plan (for Alternative 5), pilot testing, and full-scale design.

4.1.1 Ultrafiltration Membrane Separation

Solid Particle Rejection

The UF system will remove solid particles from the feed-water stream before being introduced to the downstream RO system. RO elements contain very small passageways on the feed-water channel, and excess solids, bacteria growth, or biofoulants can cause flow imbalances and reductions in effective membrane area. Turbidity is also removed across the UF system. Based on performance during the pilot test, the same UF modules are proposed for use at full-scale.

Flux Rate

The pilot-scale UF system had an average flux rate many times greater than the proposed UF flux rates for the full-scale treatment systems. The UF system was able to recover performance consistently, a demonstration of the CIP procedure efficacy, despite the pilot system operating at greater-than-normal flux rates. At full-scale, lower flux rates will drastically slow the fouling rates to more manageable levels, and 3M anticipates that any fouling can be cleaned effectively.

Recovery

UF recovery rates were held at a constant value of 96%, which exceeds proposed full-scale design rates of 95% and 92% for the NCCW/SW and WW systems, respectively. UF permeability remained sustainable at this setpoint during the NCCW/SW test phases. The WW test phase did prove to be more of a challenge in terms of permeability loss; however, with cleaning procedures in place, these impacts were minimized.

Backwash sequences can be modified to effectively remove the suspended solids cake layer that forms throughout the filtration cycle to mitigate fouling trends during full-scale treatment system operation. This impacts overall UF recovery, consuming more water during backwash operations. When backwashes alone are no longer effective or if 3M desires higher overall UF recovery, various CIP procedures can further remove foulants from the UF membrane surface and restore permeability.

Cleaning Efficacy

The observable performance loss was minimal during the NCCW/SW test phases. Therefore, conclusions on the cleaning efficacy are difficult to determine as baseline and cleaned performance levels were similar.

Cleaning efficacy during the WW test phase was observed more easily. The system responded well to high pH cleaning using sodium hypochlorite with caustic addition (sodium hydroxide) to further elevate pH during challenging feed-water quality conditions. 3M proposes the same CIP procedure and chemicals for use at full-scale.

Membrane Integrity

Turbidity monitoring of the UF feed and filtrate will allow 3M to observe membrane integrity. Any breach in the UF fiber will appear as an elevated turbidity trend in the filtrate stream. Inlet turbidity levels ranged from 0.07 to 2.4 NTU during the pilot test. The filtrate turbidity levels were lower, ranging from 0.03 to 0.38 NTU and averaging 0.11 NTU. As such, no issues with membrane integrity were observed.

4.1.2 Reverse Osmosis Membrane Separation

The performance of RO membrane systems is influenced primarily by the RO recovery setpoint and secondarily by the permeate flux rate. The proposed full-scale design setpoints were used during the pilot test to demonstrate the expected performance at full-scale.

Recovery

When the feed water is pressurized against the RO membrane surface, clean water permeates, and the ionic species rejected by the membrane remain in the outlet from the feed side of the RO element (RO concentrate). As concentrations increase, a solubility equilibrium is reached where crystalline solids may begin to form and precipitate out of solution. This precipitation is generally referred to as scale and results in a loss of permeability across the membrane.

The solubility of the ions that will remain in the RO concentrate, including calcium carbonate, among many other crystalline compounds, determines the design RO recovery.

Permeate Flux Rate

Permeate flux rate is important to select the amount of membrane area required to produce a given system's desired volumetric flow rate. Calculation of system membrane area is shown in Eqn. 4:

$$\text{Membrane area (ft}^2\text{)} = \frac{Permeate\ Flow\ (gpm)\ x\ (min.of\ operation\ per\ day)}{Permeate\ Flux\ Rate\ (GFD)} \qquad \text{Eqn. 4}$$

Permeate flux metrics also allow performance observed at a given flux rate to be characterized and leveraged up to a system with a larger membrane area. When the nominal design parameters for permeate flux and recovery are maintained, the expected performance between RO systems with different membrane areas would be equal.

Cleaning Frequency and Efficacy

Under normal conditions, a 20% increase of pressure commonly triggers a cleaning event (150 PSI x 20% = 30 PSI increase). The normal design target for CIPs will be approximately four to eight times per year.

Each cleaning cycle slightly reduces membrane rejection as chemical exposure can break bonds within the polyamide membrane layer. This damage is proportional to the strength and types of chemicals used. Elevated temperatures of CIP solutions can also influence this damage. For a normal range of CIPs, the expected RO membrane lifespan will be in the range of 3 to 5 years.

Another important consideration in evaluating membrane system performance is demonstrating that proposed cleaning procedures and methodologies can mitigate performance losses due to scaling over time. Since 3M used the same feed water during pilot testing at the same nominal setpoints, scaling trends and performance losses observed during the pilot test represent what a full-scale system will encounter.

In this specific case, the limiting sparingly soluble salt is calcium carbonate ($CaCO_3$). This particular scale responds to low pH solutions and reacts with acids to reduce the salt during offline CIP procedures. During pilot testing, membrane permeability and rejection were maintained through CIP operations, effectively removing any encountered scale.

Summary

Given the successful demonstration at 85% recovery for the NCCW/SW source during NCCW_A and NCCW_B test phases, 3M proposes the design basis of 85% recovery and 14 GFD permeate flux rate for full-scale NCCW/SW treatment system.

Phase 1/2 WW had a higher TDS concentration than the NCCW/SW source. RO projections computed a maximum attainable recovery of 87%. Given the successful demonstration at 85% recovery for this source water, 3M proposes the design basis of 85% recovery and 12 GFD permeate flux rate for full-scale Phase 1/2 WW treatment system. Due to the higher organics loading rate, lower permeate flux rates for Phase 1/2 WW treatment are proposed to slow biofouling over time. Biofouling did not increase the pressure differential observed during the WW test phase but will be monitored during full-scale operation and addressed, if necessary.

4.1.3 GAC Treatment of RO Concentrate

3M estimates that most PFAS compound mass (> 99%) will be rejected by the RO membrane operations and will report to the RO concentrate stream. 3M will treat the RO concentrate using a combination of GAC and AIX resin. First, the GAC removes long-chain PFAS compounds. The full-scale treatment system will use an array of 10-foot-diameter contactor vessels for GAC treatment. The EBCT through any single GAC contactor vessel will be at least 19 minutes at maximum flow rates. At average flow rates, the EBCT will be 26 minutes. These contact times are typical of GAC treatment for TOC and long-chain PFAS compounds. 3M operated the GAC columns at an EBCT of 30 minutes during the pilot test, which is slightly longer than the anticipated full-scale contact time; however, 3M anticipates the pilot results to be directly applicable to full-scale design.

The GAC systems will be operated in lead/lag configuration to monitor for breakthrough out of the lead vessel for the key PFAS constituents that will drive GAC changeout frequencies. Based on the pilot data, the compounds likely to drive GAC changeout are PFBS and/or HQ-115. It is important to limit the amount of long-chain, sulfonated PFAS compounds loading onto the AIX resin following GAC treatment; these compounds will be difficult to remove from the regenerable AIX resin.

4.1.4 Regenerable AIX Treatment of RO Concentrate

Following GAC treatment, the AIX treatment removes the remaining short-chain PFAS compounds in the RO concentrate stream before combining with the RO permeate stream upstream of the respective treatment system discharge locations. The AIX will remove PFPA, PFBA, and TFMS. The AIX resin will also remove low-concentration, residual PFAS that the GAC may not capture. The full-scale treatment system will use a total of ten trains of three-vessel skids that will contain SORBIX A3F media in the first vessel

(vessel 1) and a secondary high-capacity macroporous media in the second and third vessels (vessels 2 and 3). (See Large Figure 4 and Large Figure 5 for preliminary vessel configuration layout.)

The SORBIX A3F will remove the bulk of TFMS and potentially PFBS before reaching the higher capacity AIX in vessels 2 and 3. The AIX media in vessels 2 and 3 will remove PFPA and PFBA. At maximum flow rates, the EBCT through a three-vessel skid will be approximately 43 minutes for NCCW/SW and 54 minutes for Phase 1/2 WW. At average flow rates, the EBCT will be 60 minutes for NCCW/SW and 72 minutes for Phase 1/2 WW. During the pilot test, the AIX columns were operated at an EBCT of 30 minutes, which is longer than an individual vessel's EBCT but shorter than the combined three-vessel skid contact time. 3M anticipates the pilot results to be directly applicable to full-scale design.

The AIX systems will contain sample ports after each vessel and at the mid-bed location of the third vessel to monitor for breakthrough at several points in the system, enabling efficient regeneration frequencies.

Once a three-vessel skid is spent, it will be taken off-line to be regenerated, and a standby skid will be placed online. 3M will regenerate the three-vessel skid by pumping approximately five BVs of an alcohol/brine mixture countercurrent to the forward flow direction through all three vessels. After five BVs of regenerant have passed through the vessels, the residual regenerant will be flushed out with potable water (potentially RO permeate). The spent regenerant and some rinse water will be collected in a holding tank and fed to the regenerant recovery system (distillation), then to the PFAS residuals management system (loading onto additional media and potentially brine-drying).

4.2 Proposed Design Development Update

3M is proceeding with the process, mechanical, and electrical design of the full-scale treatment and regeneration systems. Per MPCA's approval of the Treatability Plan (received by email on June 25, 2021, from Scott Knowles), a mid-course design meeting will occur between 3M and MPCA at approximately 50–60% completion of the plans and specifications. Large Table 6 and Large Table 7 provide the process flow diagrams for the proposed full-scale NCCW/SW and Phase 1/2 WW treatment systems.

4.3 Remaining Risks and Uncertainties

3M will evaluate the following considerations as the full-scale system proceeds to final design:

- Pretreatment needed for NCCW/SW due to potential for algae growth in ponds
- Pretreatment of Phase 1/2 WW, in case of proposed new clarifier upset, using additional filtration, if deemed beneficial
- UF recovery in the full-scale system with a lower flux rate than the pilot-scale system
- UF CIP cleaning requirements and long-term recovery limitations for Phase 1/2 WW treatment

- Long-term RO membrane resiliency and lifespan, given decreased rejection near the end of pilot testing
- GAC BVs before changeout
- AIX run times before regeneration, based on treatment targets and full-scale operational results
- Regeneration system—management of PFAS mass and salts concentrated in still bottoms from the distillation process
- Potential for loss of AIX treatment capacity following repeated regenerations and associated AIX media bed life, especially with TFMS
- Treatment targets for combined (RO permeate and regenerable AIX effluent) effluent at SD001 and SD002

4.4 Updated Cost Estimates

PFAS breakthrough times and associated changeout frequency (for GAC) and regeneration frequency (for AIX) are expected to significantly affect the potential capital and operating costs of the proposed full-scale treatment system. They affect operating costs due to the price of additional media and labor to handle changeouts. They affect capital costs because they require vessels large enough to provide treatment without frequent media changeouts.

3M and ECT2 developed Class 3 capital and operating costs with an accuracy range of -10% to +30% at the time of this report preparation. The estimated capital cost range presented in the Treatability Plan for Alternative 5 was $17.2–$68.8MM. The estimated capital cost range of the full-scale treatment system is $167-$241MM.

The estimated annual operations and maintenance cost range presented in the Barr report for Alternative 5 was $2.9–$11.6MM. The estimated annual operations and maintenance cost range of Modified Alternative 5 is $7.3–$10.6MM. These costs include building and equipment electricity; consumables, such as UF, RO, and AIX regeneration chemicals; GAC replacement and reactivation; AIX regeneration; building maintenance; materials and supply, such as UF and RO membranes; and O&M labor, including operations and shift maintenance staff.

4.4.1 Cost Estimate Assumptions

The opinions of probable capital and O&M costs provided in this report are made based on 3M and ECT2's experience and qualifications and represent our best judgment as experienced and qualified professionals familiar with the Facility. The cost opinions are based on information available to 3M and ECT2 at this time. The opinions of cost may change as 3M completes further design. In addition, since we have no control over the cost of labor, materials, equipment, or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, 3M cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from the opinions of probable capital and O&M costs presented in this report. 3M can provide further accuracy in the opinions of probable capital and O&M cost with further design.

3M and ECT2 have based this budgetary-level (Class 3, 10–40% design completion per ASTM E 2516-06) cost estimate on 30% designs, alignments, quantities, and unit prices. Costs will change with further design. We have not included time value-of-money escalation costs. Contingency is an allowance for the net sum of costs in the final total cost at the time of design completion but not included at this level of project definition. The estimated accuracy range for the opinions of cost provided is -10% to +30%. 3M has based the accuracy range on professional judgment considering the level of design completed, the complexity, and the uncertainties associated with each alternative. The accuracy range does not include costs for future scope changes that are not part of the current design or risk contingency costs.

Large Tables

Large Table 1: Background water quality summary

Lab Report	Normalized Sample ID	Sample Date	Alkalinity, Total as CaCO3	Alkalinity,Bicarbonate (CaCO3)	Alkalinity,Carbonate (CaCO3)	Allyl chloride	Aluminum	Barium	BOD, 5 day	Boron	Bromide	Calcium	Chemical Oxygen Demand	Chloride	Copper	Copper, Dissolved	Fluoride	Iron	Magnesium	Manganese	Nickel	Nitrate as N	Nitrite as N	Nitrogen, Ammonia	Nitrogen, NO2 plus NO3	Oil and Grease	Orthophosphate as P	pH at 25 Degrees C	Phosphorus	Potassium
			mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Std. Units	mg/L	mg/L
NCCW PRE-PILOT SAMPLE																														
10571670	3MCG-NCCW-PRE-PILOT SAMPLE-2021-072	7/26/2021	243.0	243.0	< 5	< 5	< 0.2	0.1	< 2	< 0.15	0.2	101.0	< 50	62.7	< 0.01	0.010	0.8	< 0.05	35.3	< 0.005	< 0.02	10.7	< 0.1	< 0.1	13.4	< 4.8	0.1	8.3	0.2	3.4
UF/RO																														
UF Influent																														
10572757	3MCG-NCCW-UF INF-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.1	< 2	< 0.15	0.2	101.0	55.7	64.4	< 0.01	< 0.01	0.9	< 0.05	34.6	< 0.005	NR	10.5	< 0.1	< 0.1	NR	< 4.8	0.1	NR	1.9	3.8
10573932	3MCG-NCCW-UF INF-2021-0810	8/10/2021	224.0	224.0	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	55.6	NR	NR	NR	< 0.05	NR	< 0.005	NR	9.5	NR	NR	NR	NR	NR	NR	NR	NR
10584328	3MCG-NCCW-UF INF-2021-1021	10/21/2021	228.0	228.0	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	50.8	NR	NR	NR	< 0.05	NR	< 0.005	NR	7.8	NR	NR	NR	NR	NR	NR	NR	NR
UF Permeate																														
10572757	3MCG-NCCW-UF PERM-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.1	< 2	< 0.15	0.2	99.7	< 50	60.3	0.016	0.015	0.8	< 0.05	34.0	< 0.005	NR	10.1	< 0.1	< 0.1	NR	< 4.8	0.1	NR	2.3	3.4
10573932	3MCG-NCCW-UF PERM-2021-0810	8/10/2021	219.0	219.0	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	55.6	NR	NR	NR	< 0.05	NR	< 0.005	NR	9.4	NR	NR	NR	NR	NR	NR	NR	NR
10584328	3MCG-NCCW-UF PERM-2021-1021	10/21/2021	228.0	228.0	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	50.7	NR	NR	NR	< 0.05	NR	< 0.005	NR	7.8	NR	NR	NR	NR	NR	NR	NR	NR
RO Permeate																														
10572757	3MCG-NCCW-RO PERM-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	< 0.01	< 2	< 0.15	< 0.08	0.9	< 50	2.1	< 0.01	< 0.01	< 0.05	< 0.05	< 0.5	< 0.005	NR	1.6	< 0.1	< 0.1	NR	< 4.8	< 0.01	NR	0.1	< 2.5
10573932	3MCG-NCCW-RO PERM-2021-0810	8/10/2021	< 5	< 5	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	2.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	1.6	NR	NR	NR	NR	NR	NR	NR	NR
10584328	3MCG-NCCW-RO PERM-2021-1021	10/21/2021	28.5	28.5	< 5	NR	NR	NR	NR	NR	NR	NR	< 50	12.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	5.0	NR	NR	NR	NR	NR	NR	NR	NR
RO Concentrate																														
10572757	3MCG-NCCW-RO REJ-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.3	< 2	< 0.15	1.1	594.0	78.4	358.0	0.120	0.120	4.8	< 0.05	208.0	< 0.005	NR	59.7	< 0.1	< 0.1	NR	< 4.9	0.6	NR	13.1	19.9
10573932	3MCG-NCCW-RO REJ-2021-0810	8/10/2021	1,370.0	1,370.0	< 5	NR	NR	NR	NR	NR	NR	NR	106.0	346.0	NR	NR	NR	< 0.05	NR	0.0	NR	58.1	NR	NR	NR	NR	NR	NR	NR	NR
10584328	3MCG-NCCW-RO REJ-2021-1021	10/21/2021	2,040.0	2,040.0	< 5	NR	NR	NR	NR	NR	NR	NR	93.5	675.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	89.6	NR	NR	NR	NR	NR	NR	NR	NR
TRAIN A (RO CONCENTRATE - GAC + CALRES)																														
GAC1																														
10572757	3MCG-NCCW-GAC1-A-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.2	3.2	< 0.15	0.8	425.0	64.7	256.0	0.023	0.025	2.2	< 0.05	148.0	< 0.005	NR	42.7	< 0.1	< 0.1	NR	< 5	0.6	NR	11.9	13.3
10573930	3MCG-NCCW-GAC1-A-2021-0810	8/10/2021	1,240.0	1,240.0	< 5	NR	NR	NR	NR	NR	NR	NR	NR	314.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	52.4	NR	NR	NR	NR	NR	NR	NR	NR
10584327	3MCG-NCCW-GAC1-A-2021-1021	10/21/2021	2,050.0	2,050.0	< 5	NR	NR	NR	NR	NR	NR	NR	NR	662.0	NR	NR	NR	0.1	NR	< 0.005	NR	87.7	NR	NR	NR	NR	NR	NR	NR	NR
IX1																														
10572757	3MCG-NCCW-IX1-A-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.2	7.3	< 0.15	0.7	411.0	55.3	246.0	0.019	0.019	2.7	0.1	144.0	< 0.005	NR	38.0	< 0.1	< 0.1	NR	< 4.9	0.6	NR	10.2	12.7
10573930	3MCG-NCCW-IX1-A-2021-0810	8/10/2021	1,230.0	1,230.0	< 5	NR	NR	NR	NR	NR	NR	NR	NR	311.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	52.0	NR	NR	NR	NR	NR	NR	NR	NR
10584327	3MCG-NCCW-IX1-A-2021-1021	10/21/2021	1,840.0	1,840.0	< 5	NR	NR	NR	NR	NR	NR	NR	NR	661.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	88.0	NR	NR	NR	NR	NR	NR	NR	NR
TRAIN B (RO CONCENTRATE - GAC + A3F)																														
IXR1																														
10572757	3MCG-NCCW-IXR1-B-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	0.2	8.4	< 0.15	0.7	410.0	54.3	242.0	0.018	0.018	2.1	0.1	144.0	< 0.005	NR	38.6	< 0.1	< 0.1	NR	< 5	0.5	NR	10.2	12.8
10573930	3MCG-NCCW-IXR1-B-2021-0810	8/10/2021	1,210.0	1,210.0	< 5	NR	NR	NR	NR	NR	NR	NR	NR	314.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	49.9	NR	NR	NR	NR	NR	NR	NR	NR
TRAIN C (RO PERMEATE POLISH - CALRES)																														
IX1																														
10572757	3MCG-NCCW-IX1-C-2021-0803	8/3/2021	NR	NR	NR	NR	< 0.2	< 0.01	< 2	< 0.15	< 0.08	0.9	< 50	6.4	< 0.01	< 0.01	< 0.05	< 0.05	< 0.5	< 0.005	NR	< 0.1	< 0.1	< 0.1	NR	< 4.8	< 0.01	NR	0.2	< 2.5
10573930	3MCG-NCCW-IX1-C-2021-0810	8/10/2021	< 5	< 5	< 5	NR	NR	NR	NR	NR	NR	NR	NR	2.0	NR	NR	NR	< 0.05	NR	< 0.005	NR	1.7	NR	NR	NR	NR	NR	NR	NR	NR
10584327	3MCG-NCCW-IX1-C-2021-1021	10/21/2021	28.6	28.6	< 5	NR	NR	NR	NR	NR	NR	NR	NR	11.9	NR	NR	NR	0.1	NR	< 0.005	NR	5.1	NR	NR	NR	NR	NR	NR	NR	NR

Large Table 1: Background water quality summary

Lab Report	Normalized Sample ID	Silica	Silicon	Sodium	Soluble Chemical Oxygen Demand	Strontium	Styrene	Sulfate	Sulfide	Total Dissolved Solids	Total Hardness by 2340B	Total Organic Carbon	Total Suspended Solids	Zinc
		mg/L	ug/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
NCCW PRE-PILOT SAMPLE														
10571670	3MCG-NCCW-PRE-PILOT SAMPLE-2021-072	**24.9**	NR	**31.9**	< 50	**0.120**	< 1	**107.0**	< 0.1	**610.0**	**398.0**	**2.9**	< 10	< 0.02
UF/RO														
UF Influent														
10572757	3MCG-NCCW-UF INF-2021-0803	**26.1**	NR	**29.8**	< 50	**0.120**	NR	**128.0**	NR	**570.0**	**396.0**	**4.8**	< 10	< 0.02
10573932	3MCG-NCCW-UF INF-2021-0810	**19.9**	NR	**30.9**	NR	NR	NR	**96.5**	NR	**292.0**	NR	NR	< 10	NR
10584328	3MCG-NCCW-UF INF-2021-1021	**25.2**	NR	**24.4**	NR	NR	NR	**69.0**	NR	**433.0**	NR	NR	< 10	NR
UF Permeate														
10572757	3MCG-NCCW-UF PERM-2021-0803	**23.9**	NR	**29.7**	< 50	**0.100**	NR	**98.4**	NR	**496.0**	**389.0**	**4.9**	< 10	< 0.02
10573932	3MCG-NCCW-UF PERM-2021-0810	**21.0**	NR	**29.7**	NR	NR	NR	**96.4**	NR	**514.0**	NR	NR	< 10	NR
10584328	3MCG-NCCW-UF PERM-2021-1021	**20.8**	NR	**24.6**	NR	NR	NR	**68.8**	NR	**437.0**	NR	NR	< 10	NR
RO Permeate														
10572757	3MCG-NCCW-RO PERM-2021-0803	**0.4**	NR	**3.5**	< 50	**0.001**	NR	< 1.2	NR	**21.0**	**3.5**	**1.4**	< 10	< 0.02
10573932	3MCG-NCCW-RO PERM-2021-0810	< 1.1	NR	**3.5**	NR	NR	NR	< 1.2	NR	**10.0**	NR	NR	< 10	NR
10584328	3MCG-NCCW-RO PERM-2021-1021	**17.8**	NR	**12.7**	NR	NR	NR	**10.7**	NR	**87.0**	NR	NR	< 10	NR
RO Concentrate														
10572757	3MCG-NCCW-RO REJ-2021-0803	**133.0**	NR	**165.0**	**88.0**	**0.560**	NR	**639.0**	NR	**3,310.0**	**2,340.0**	**22.6**	< 10	**0.056**
10573932	3MCG-NCCW-RO REJ-2021-0810	**113.0**	NR	**170.0**	NR	NR	NR	**622.0**	NR	**3,170.0**	NR	NR	< 10	NR
10584328	3MCG-NCCW-RO REJ-2021-1021	**284.0**	**133,000**	**306.0**	NR	NR	NR	**1,420.0**	NR	**5,680.0**	NR	NR	**302.0**	NR
TRAIN A (RO CONCENTRATE - GAC + CALRES)														
GAC1														
10572757	3MCG-NCCW-GAC1-A-2021-0803	**88.2**	NR	**129.0**	**76.5**	**0.390**	NR	**474.0**	NR	**2,370.0**	**1,670.0**	**18.5**	< 10	**0.041**
10573930	3MCG-NCCW-GAC1-A-2021-0810	NR	NR	NR	NR	**0.540**	NR	**568.0**	NR	**2,770.0**	NR	**20.0**	< 10	NR
10584327	3MCG-NCCW-GAC1-A-2021-1021	**249.0**	NR	NR	NR	NR	NR	**1,400.0**	NR	**5,640.0**	NR	**16.6**	**470.0**	NR
IX1														
10572757	3MCG-NCCW-IX1-A-2021-0803	**92.3**	NR	**127.0**	**58.7**	**0.400**	NR	**496.0**	NR	**2,390.0**	**1,620.0**	**15.9**	< 10	**0.042**
10573930	3MCG-NCCW-IX1-A-2021-0810	NR	NR	NR	NR	**0.500**	NR	**561.0**	NR	**2,840.0**	NR	**16.9**	< 10	NR
10584327	3MCG-NCCW-IX1-A-2021-1021	**3.8**	NR	NR	NR	NR	NR	**1,410.0**	NR	**5,440.0**	NR	**14.8**	**358.0**	NR
TRAIN B (RO CONCENTRATE - GAC + A3F)														
IXR1														
10572757	3MCG-NCCW-IXR1-B-2021-0803	**95.0**	NR	**127.0**	**61.1**	**0.410**	NR	**475.0**	NR	**2,410.0**	**1,620.0**	**16.1**	< 10	**0.040**
10573930	3MCG-NCCW-IXR1-B-2021-0810	NR	NR	NR	NR	**0.530**	NR	**558.0**	NR	**2,760.0**	NR	**16.2**	< 10	NR
TRAIN C (RO PERMEATE POLISH - CALRES)														
IX1														
10572757	3MCG-NCCW-IX1-C-2021-0803	**0.5**	NR	**3.6**	< 50	**0.001**	NR	< 1.2	NR	**11.0**	**3.5**	**1.2**	< 10	< 0.02
10573930	3MCG-NCCW-IX1-C-2021-0810	NR	NR	NR	NR	< 0.0025	NR	< 1.2	NR	< 10	NR	**1.3**	< 10	NR
10584327	3MCG-NCCW-IX1-C-2021-1021	**261.0**	NR	NR	NR	NR	NR	**10.5**	NR	**79.0**	NR	< 1	< 10	NR

Large Table 1: Background water quality summary

Lab Report	Normalized Sample ID	Sample Date	Alkalinity, Total as CaCO3	Alkalinity,Bicarbonate (CaCO3)	Alkalinity,Carbonate (CaCO3)	Allyl chloride	Aluminum	Barium	BOD, 5 day	Boron	Bromide	Calcium	Chemical Oxygen Demand	Chloride	Copper	Copper, Dissolved	Fluoride	Iron	Magnesium	Manganese	Nickel	Nitrate as N	Nitrite as N	Nitrogen, Ammonia	Nitrogen, NO2 plus NO3	Oil and Grease
			mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WW PRE-PILOT SAMPLE																										
10571670	3MCG-WW-PRE-PILOT SAMPLE-2021-0726	7/26/2021	454.0	454.0	< 5	< 5	< 0.2	0.0	< 6	0.5	0.4	52.8	< 50	132.0	< 0.01	< 0.01	0.7	< 0.05	24.5	0.0	< 0.02	24.5	0.4	0.3	25.2	< 4.7
UF/RO																										
UF Influent																										
10579940	3MCG-WW-UF INF-2021-0922	9/22/2021	344.0	344.0	< 5	NR	< 0.2	0.0	6.7	0.6	0.2	67.1	< 50	98.4	< 0.01	< 0.01	0.4	< 0.05	29.3	0.0	NR	10.5	0.1	1.5	NR	< 5
UF Permeate																										
10579940	3MCG-WW-UF PERM-2021-0922	9/22/2021	344.0	344.0	< 5	NR	< 0.2	0.0	3.5	0.5	0.2	64.1	< 50	98.0	< 0.01	< 0.01	0.4	< 0.05	27.9	0.0	NR	10.5	0.1	1.4	NR	< 4.8
RO Permeate																										
10579940	3MCG-WW-RO PERM-2021-0922	9/22/2021	10.7	10.7	< 5	NR	< 0.2	< 0.01	< 2	0.4	< 0.08	< 0.5	< 50	4.4	< 0.01	< 0.01	< 0.05	< 0.05	< 0.5	< 0.005	NR	1.8	< 0.1	0.4	NR	< 5
RO Concentrate																										
10579940	3MCG-WW-RO REJ-2021-0922	9/22/2021	2,600.0	2,600.0	< 5	NR	< 0.2	0.3	3.9	1.8	1.3	478.0	264.0	832.0	0.2	0.2	2.7	< 0.05	227.0	0.0	NR	76.9	1.8 J	8.0	NR	< 4.8
TRAIN A (RO CONCENTRATE - GAC + CALRES)																										
GAC1																										
10579708	3MCG-WW-GAC1-A-2021-0921	9/21/2021	2,850.0	2,850.0	< 5	NR	< 0.2	0.3	3.3	1.6	2.7	352.0	88.6	934.0	0.0	0.0	2.0	< 0.05	206.0	0.0	NR	93.9	33.0	1.5	NR	< 4.9
IX1																										
10579708	3MCG-WW-IX1-A-2021-0921	9/21/2021	2,860.0	2,860.0	< 5	NR	< 0.2	0.3	2.2	1.7	3.3	358.0	84.6	926.0	0.0	0.0	1.9	0.1	218.0	0.0	NR	99.2	40.7	1.4	NR	< 4.9
TRAIN B (RO CONCENTRATE - GAC + A3F)																										
IXR1																										
10579708	3MCG-WW-IXR1-B-2021-0921	9/21/2021	2,840.0	2,840.0	< 5	NR	< 0.2	0.3	2.5	1.7	3.1	355.0	87.5	931.0	0.1	0.1	1.8	< 0.05	212.0	0.0	NR	101.0	39.6	1.6	NR	< 4.8
TRAIN C (RO PERMEATE POLISH - CALRES)																										
IX1																										
10579708	3MCG-WW-IX1-C-2021-0921	9/21/2021	33.9	33.9	< 5	NR	< 0.2	< 0.01	< 2	0.4	< 0.08	< 0.5	< 50	6.1	< 0.01	< 0.01	< 0.05	< 0.05	< 0.5	< 0.005	NR	2.2	0.1	0.3	NR	< 4.8

Large Table 1: Background water quality summary

Lab Report	Normalized Sample ID	Orthophosphate as P	pH at 25 Degrees C	Phosphorus	Potassium	Silica	Silicon	Sodium	Soluble Chemical Oxygen Demand	Strontium	Styrene	Sulfate	Sulfide	Total Dissolved Solids	Total Hardness by 2340B	Total Organic Carbon	Total Suspended Solids	Zinc
		mg/L	Std. Units	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
WW PRE-PILOT SAMPLE																		
10571670	3MCG-WW-PRE-PILOT SAMPLE-2021-0726	< 0.01	**8.0**	< 0.1	**4.5**	**16.3**	NR	**293.0**	< 50	**0.1**	< 25	**222.0**	< 0.1	**1,160.0**	**233.0**	**6.1**	< 10	< 0.02
UF/RO																		
UF Influent																		
10579940	3MCG-WW-UF INF-2021-0922	< 0.01	NR	< 0.1	**12.8**	**18.2**	NR	**165.0**	< 50	**0.1**	NR	**130.0**	NR	**782.0**	**288.0**	**7.0**	< 10	< 0.02
UF Permeate																		
10579940	3MCG-WW-UF PERM-2021-0922	< 0.01	NR	< 0.1	**11.8**	**18.4**	NR	**157.0**	< 50	**0.1**	NR	**128.0**	NR	**776.0**	**275.0**	**6.0**	< 10	< 0.02
RO Permeate																		
10579940	3MCG-WW-RO PERM-2021-0922	< 0.01	NR	**0.2**	< 2.5	**0.4**	NR	**10.7**	< 50	< 0.0005	NR	**1.2**	NR	**37.0**	< 3.3	**1.4**	< 10	< 0.02
RO Concentrate																		
10579940	3MCG-WW-RO REJ-2021-0922	**0.1**	NR	**11.2**	**123.0**	**142.0**	NR	**1,410.0**	**276.0**	**0.6**	NR	**1,160.0**	NR	**6,330.0**	**2,130.0**	**31.0**	< 10	**0.1**
TRAIN A (RO CONCENTRATE - GAC + CALRES)																		
GAC1																		
10579708	3MCG-WW-GAC1-A-2021-0921	**0.3**	NR	**14.4**	**243.0**	**112.0**	NR	**1,880.0**	**109.0**	**0.6**	NR	**1,260.0**	NR	**7,020.0**	**1,730.0**	**19.0**	**72.5**	**0.1**
IX1																		
10579708	3MCG-WW-IX1-A-2021-0921	**0.3**	NR	**14.1**	**260.0**	**115.0**	NR	**2,140.0**	**93.3**	**0.6**	NR	**1,260.0**	NR	**7,120.0**	**1,790.0**	**15.3**	**71.2**	**0.1**
TRAIN B (RO CONCENTRATE - GAC + A3F)																		
IXR1																		
10579708	3MCG-WW-IXR1-B-2021-0921	**0.3**	NR	**14.2**	**261.0**	**115.0**	NR	**2,070.0**	**89.5**	**0.6**	NR	**1,240.0**	NR	**6,980.0**	**1,760.0**	**16.2**	**58.7**	**0.1**
TRAIN C (RO PERMEATE POLISH - CALRES)																		
IX1																		
10579708	3MCG-WW-IX1-C-2021-0921	< 0.01	NR	**0.3**	< 2.5	**0.4**	NR	**10.8**	< 50	< 0.0005	NR	< 1.2	NR	**40.0**	< 3.3	**1.9**	< 10	< 0.02

Large Table 2: Field data summary

		Raw Feed						Post-Cartridge Filter						
		Temperature	Conductivity	ORP	pH	TDS	Turbidity	Temperature	Conductivity	ORP	Resistivity	pH	TDS	Turbidity
		C or F	uS/cm	mV	SU	ppm	NTU	C or F	uS/cm	mV	KΩ	SU	ppm	FTU
	min	23	1480	-100	7.7	1039	1.18	23	1856	-14		7.7	1329	0.81
	avg	23	1671	-38	7.7	1188	1.18	23	1856	-14		7.7	1329	0.81
WW	max	23	1862	24	7.7	1336	1.18	23	1856	-14		7.7	1329	0.81
	min	19	745	77	8	509		18	745	90		8	509	
	avg	20	822	127	8	567		20	822	124		8	567	
NCCW_A	max	21	889	174	8	618		21	893	183		8	621	
	min	20	709	-41	8	486		20	706	98		8	484	
	avg	21	716	15	8	489		20	706	98		8	484	
NCCW_B	max	22	723	71	8	492		20	706	98		8	484	

		UF Inlet						UF-1 Permeate						UF-2 Permeate					
		Temperature	Conductivity	ORP	pH	TDS	Turbidity	Temperature	Conductivity	ORP	pH	TDS	Turbidity	Temperature	Conductivity	ORP	pH	TDS	Turbidity
		C or F	uS/cm	mV	SU	ppm	FTU	C or F	uS/cm	mV	SU	ppm	FTU	C or F	uS/cm	mV	SU	ppm	FTU
	min	20	1294	-31	7.8	909	0.86	22	1837	-34	7.9	1314	0.06	20	1291	-27	7.7	908	
	avg	21	1475	101	8.0	1044	0.86	22	1837	-34	7.9	1314	0.06	21	1478	104	8.0	1047	
WW	max	22	1835	208	8.4	1312	0.86	22	1837	-34	7.9	1314	0.06	22	1837	207	8.4	1314	
	min	18	794	73	8	546		18	796	-9	5	546		19	796	65	8	548	
	avg	20	845	96	8	583		20	870	67	8	607		21	845	95	8	582	
NCCW_A	max	22	884	119	8	611		22	950	136	8	687		22	882	145	8	610	
	min	19	837	82	8	579		19	826	36	8	571		19	837	-33	8	571	
	avg	19	837	82	8	579		20	1463	54	8	1047		22	1264	31	8	893	
NCCW_B	max	19	837	82	8	579		20	2100	71	8	1523		25	2112	81	8	1529	

		RO Inlet						RO Internal Recycle						RO Permeate			
		Temperature	Conductivity	ORP	TDS	Flowrate	Turbidity	Temperature	Conductivity	ORP	pH	TDS	Turbidity	Conductivity	ORP	Resistivity	pH
		C or F	uS/cm	mV	ppm	gpm	FTU	C or F	uS/cm	mV	SU	ppm	FTU	uS/cm	mV	KΩ	SU
	min	17	960	-95	664			17	2768	-137	8	2054	1.172	25	-69	7	6.0
	avg	21	1593	-15	1131			21	5894	-37	8	4654	1.172	80	-5	14	7.0
WW	max	24	2013	77	1445			23	7446	38	9	5972	1.172	137	86	19	8.5
	min	21	810	-5	557			21	2006	13	8	1447		25	9	31	6
	avg	22	862	48	593			22	2329	48	8	1702		29	59	35	7
NCCW_A	max	23	923	114	633			23	2820	88	8	2093		32	105	40	8
	min	19	19	-57	510			19	1455	-62	8	1022		15	-54	12	6
	avg	21	1069	16	883			21	2804	-15	8	2101		269	14	425	7
NCCW_B	max	22	3189	87	2374			23	7310	22	9	5867		2560	64	3891	9
	min	15	848	-66	582			0	915	-91	7	1470		35	8	11	6
	avg	19	926	-7	643			18	3463	-36	8	2976		119	29	14	7
NCCW_D	max	23	1023	44	714			22	5995	21	8	4726		300	44	17	8

		RO Concentrate				Concentrate Tank				Train A Influent				
		Temperature	Conductivity	pH	TDS	Temperature	Conductivity	pH	TDS	Temperature	Conductivity	ORP	pH	Turbidity
		C or F	uS/cm	SU	ppm	C or F	uS/cm	SU	ppm	C or F	uS/cm	mV	SU	FTU
	min	17	11	8	4410					17	11	-45	8.1	
	avg	21	7927	8	7860					20	7133	22	8.4	
WW	max	23	11820	9	11820					23	10140	111	9.1	
	min	21	1983	8	1725	24	4056	8	3078	19	3903	-62	8.1	
	avg	23	3746	8	2882	24	4056	8	3078	23	4010	-18	8.1	
NCCW_A	max	27	4691	8	3605	24	4056	8	3078	27	4067	47	8.1	
	min	19	782	8	536					21	3795	-71	8.1	1.3
	avg	22	4440	8	3479					22	3851	-45	8.2	1.3
NCCW_B	max	27	11970	9	10130					23	3896	-8	8.3	1.4
	min	20	2720	8	2011									
	avg	21	4475	8	3476									
NCCW_D	max	22	7437	9	6007									

		GAC1-A Effluent					GAC2-A Effluent						IX1-A Effluent				
		Temperature	Conductivity	ORP	TDS	Turbidity	Temperat	Conductivity	ORP	pH	TDS	Turbidity	Temperature	ORP	pH	TDS	Turbidity
		C or F	uS/cm	mV	ppm	FTU	C or F	uS/cm	mV	SU	ppm	NTU	C or F	mV	SU	ppm	FTU
	min	17	12	-30	10		17	12	-18	8.1	11		17	-2	8.1	13	
	avg	20	7108	58	5935		20	8302	62	8.4	6930		20	67	8.5	5953	
WW	max	22	10150	164	8495		22	10150	156	9.1	8489		22	101	9.2	8478	
	min	19	125	5	2926		19	2459	-15	8.0	1796		20	3	8.1	2109	
	avg	818	3229	58	3033		22	3816	57	8.1	2888		22	64	8.2	2899	
NCCW_A	max	3991	4072	126	3088		24	4060	139	8.3	3093		23	135	8.6	3093	
	min	21	3800	-48	2867	2.1	21	3781	-18	8.0	2542	1.5	21	9	8.0	2851	0.3
	avg	22	3867	-37	2916	2.1	23	3861	12	9.3	2863	1.6	22	30	8.2	2959	0.5
NCCW_B	max	30	3941	-12	2949	2.1	29	3931	65	17.0	2939	1.7	29	52	8.3	3349	0.7

		IX2-A Effluent				Train B Influent				IXR1-B Effluent				IXR2-B Effluent				
		Conductivity	ORP	TDS	Turbidity	Temperature	Conductivity	Resist	pH	Temperature	Conductivity	ORP	pH	Temperature	Conductivity	pH	TDS	Turbidity
		uS/cm	mV	ppm	FTU	C or F	uS/cm	KΩ	SU	C or F	uS/cm	mV	SU	C or F	uS/cm	SU	ppm	FTU
	min	13	7	11						18	11	9	8.1	17	11	7.7	10	
	avg	8328	96	6956						21	6243	87	8.9	21	6245	8.3	6333	
WW	max	10160	255	8502						24	10090	173	12.8	24	10090	8.9	8961	
	min	2891	19	2198		22	4043		8.1	20	3197	42	5.8	21	3057	6	2258	
	avg	3693	77	2900		23	4045		8.1	22	3869	89	7.8	22	3841	8	2903	
NCCW_A	max	4042	140	3078		23	4046		8.2	24	4049	128	8.2	23	4035	8	3066	
	min	3763	28	2844	0.2					21	3777	42	8.0	20	2886	6	2810	1.5
	avg	3970	54	3007	0.5					23	3946	73	8.2	22	3896	8	3033	1.5
NCCW_B	max	5051	75	3879	0.9					29	4789	141	8.3	28	5465	8	4232	1.5

		Train C Influent							IX1-C Effluent							IX2-C Effluent						
		Temperature	Conductivity	ORP	pH	TDS	Flowrate	Turbidity	Temperature	Conductivity	ORP	Resistivity	pH	Totalizer	Turbidity	Temperature	Conductiv	Resistivity	pH	Flowrate	Totalizer	Turbidity
		C or F	uS/cm	mV	SU	ppm	gpm	NTU	C or F	uS/cm	mV	KΩ	SU	gal	FTU	C or F	uS/cm	KΩ	SU	gpm	gal	NTU
	min	17	56	11	5	36			17	50	2	8	6			17	51	13	6			
	avg	20	111	93	7	71			20	169	54	14	24			20	91	15	7			
WW	max	24	171	295	9	109			22	529	120	20	124			22	172	19	8			
	min	21	26	0	6	16			21	26	27	19	4			21	27	33	5			
	avg	23	33	70	6	21			23	32	77	33	6			23	33	35	6			
NCCW_A	max	25	56	111	7	34			25	51	122	38	6			24	63	38	7			
	min	20	22	-47	6	15			21	24	18	34	6			21	24	34	6			
	avg	23	337	27	7	17			22	26	42	39	6			22	26	39	6			
NCCW_B	max	27	2509	65	9	20			27	30	67	42	7			27	29	42	7			

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

					Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream	Lab Report	Sample ID	Date	Time	ID in SAP																
UF INFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-UF-INF-20210802	8/2/2021	12:00	PFAS 001	8,060	561	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	2,750	< 700	8,530
	0821-763	3MCG-NCCW-UF-INF-20210813	8/13/2021	12:00	PFAS 002	4,080	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	10,900	< 3500	< 3500	< 5000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-UF-INF-20210823	8/23/2021	15:30	PFAS 095	< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	< 3500	< 3500	< 5000
	0821-797	3MCG-NCCW-UF-INF-20210824	8/24/2021	8:00	PFAS 096	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0821-797	3MCG-NCCW-UF-INF-20210824	8/24/2021	14:00	PFAS 097	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	26,600	< 7000	< 7000	< 10000
	0821-801	3MCG-NCCW-UF-INF-20210825	8/25/2021	8:00	PFAS 098	< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	18,400	< 3500	< 3500	5,660
	0821-801	3MCG-NCCW-UF-INF-20210825	8/25/2021	14:00	PFAS 099	< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	8,100	< 3500	< 3500	6,050
	0821-804	3MCG-NCCW-UF-INF-20210826	8/26/2021	8:00	PFAS 100	< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	< 3500	< 3500	6,670
	0821-804	3MCG-NCCW-UF-INF-20210826	8/26/2021	14:00	PFAS 101	< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	< 3500	< 3500	6,910
	0921-700	3MCG-NCCW-UF-INF-20210827	8/27/2021	8:00	PFAS 102	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	27,000	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210827	8/27/2021	14:00	PFAS 103	< 1910	< 2120	< 2410	< 1520	< 2210	12,900	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	10,700	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210828	8/28/2021	8:00	PFAS 104	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210828	8/28/2021	14:00	PFAS 105	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210829	8/29/2021	8:00	PFAS 106	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210830	8/30/2021	8:00	PFAS 107	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-700	3MCG-NCCW-UF-INF-20210830	8/30/2021	14:00	PFAS 108	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-702	3MCG-NCCW-UF-INF-20210831	8/31/2021	8:00	PFAS 109	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	7,520	< 7000	< 10000
	0921-702	3MCG-NCCW-UF-INF-20210831	8/31/2021	14:00	PFAS 110	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-713	3MCG-NCCW-UF-INF-20210901	9/1/2021	8:00	PFAS 111	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-713	3MCG-NCCW-UF-INF-20210901	9/1/2021	14:00	PFAS 112	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	NCCW_D Phase																				
		3MCG-NCCW_D-UF-INF	10/16/2021	8:00		4,710	378	< 483	< 305	< 443	119	< 111	< 478	< 338	< 400	< 4871	< 4323	2,980	2,270	< 23461	10,800
UF PERMEATE	NCCW_A Phase																				
	0821-705	3MCG-NCCW-UF-PERM-20210730	7/30/2021	12:00	PFAS 003	7,370	432	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	2,740	< 700	7,890
	0821-705	3MCG-NCCW-UF-PERM-20210802	8/2/2021	12:00	PFAS 004	8,450	562	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	2,740	< 700	7,860
	0821-730	3MCG-NCCW-UF-PERM-20210806	8/6/2021	12:00	PFAS 005	8,180	664	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	2,850	1,940	< 700	6,690
	0821-733	3MCG-NCCW-UF-PERM-20210809	8/9/2021	12:00	PFAS 006	7,810	717	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	10,500	2,860	< 700	11,400
	0821-748	3MCG-NCCW-UF-PERM-20210811	8/11/2021	12:00	PFAS 007	6,340	523	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	82,700	1,500	< 700	7,960
	0821-763	3MCG-NCCW-UF-PERM-20210813	8/13/2021	12:00	PFAS 008	3,920	281	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	13,000	1,390	< 700	2,990
	0821-763	3MCG-NCCW-UF-PERM-20210816	8/16/2021	12:00	PFAS 009	3,410	304	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	5,190	1,580	< 700	3,210
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-UF-PERM-20210823	8/23/2021	15:30	PFAS 114	398	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	4,370	1,420	< 700	1,600
	0821-797	3MCG-NCCW-UF-PERM-20210824	8/24/2021	8:00	PFAS 115	601	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	5,070	1,960	< 700	4,680
	0821-797	3MCG-NCCW-UF-PERM-20210824	8/24/2021	14:00	PFAS 116	552	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	7,480	1,990	< 700	3,830
	0821-801	3MCG-NCCW-UF-PERM-20210825	8/25/2021	8:00	PFAS 117	475	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	16,200	1,960	< 700	4,960
	0821-801	3MCG-NCCW-UF-PERM-20210825	8/25/2021	14:00	PFAS 118	527	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	11,600	1,610	< 700	4,930
	0821-804	3MCG-NCCW-UF-PERM-20210826	8/26/2021	8:00	PFAS 119	565	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	5,700	2,370	< 700	5,570
	0821-804	3MCG-NCCW-UF-PERM-20210826	8/26/2021	14:00	PFAS 120	626	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	3,340	2,370	< 700	6,180
	0921-700	3MCG-NCCW-UF-PERM-20210827	8/27/2021	8:00	PFAS 121	570	< 212	< 241	< 152	< 221	752	< 258	< 239	< 169	< 200	< 1000	< 752	5,530	1,470	< 700	4,140
	0921-700	3MCG-NCCW-UF-PERM-20210827	8/27/2021	14:00	PFAS 122	756	< 212	< 241	< 152	< 221	17,700	< 258	< 239	< 169	< 200	< 1000	< 752	11,700	2,060	< 700	4,310
	0921-700	3MCG-NCCW-UF-PERM-20210828	8/28/2021	8:00	PFAS 123	753	< 212	< 241	< 152	< 221	3,100	< 258	< 239	< 169	< 200	< 1000	< 752	5,760	2,250	< 700	6,060
	0921-700	3MCG-NCCW-UF-PERM-20210828	8/28/2021	14:00	PFAS 124	767	< 212	< 241	< 152	< 221	4,230	< 258	< 239	< 169	< 200	< 1000	< 752	7,150	2,010	< 700	5,650
	0921-700	3MCG-NCCW-UF-PERM-20210829	8/29/2021	8:00	PFAS 125	1,250	< 212	< 241	< 152	< 221	3,280	< 258	< 239	< 169	< 200	< 1000	< 752	6,180	3,570	< 700	8,180
	0921-700	3MCG-NCCW-UF-PERM-20210830	8/30/2021	8:00	PFAS 126	1,320	< 212	< 241	< 152	< 221	1,120	< 258	< 239	< 169	< 200	< 1000	< 752	5,550	3,430	< 700	7,860
	0921-700	3MCG-NCCW-UF-PERM-20210830	8/30/2021	14:00	PFAS 127	1,340	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	1,720	2,690	< 700	7,140
	0921-702	3MCG-NCCW-UF-PERM-20210831	8/31/2021	8:00	PFAS 128	1,300	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	1,310	2,590	< 700	6,690
	0921-702	3MCG-NCCW-UF-PERM-20210831	8/31/2021	14:00	PFAS 129	1,640	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	1,050	2,670	< 700	8,040
	0921-713	3MCG-NCCW-UF-PERM-20210901	9/1/2021	8:00	PFAS 130	1,590	< 212	< 241	< 152	< 221	1,020	< 258	< 239	< 169	< 200	< 1000	< 752	2,040	2,570	< 700	6,530
	0921-713	3MCG-NCCW-UF-PERM-20210901	9/1/2021	14:00	PFAS 131	1,460	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	1,560	2,670	< 700	6,310
	0921-719	3MCG-NCCW-UF-PERM-20210902	9/2/2021	8:00	PFAS 132	1,640	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	2,290	< 700	6,540
	NCCW_D Phase																				
	1021-784	3MCG-NCCW_D-UF-PERM	10/16/2021	8:00		4,430	425	61	< 152	< 221	129	41	< 239	< 169	< 200	< 2089	< 2259	2,480	5,910	< 7378	10,500
	NCCW_A Phase																				

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

Stream	Lab Report	Sample ID	Date	Time	Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream	Lab Report	Sample ID	Date	Time	ID in SAP																
RO PERMEATE	0821-705	3MCG-NCCW-RO-PERM-20210730	7/30/2021	12:00	PFAS 010	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-RO-PERM-20210802	8/2/2021	12:00	PFAS 011	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-RO-PERM-20210806	8/6/2021	12:00	PFAS 012	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-733	3MCG-NCCW-RO-PERM-20210809	8/9/2021	12:00	PFAS 013	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-748	3MCG-NCCW-RO-PERM-20210811	8/11/2021	12:00	PFAS 014	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-RO-PERM-20210813	8/13/2021	12:00	PFAS 015	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-RO-PERM-20210816	8/16/2021	12:00	PFAS 016	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-RO-PERM-20210818	8/18/2021	12:00	PFAS 017	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-RO-PERM-20210820	8/20/2021	12:00	PFAS 018	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-RO-PERM-20210823	8/23/2021	12:00	PFAS 133	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-RO-PERM-20210825	8/25/2021	12:00	PFAS 134	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-RO-PERM-20210827	8/27/2021	12:00	PFAS 135	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-RO-PERM-20210830	8/30/2021	12:00	PFAS 136	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-713	3MCG-NCCW-RO-PERM-20210901	9/1/2021	12:00	PFAS 137	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-RO-PERM	10/16/2021	12:00		**14**	< 425	< 483	< 305	< 443	< 888	< 67.1	< 478	< 338	< 400	< 5639	< 5097	**75**	< 13463	< 23727	**474**
	1021-798	3MCG-NCCW-RO-PERM	10/19/2021	12:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 162	< 1194	< 844	< 1000	< 17764	< 14021	**408**	< 10950	< 42505	**963**
	1021-798	3MCG-NCCW-RO-PERM	10/20/2021	12:00		**43**	< 1062	< 1206	< 762	< 1106	< 2219	< 166	< 1194	< 844	< 1000	< 12905	< 13461	**2,620**	< 27522	< 13.9	**1,190**
	1021-798	3MCG-NCCW-RO-PERM	10/21/2021	12:00		**70**	< 1062	< 1206	< 762	< 1106	< 2219	< 167	< 1194	< 844	< 1000	< 13593	< 11309	**3,670**	< 51058	< 69853	**1,310**
	1021-837	3MCG-NCCW-RO-PERM	10/23/2021	11:15		< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**6,200**	< 3500	< 3500	< 5000
RO REJECT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-RO-REJ-20210730	7/30/2021	12:00	PFAS 019	**21,200**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	**26,200**
	0821-705	3MCG-NCCW-RO-REJ-20210802	8/2/2021	12:00	PFAS 020	**32,200**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	**9,200**	< 7000	**36,100**
	0821-730	3MCG-NCCW-RO-REJ-20210804	8/4/2021	12:00	PFAS 021	**48,900**	**3,210**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	**22,300**	< 3500	**31,500**
	0821-730	3MCG-NCCW-RO-REJ-20210806	8/6/2021	12:00	PFAS 022	**45,500**	**2,880**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	**25,800**	< 3500	**33,500**
	0821-733	3MCG-NCCW-RO-REJ-20210809	8/9/2021	12:00	PFAS 023	**43,300**	**3,240**	< 1210	< 762	**4,360**	< 2220	< 1290	**1,270**	< 844	< 1000	< 5000	< 3760	**13,500**	**12,200**	< 3500	**54,900**
	0821-748	3MCG-NCCW-RO-REJ-20210811	8/11/2021	12:00	PFAS 024	**45,500**	**3,480**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**91,300**	**13,900**	< 3500	**51,800**
	0821-763	3MCG-NCCW-RO-REJ-20210813	8/13/2021	12:00	PFAS 025	**54,100**	**2,780**	**1,500**	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**165,000**	**18,900**	< 3500	**32,400**
	0821-763	3MCG-NCCW-RO-REJ-20210816	8/16/2021	12:00	PFAS 026	**54,200**	**3,390**	**1,620**	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**171,000**	**17,600**	< 3500	**31,700**
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-RO-REJ-20210823	8/23/2021	15:30	PFAS 138	**16,500**	**1,310**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**71,000**	**7,670**	< 3500	**14,900**
	0821-797	3MCG-NCCW-RO-REJ-20210824	8/24/2021	8:00	PFAS 139	**23,100**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**127,000**	**16,800**	< 7000	**44,600**
	0821-797	3MCG-NCCW-RO-REJ-20210824	8/24/2021	14:00	PFAS 140	**17,600**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**103,000**	**14,700**	< 7000	**41,300**
	0821-801	3MCG-NCCW-RO-REJ-20210825	8/25/2021	8:00	PFAS 141	**18,500**	**1,390**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**114,000**	**10,500**	< 3500	**39,200**
	0821-801	3MCG-NCCW-RO-REJ-20210825	8/25/2021	14:00	PFAS 142	**16,900**	**1,240**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**105,000**	**11,800**	< 3500	**37,000**
	0821-804	3MCG-NCCW-RO-REJ-20210826	8/26/2021	8:00	PFAS 143	**15,800**	**1,320**	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**104,000**	**10,800**	< 3500	**38,400**
	0821-804	3MCG-NCCW-RO-REJ-20210826	8/26/2021	14:00	PFAS 144	**13,400**	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	**91,100**	**11,700**	< 3500	**35,900**
	0921-700	3MCG-NCCW-RO-REJ-20210827	8/27/2021	8:00	PFAS 145	**13,200**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**81,800**	**10,200**	< 7000	**28,600**
	0921-700	3MCG-NCCW-RO-REJ-20210827	8/27/2021	14:00	PFAS 146	**12,800**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**78,600**	< 7000	< 7000	**25,500**
	0921-700	3MCG-NCCW-RO-REJ-20210828	8/28/2021	8:00	PFAS 147	**11,200**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**79,300**	**8,120**	< 7000	**31,900**
	0921-700	3MCG-NCCW-RO-REJ-20210828	8/28/2021	14:00	PFAS 148	**11,700**	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**82,800**	< 7000	< 7000	**32,200**
	0921-700	3MCG-NCCW-RO-REJ-20210829	8/29/2021	8:00	PFAS 149	**15,600**	< 2120	< 2410	< 1520	< 2210	**5,010**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**102,000**	**9,480**	< 7000	**41,900**
	0921-700	3MCG-NCCW-RO-REJ-20210830	8/30/2021	8:00	PFAS 150	**10,800**	< 2120	< 2410	< 1520	< 2210	**11,400**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**81,400**	**8,420**	< 7000	**33,900**
	0921-700	3MCG-NCCW-RO-REJ-20210830	8/30/2021	14:00	PFAS 151	**9,530**	< 2120	< 2410	< 1520	< 2210	**15,300**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**74,400**	**17,300**	< 7000	**38,200**
	0921-702	3MCG-NCCW-RO-REJ-20210831	8/31/2021	8:00	PFAS 152	**11,500**	< 2120	< 2410	< 1520	< 2210	**17,100**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**84,900**	**19,700**	< 7000	**40,600**
	0921-702	3MCG-NCCW-RO-REJ-20210831	8/31/2021	14:00	PFAS 153	**8,530**	< 2120	< 2410	< 1520	< 2210	**14,700**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**57,100**	**11,100**	< 7000	**29,700**
	0921-713	3MCG-NCCW-RO-REJ-20210901	9/1/2021	8:00	PFAS 154	**8,180**	< 2120	< 2410	< 1520	< 2210	**12,900**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**60,600**	**8,820**	< 7000	**29,100**
	0921-713	3MCG-NCCW-RO-REJ-20210901	9/1/2021	14:00	PFAS 155	**7,890**	< 2120	< 2410	< 1520	< 2210	**9,200**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**56,700**	**12,500**	< 7000	**29,300**
	0921-719	3MCG-NCCW-RO-REJ-20210902	9/2/2021	8:00	PFAS 156	**10,900**	< 2120	< 2410	< 1520	< 2210	**16,900**	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	**76,500**	**17,000**	< 7000	**43,400**
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-RO-REJ	10/16/2021	8:00		**50,700**	**5,440**	**1,250**	**40**	**2,040**	**2,500**	**352**	**717**	**222**	**4,210**	< 4646	< 3954	**63,800**	**29,300**	< 15449	**147,000**
	1021-784	3MCG-NCCW-RO-REJ	10/17/2021	8:00		**45,500**	**4,920**	**977**	< 305	**490**	**2,180**	**344**	**247**	< 338	**934**	< 4230	< 3648	**44,100**	**32,700**	< 4.42	**96,600**
	1021-784	3MCG-NCCW-RO-REJ	10/18/2021	8:00		**51,000**	**5,430**	**1,150**	**2**	**863**	**2,620**	**386**	**424**	**48**	**1,380**	< 4269	< 3683	**48,600**	**31,100**	< 5.07	**110,000**
	1021-798	3MCG-NCCW-RO-REJ	10/19/2021	8:00		**65,400**	**7,630**	**1,420**	< 762	**17**	**3,010**	**614**	**172**	< 844	< 1000	< 10423	< 9221	**56,200**	**37,800**	< 34770	**120,000**

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

					Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream	Lab Report	Sample ID	Date	Time	ID in SAP																
	1021-798	3MCG-NCCW-RO-REJ	10/20/2021	8:00		76,600	9,050	2,200	< 762	392	2,860	811	381	< 844	103	< 12662	< 10198	181,000	44,900	< 47065	135,000
	1021-798	3MCG-NCCW-RO-REJ	10/21/2021	8:00		66,500	7,970	1,730	< 762	301	2,730	765	233	< 844	< 1000	< 12092	< 10052	233,000	44,500	< 63422	122,000
	1021-837	3MCG-NCCW-RO-REJ	10/22/2021	11:30		70,400	9,350	2,440	< 762	< 1110	3,730	< 1290	< 1190	< 844	4,510	< 5000	< 3760	413,000	33,900	14,900	142,000
	1021-837	3MCG-NCCW-RO-REJ	10/23/2021	11:15		70,900	9,140	2,070	< 762	< 1110	3,650	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	366,000	36,100	< 3500	120,000
	1021-837	3MCG-NCCW-RO-REJ	10/24/2021	9:00		66,000	8,770	2,640	< 762	2,710	3,600	< 1290	2,140	< 844	1,380	< 5000	< 3760	323,000	29,800	< 3500	107,000
	1021-837	3MCG-NCCW-RO-REJ	10/25/2021	9:00		68,000	8,980	2,180	< 762	11,200	3,500	< 1290	5,610	< 844	11,800	< 5000	< 3760	480,000	30,100	< 3500	174,000
	1021-837	3MCG-NCCW-RO-REJ	10/26/2021	9:00		67,400	9,090	2,650	< 762	8,490	4,080	< 1290	4,440	< 844	8,350	< 5000	< 3760	452,000	33,900	< 3500	159,000
	1021-837	3MCG-NCCW-RO-REJ	10/27/2021	9:00		76,200	10,100	2,660	< 762	4,590	4,460	< 1290	3,700	< 844	2,550	< 5000	< 3760	369,000	35,400	6,580	122,000
TRAIN A GAC / GAC1-A EFFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-GAC1-A-20210730	7/30/2021	12:00	PFAS 027	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0821-705	3MCG-NCCW-GAC1-A-20210802	8/2/2021	12:00	PFAS 028	18,400	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,500	< 7000	28,200
	0821-730	3MCG-NCCW-GAC1-A-20210804	8/4/2021	12:00	PFAS 029	32,600	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	26,700	< 3500	30,100
	0821-730	3MCG-NCCW-GAC1-A-20210806	8/6/2021	12:00	PFAS 030	44,400	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	31,400	< 3500	35,900
	0821-733	3MCG-NCCW-GAC1-A-20210809	8/9/2021	12:00	PFAS 031	61,200	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	20,600	< 3500	78,200
	0821-748	3MCG-NCCW-GAC1-A-20210811	8/11/2021	12:00	PFAS 032	67,200	1,410	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	16,600	< 3500	62,300
	0821-763	3MCG-NCCW-GAC1-A-20210813	8/13/2021	12:00	PFAS 033	56,200	1,420	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	17,500	< 3500	29,900
	0821-763	3MCG-NCCW-GAC1-A-20210816	8/16/2021	12:00	PFAS 034	49,600	1,530	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	16,000	< 3500	27,400
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-GAC1-A-20210823	8/23/2021	15:30	PFAS 157	30,000	1,560	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	15,000	< 3500	21,400
	0821-797	3MCG-NCCW-GAC1-A-20210824	8/24/2021	8:00	PFAS 158	31,200	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	14,900	< 7000	42,200
	0821-797	3MCG-NCCW-GAC1-A-20210824	8/24/2021	14:00	PFAS 159	30,600	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	15,600	< 7000	43,400
	0821-801	3MCG-NCCW-GAC1-A-20210825	8/25/2021	8:00	PFAS 160	29,200	1,390	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	10,600	< 3500	33,900
	0821-801	3MCG-NCCW-GAC1-A-20210825	8/25/2021	14:00	PFAS 161	34,500	2,090	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	5,650	10,900	< 3500	41,000
	0821-804	3MCG-NCCW-GAC1-A-20210826	8/26/2021	8:00	PFAS 162	29,600	1,890	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	5,270	14,600	< 3500	37,400
	0821-804	3MCG-NCCW-GAC1-A-20210826	8/26/2021	14:00	PFAS 163	26,600	1,860	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	5,160	10,800	< 3500	34,500
	0921-700	3MCG-NCCW-GAC1-A-20210827	8/27/2021	8:00	PFAS 164	19,300	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	9,210	< 7000	26,000
	0921-700	3MCG-NCCW-GAC1-A-20210827	8/27/2021	14:00	PFAS 165	19,200	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	8,290	< 7000	22,800
	0921-700	3MCG-NCCW-GAC1-A-20210828	8/28/2021	8:00	PFAS 166	15,600	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	8,430	< 7000	32,200
	0921-700	3MCG-NCCW-GAC1-A-20210828	8/28/2021	14:00	PFAS 167	13,600	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	34,300	< 7000	30,800
	0921-700	3MCG-NCCW-GAC1-A-20210829	8/29/2021	8:00	PFAS 168	16,000	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,100	< 7000	35,700
	0921-700	3MCG-NCCW-GAC1-A-20210830	8/30/2021	8:00	PFAS 169	16,100	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	13,900	< 7000	35,100
	0921-700	3MCG-NCCW-GAC1-A-20210830	8/30/2021	14:00	PFAS 170	15,500	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	12,100	< 7000	31,500
	0921-702	3MCG-NCCW-GAC1-A-20210831	8/31/2021	8:00	PFAS 171	12,000	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	11,000	< 7000	34,700
	0921-702	3MCG-NCCW-GAC1-A-20210831	8/31/2021	14:00	PFAS 172	10,900	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	11,300	< 7000	31,500
	0921-713	3MCG-NCCW-GAC1-A-20210901	9/1/2021	8:00	PFAS 173	9,730	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	8,770	< 7000	30,100
	0921-713	3MCG-NCCW-GAC1-A-20210901	9/1/2021	14:00	PFAS 174	11,300	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,200	< 7000	31,300
	0921-719	3MCG-NCCW-GAC1-A-20210902	9/2/2021	8:00	PFAS 175	9,120	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	8,100	< 7000	28,000
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-GAC1-A	10/16/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 63.7	< 478	< 338	< 400	< 3588	< 4806	< 33.1	< 7550	< 12169	< 1659
	1021-784	3MCG-NCCW-GAC1-A	10/17/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 65.8	< 478	< 338	< 400	< 3692	< 2661	< 21	21,200	< 13079	64,500
	1021-784	3MCG-NCCW-GAC1-A	10/18/2021	8:00		2,300	< 425	< 483	< 305	< 443	< 888	< 64	< 478	< 338	< 400	< 4231	< 3499	62	27,300	< 3.98	86,600
	1021-798	3MCG-NCCW-GAC1-A	10/19/2021	8:00		14,300	< 1062	< 1206	< 762	< 1106	< 2219	< 157	< 1194	< 844	< 1000	< 11177	< 8484	< 15.4	39,900	< 33115	116,000
	1021-798	3MCG-NCCW-GAC1-A	10/20/2021	8:00		26,500	< 1062	< 1206	< 762	< 1106	< 2219	< 159	< 1194	< 844	< 1000	< 12390	< 8870	< 21.7	39,000	< 23516	105,000
	1021-798	3MCG-NCCW-GAC1-A	10/21/2021	8:00		35,500	< 1062	< 1206	< 762	< 1106	< 2219	< 159	< 1194	< 844	< 1000	< 11883	< 11997	< 30.9	32,400	< 62560	93,000
	1021-837	3MCG-NCCW-GAC1-A	10/22/2021	11:30		33,200	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	24,600	7,110	108,000
	1021-837	3MCG-NCCW-GAC1-A	10/23/2021	11:15		29,600	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	24,100	< 3500	117,000
	1021-837	3MCG-NCCW-GAC1-A	10/24/2021	9:00		22,900	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	19,700	< 3500	63,500
TRAIN A GAC	NCCW_A Phase																				
	0821-705	3MCG-NCCW-GAC2-A-20210730	7/30/2021	12:00	PFAS 035	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0821-705	3MCG-NCCW-GAC2-A-20210802	8/2/2021	12:00	PFAS 036	4,730	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	9,100	< 7000	31,900
	0821-730	3MCG-NCCW-GAC2-A-20210804	8/4/2021	12:00	PFAS 037	23,100	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	33,900	< 3500	33,300
	0821-730	3MCG-NCCW-GAC2-A-20210806	8/6/2021	12:00	PFAS 038	43,800	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	27,500	< 3500	35,200
	0821-733	3MCG-NCCW-GAC2-A-20210809	8/9/2021	12:00	PFAS 039	70,100	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	21,000	< 3500	77,100
	0821-748	3MCG-NCCW-GAC2-A-20210811	8/11/2021	12:00	PFAS 040	70,800	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	18,200	< 3500	64,300
	0821-763	3MCG-NCCW-GAC2-A-20210813	8/13/2021	12:00	PFAS 041	76,100	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	16,700	< 3500	33,700
	0821-763	3MCG-NCCW-GAC2-A-20210816	8/16/2021	12:00	PFAS 042	43,800	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	14,500	< 3500	26,600

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

Stream	Lab Report	Sample ID	Date	Time	ID in SAP	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
GAC2-A EFFLUENT	NCCW_B Phase																				
	0821-791	3MCG-NCCW-GAC2-A-20210823	8/23/2021	15:30	PFAS 176	29,300	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	13,000	< 3500	24,200
	0821-797	3MCG-NCCW-GAC2-A-20210824	8/24/2021	8:00	PFAS 177	31,700	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	11,200	< 7000	40,600
	0821-797	3MCG-NCCW-GAC2-A-20210824	8/24/2021	14:00	PFAS 178	28,900	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,900	< 7000	39,900
	0821-801	3MCG-NCCW-GAC2-A-20210825	8/25/2021	8:00	PFAS 179	32,600	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	13,200	< 3500	40,600
	0821-801	3MCG-NCCW-GAC2-A-20210825	8/25/2021	14:00	PFAS 180	34,200	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	9,490	< 3500	40,800
	0821-804	3MCG-NCCW-GAC2-A-20210826	8/26/2021	8:00	PFAS 181	29,800	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	9,000	< 3500	35,300
	0821-804	3MCG-NCCW-GAC2-A-20210826	8/26/2021	14:00	PFAS 182	32,600	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	16,500	< 3500	38,400
	0921-700	3MCG-NCCW-GAC2-A-20210827	8/27/2021	8:00	PFAS 183	26,100	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	12,200	< 7000	23,500
	0921-700	3MCG-NCCW-GAC2-A-20210827	8/27/2021	14:00	PFAS 184	26,500	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	11,000	< 7000	26,000
	0921-700	3MCG-NCCW-GAC2-A-20210828	8/28/2021	8:00	PFAS 185	18,700	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	28,600
	0921-700	3MCG-NCCW-GAC2-A-20210828	8/28/2021	14:00	PFAS 186	20,100	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	9,100	< 7000	36,400
	0921-700	3MCG-NCCW-GAC2-A-20210829	8/29/2021	8:00	PFAS 187	17,300	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,800	< 7000	36,500
	0921-700	3MCG-NCCW-GAC2-A-20210830	8/30/2021	8:00	PFAS 188	16,400	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	13,000	< 7000	35,900
	0921-700	3MCG-NCCW-GAC2-A-20210830	8/30/2021	14:00	PFAS 189	16,600	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	15,400	< 7000	38,200
	0921-702	3MCG-NCCW-GAC2-A-20210831	8/31/2021	8:00	PFAS 190	12,100	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	23,000	< 7000	31,500
	0921-702	3MCG-NCCW-GAC2-A-20210831	8/31/2021	14:00	PFAS 191	< 1910	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	< 7000	< 7000	< 10000
	0921-713	3MCG-NCCW-GAC2-A-20210901	9/1/2021	8:00	PFAS 192	11,400	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	13,600	< 7000	27,500
	0921-713	3MCG-NCCW-GAC2-A-20210901	9/1/2021	14:00	PFAS 193	11,600	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	12,900	< 7000	33,700
	0921-719	3MCG-NCCW-GAC2-A-20210902	9/2/2021	8:00	PFAS 194	9,160	< 2120	< 2410	< 1520	< 2210	< 4440	< 2580	< 2390	< 1690	< 2000	< 10000	< 7520	< 10000	10,900	< 7000	27,000
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-GAC2-A	10/16/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 62.8	< 478	< 338	< 400	< 3687	< 3489	< 6.29	< 8698	< 14659	< 1417
	1021-784	3MCG-NCCW-GAC2-A	10/17/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 64.4	< 478	< 338	< 400	< 3227	< 3315	< 28.2	6,700	< 4.06	26,400
	1021-784	3MCG-NCCW-GAC2-A	10/18/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 63.9	< 478	< 338	< 400	< 4532	< 3595	8	27,600	< 11762	92,400
	1021-798	3MCG-NCCW-GAC2-A	10/19/2021	8:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 158	< 1194	< 844	< 1000	< 9242	< 9697	< 31	51,700	< 36034	126,000
	1021-798	3MCG-NCCW-GAC2-A	10/20/2021	8:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 154	< 1194	< 844	< 1000	< 11514	< 10178	< 52.4	39,700	< 61248	116,000
	1021-798	3MCG-NCCW-GAC2-A	10/21/2021	8:00		98	< 1062	< 1206	< 762	< 1106	< 2219	< 162	< 1194	< 844	< 1000	< 12049	< 12369	< 24.6	37,100	< 61485	93,300
	1021-837	3MCG-NCCW-GAC2-A	10/22/2021	11:30		1,980	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	27,700	< 3500	83,700
	1021-837	3MCG-NCCW-GAC2-A	10/23/2021	11:15		4,010	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	23,100	< 3500	98,400
	1021-837	3MCG-NCCW-GAC2-A	10/24/2021	9:00		8,020	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	21,800	< 700	195,000
	1021-837	3MCG-NCCW-GAC2-A	10/25/2021	9:00		12,900	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	20,400	< 3500	122,000
	1021-837	3MCG-NCCW-GAC2-A	10/26/2021	9:00		17,200	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	23,900	< 3500	110,000
	1021-837	3MCG-NCCW-GAC2-A	10/27/2021	9:00		18,300	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	24,500	4,750	77,200
LEAD EFFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-IX1-A-20210730	7/30/2021	12:00	PFAS 043	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-IX1-A-20210802	8/2/2021	12:00	PFAS 044	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IX1-A-20210804	8/4/2021	12:00	PFAS 045	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,680	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IX1-A-20210806	8/6/2021	12:00	PFAS 046	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,560	< 1000	5,170	< 700	< 1000
	0821-733	3MCG-NCCW-IX1-A-20210809	8/9/2021	12:00	PFAS 047	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	2,560	< 1000	26,400	< 700	< 1000
	0821-748	3MCG-NCCW-IX1-A-20210811	8/11/2021	12:00	PFAS 048	370	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,930	< 1000	22,000	< 700	< 1000
	0821-763	3MCG-NCCW-IX1-A-20210813	8/13/2021	12:00	PFAS 049	1,610	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	23,000	< 700	< 1000
	0821-763	3MCG-NCCW-IX1-A-20210816	8/16/2021	12:00	PFAS 050	5,580	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	18,600	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-IX1-A-20210823	8/23/2021	15:30	PFAS 195	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IX1-A-20210824	8/24/2021	8:00	PFAS 196	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IX1-A-20210824	8/24/2021	14:00	PFAS 197	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IX1-A-20210825	8/25/2021	8:00	PFAS 198	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IX1-A-20210825	8/25/2021	14:00	PFAS 199	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IX1-A-20210826	8/26/2021	8:00	PFAS 200	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,230	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IX1-A-20210826	8/26/2021	14:00	PFAS 201	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,300	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210827	8/27/2021	8:00	PFAS 202	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,260	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210827	8/27/2021	14:00	PFAS 203	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,300	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210828	8/28/2021	8:00	PFAS 204	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,040	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210828	8/28/2021	14:00	PFAS 205	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	970	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210829	8/29/2021	8:00	PFAS 206	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,170	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-A-20210830	8/30/2021	8:00	PFAS 207	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	1,110	< 1000	< 700	< 700	< 1000

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

						Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
						CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream		Lab Report	Sample ID	Date	Time	ID in SAP																
CALRES CONCENTRATE TRAIN	IX	0921-700	3MCG-NCCW-IX1-A-20210830	8/30/2021	14:00	PFAS 208	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,130**	< 1000	< 700	< 700	< 1000
		0921-702	3MCG-NCCW-IX1-A-20210831	8/31/2021	8:00	PFAS 209	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,020**	< 1000	< 700	< 700	< 1000
		0921-702	3MCG-NCCW-IX1-A-20210831	8/31/2021	14:00	PFAS 210	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,120**	< 1000	< 700	< 700	< 1000
		0921-713	3MCG-NCCW-IX1-A-20210901	9/1/2021	8:00	PFAS 211	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**983**	< 1000	< 700	< 700	< 1000
		0921-713	3MCG-NCCW-IX1-A-20210901	9/1/2021	14:00	PFAS 212	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,120**	< 1000	< 700	< 700	< 1000
		0921-719	3MCG-NCCW-IX1-A-20210902	9/2/2021	8:00	PFAS 213	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,280**	< 1000	**964**	< 700	< 1000
		NCCW_D Phase																				
		1021-784	3MCG-NCCW-IX1-A	10/16/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.1	< 239	< 169	< 200	< 1622	< 1530	< 4.78	< 3410	< 13191	< 622
		1021-784	3MCG-NCCW-IX1-A	10/17/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.7	< 239	< 169	< 200	< 2216	< 1500	< 8.19	< 2603	< 2.29	< 822
		1021-784	3MCG-NCCW-IX1-A	10/18/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.7	< 239	< 169	< 200	< 1775	< 1470	< 7.98	< 4520	< 5665	< 608
		1021-798	3MCG-NCCW-IX1-A	10/19/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 33.3	< 239	< 169	< 200	< 2112	< 1684	< 12	< 214	< 6462	< 346
		1021-798	3MCG-NCCW-IX1-A	10/20/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.2	< 239	< 169	< 200	< 2118	< 2043	< 12.2	< 2681	< 8219	< 638
		1021-798	3MCG-NCCW-IX1-A	10/21/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32	< 239	< 169	< 200	< 2127	< 2074	< 5.67	< 3392	< 18492	< 796
		1021-837	3MCG-NCCW-IX1-A	10/22/2021	11:30		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**3,110**	**6,190**	< 1000
		1021-837	3MCG-NCCW-IX1-A	10/23/2021	11:15		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**7,940**	**15,700**	< 1000
		1021-837	3MCG-NCCW-IX1-A	10/24/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	**17,700**	< 1000
		1021-837	3MCG-NCCW-IX1-A	10/25/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**12,600**	**7,060**	< 1000
		1021-837	3MCG-NCCW-IX1-A	10/26/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**25,000**	**13,700**	< 1000
		1021-837	3MCG-NCCW-IX1-A	10/27/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**27,000**	**11,500**	< 1000
	IX LAG EFFLUENT	NCCW_A Phase																				
		0821-705	3MCG-NCCW-IX2-A-20210730	7/30/2021	12:00	PFAS 051	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-705	3MCG-NCCW-IX2-A-20210802	8/2/2021	12:00	PFAS 052	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-730	3MCG-NCCW-IX2-A-20210804	8/4/2021	12:00	PFAS 053	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,550**	< 1000	< 700	< 700	< 1000
		0821-730	3MCG-NCCW-IX2-A-20210806	8/6/2021	12:00	PFAS 054	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,560**	< 1000	< 700	< 700	< 1000
		0821-733	3MCG-NCCW-IX2-A-20210809	8/9/2021	12:00	PFAS 055	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**2,790**	< 1000	< 700	< 700	< 1000
		0821-748	3MCG-NCCW-IX2-A-20210811	8/11/2021	12:00	PFAS 056	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,700**	< 1000	**2,630**	< 700	< 1000
		0821-763	3MCG-NCCW-IX2-A-20210813	8/13/2021	12:00	PFAS 057	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**9,840**	< 700	< 1000
		0821-763	3MCG-NCCW-IX2-A-20210816	8/16/2021	12:00	PFAS 058	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**16,000**	< 700	< 1000
		NCCW_B Phase																				
		0821-791	3MCG-NCCW-IX2-A-20210823	8/23/2021	15:30	PFAS 214	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-797	3MCG-NCCW-IX2-A-20210824	8/24/2021	8:00	PFAS 215	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-797	3MCG-NCCW-IX2-A-20210824	8/24/2021	14:00	PFAS 216	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-801	3MCG-NCCW-IX2-A-20210825	8/25/2021	8:00	PFAS 217	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-801	3MCG-NCCW-IX2-A-20210825	8/25/2021	14:00	PFAS 218	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-804	3MCG-NCCW-IX2-A-20210826	8/26/2021	8:00	PFAS 219	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0821-804	3MCG-NCCW-IX2-A-20210826	8/26/2021	14:00	PFAS 220	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210827	8/27/2021	8:00	PFAS 221	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210827	8/27/2021	14:00	PFAS 222	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210828	8/28/2021	8:00	PFAS 223	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,690**	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210828	8/28/2021	14:00	PFAS 224	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,060**	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210829	8/29/2021	8:00	PFAS 225	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,060**	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210830	8/30/2021	8:00	PFAS 226	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**961**	< 1000	< 700	< 700	< 1000
		0921-700	3MCG-NCCW-IX2-A-20210830	8/30/2021	14:00	PFAS 227	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,030**	< 1000	< 700	< 700	< 1000
		0921-702	3MCG-NCCW-IX2-A-20210831	8/31/2021	8:00	PFAS 228	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,150**	< 1000	< 700	< 700	< 1000
		0921-702	3MCG-NCCW-IX2-A-20210831	8/31/2021	14:00	PFAS 229	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,170**	< 1000	< 700	< 700	< 1000
		0921-713	3MCG-NCCW-IX2-A-20210901	9/1/2021	8:00	PFAS 230	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,270**	< 1000	< 700	< 700	< 1000
		0921-713	3MCG-NCCW-IX2-A-20210901	9/1/2021	14:00	PFAS 231	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,080**	< 1000	< 700	< 700	< 1000
		0921-719	3MCG-NCCW-IX2-A-20210902	9/2/2021	8:00	PFAS 232	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,220**	< 1000	< 700	< 700	< 1000
		NCCW_D Phase																				
		1021-784	3MCG-NCCW-IX2-A	10/16/2021	8:00		< 191	< 212	< 241	< 152	< 221	**19**	**36**	< 239	< 169	< 200	< 1949	< 1502	< 3.52	< 1766	< 5100	< 594
		1021-784	3MCG-NCCW-IX2-A	10/17/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.6	< 239	< 169	< 200	< 1374	< 1609	< 2.61	< 2295	< 4149	< 725
		1021-784	3MCG-NCCW-IX2-A	10/18/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.3	< 239	< 169	< 200	< 2017	< 1677	< 8.71	< 3148	< 10682	< 575
		1021-798	3MCG-NCCW-IX2-A	10/19/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.5	< 239	< 169	< 200	< 2009	< 2239	< 4.83	< 4530	< 4680	< 651
		1021-798	3MCG-NCCW-IX2-A	10/20/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	**34**	< 239	< 169	< 200	< 1942	< 1726	< 40.1	< 821	< 5224	< 733
		1021-798	3MCG-NCCW-IX2-A	10/21/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 31.8	< 239	< 169	< 200	< 2854	< 2253	< 5.28	< 8.42	< 18009	< 748
		1021-837	3MCG-NCCW-IX2-A	10/22/2021	11:30		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	**16,000**	< 1000

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

Stream	Lab Report	Sample ID	Date	Time	Compound / ID in SAP	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
	1021-837	3MCG-NCCW-IX2-A	10/23/2021	11:15		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	**17,900**	< 1000
	1021-837	3MCG-NCCW-IX2-A	10/24/2021	9:00		< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	**15,900**	**6,030**	< 5000
	1021-837	3MCG-NCCW-IX2-A	10/25/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	1021-837	3MCG-NCCW-IX2-A	10/26/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	**7,000**	< 1000
	1021-837	3MCG-NCCW-IX2-A	10/27/2021	9:00		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
SORBIX CONCENTRATE TRAIN / IXR LEAD EFFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-IXR1-B-20210730	7/30/2021	12:00	PFAS 059	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-IXR1-B-20210802	8/2/2021	12:00	PFAS 060	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IXR1-B-20210804	8/4/2021	12:00	PFAS 061	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,730**	< 1000	**17,200**	< 700	< 1000
	0821-730	3MCG-NCCW-IXR1-B-20210806	8/6/2021	12:00	PFAS 062	**3,860**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,470**	< 1000	**18,300**	< 700	< 1000
	0821-733	3MCG-NCCW-IXR1-B-20210809	8/9/2021	12:00	PFAS 063	**28,800**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**2,110**	< 1000	**18,600**	< 700	< 1000
	0821-748	3MCG-NCCW-IXR1-B-20210811	8/11/2021	12:00	PFAS 064	**49,400**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,950**	< 1000	**19,300**	< 700	< 1000
	0821-763	3MCG-NCCW-IXR1-B-20210813	8/13/2021	12:00	PFAS 065	**60,500**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**20,000**	< 700	< 1000
	0821-763	3MCG-NCCW-IXR1-B-20210816	8/16/2021	12:00	PFAS 066	**58,100**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**14,000**	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-IXR1-B-20210823	8/23/2021	15:30	PFAS 233	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IXR1-B-20210824	8/24/2021	8:00	PFAS 234	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IXR1-B-20210824	8/24/2021	14:00	PFAS 235	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IXR1-B-20210825	8/25/2021	8:00	PFAS 236	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IXR1-B-20210825	8/25/2021	14:00	PFAS 237	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IXR1-B-20210826	8/26/2021	8:00	PFAS 238	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,220**	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IXR1-B-20210826	8/26/2021	14:00	PFAS 239	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,350**	< 1000	< 700	**12,100**	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210827	8/27/2021	8:00	PFAS 240	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,320**	< 1000	**2,950**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210827	8/27/2021	14:00	PFAS 241	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,130**	< 1000	**1,830**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210828	8/28/2021	8:00	PFAS 242	**643**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,100**	< 1000	**7,030**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210828	8/28/2021	14:00	PFAS 243	**961**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,140**	< 1000	**7,690**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210829	8/29/2021	8:00	PFAS 244	**2,510**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,150**	< 1000	**11,000**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210830	8/30/2021	8:00	PFAS 245	**5,000**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,170**	< 1000	**11,200**	< 700	< 1000
	0921-700	3MCG-NCCW-IXR1-B-20210830	8/30/2021	14:00	PFAS 246	**4,880**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,180**	< 1000	**9,570**	< 700	< 1000
	0921-702	3MCG-NCCW-IXR1-B-20210831	8/31/2021	8:00	PFAS 247	**8,170**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,250**	< 1000	**11,100**	< 700	< 1000
	0921-702	3MCG-NCCW-IXR1-B-20210831	8/31/2021	14:00	PFAS 248	**8,580**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,170**	< 1000	**10,900**	< 700	< 1000
	0921-713	3MCG-NCCW-IXR1-B-20210901	9/1/2021	8:00	PFAS 249	**11,500**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,270**	< 1000	**10,300**	< 700	< 1000
	0921-713	3MCG-NCCW-IXR1-B-20210901	9/1/2021	14:00	PFAS 250	**11,800**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,070**	< 1000	**10,500**	< 700	< 1000
	0921-719	3MCG-NCCW-IXR1-B-20210902	9/2/2021	8:00	PFAS 251	**12,800**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,280**	< 1000	**9,730**	< 700	< 1000
	NCCW_D Phase																				
		3MCG-NCCW-IXR1-B	10/16/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.8	< 239	< 169	< 200	< 2532	< 2260	< 4.18	< 3634	< 8526	< 891
		3MCG-NCCW-IXR1-B	10/19/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.1	< 239	< 169	< 200	< 2413	< 2424	< 3.88	< 2632	< 4953	< 623
		3MCG-NCCW-IXR1-B	10/20/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 33	< 239	< 169	< 200	< 3227	< 2013	< 4.55	< 5994	< 2.84	< 939
		3MCG-NCCW-IXR1-B	10/21/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.4	< 239	< 169	< 200	< 3717	< 2053	< 3.78	< 6584	< 10004	< 1032
	NCCW_A Phase																				
	0821-705	3MCG-NCCW-IXR2-B-20210730	7/30/2021	12:00	PFAS 067	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-IXR2-B-20210802	8/2/2021	12:00	PFAS 068	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**25,100**	< 700	< 1000
	0821-730	3MCG-NCCW-IXR2-B-20210804	8/4/2021	12:00	PFAS 069	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,720**	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IXR2-B-20210806	8/6/2021	12:00	PFAS 070	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,550**	< 1000	**13,700**	< 700	< 1000
	0821-733	3MCG-NCCW-IXR2-B-20210809	8/9/2021	12:00	PFAS 071	**1,010**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,890**	< 1000	**20,000**	< 700	< 1000
	0821-748	3MCG-NCCW-IXR2-B-20210811	8/11/2021	12:00	PFAS 072	**6,560**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,830**	< 1000	**21,200**	< 700	< 1000
	0821-763	3MCG-NCCW-IXR2-B-20210813	8/13/2021	12:00	PFAS 073	**20,000**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**18,800**	< 700	< 1000
	0821-763	3MCG-NCCW-IXR2-B-20210816	8/16/2021	12:00	PFAS 074	**38,100**	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**13,900**	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-IXR2-B-20210823	8/23/2021	15:30	PFAS 252	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IXR2-B-20210824	8/24/2021	8:00	PFAS 253	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-797	3MCG-NCCW-IXR2-B-20210824	8/24/2021	14:00	PFAS 254	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IXR2-B-20210825	8/25/2021	8:00	PFAS 255	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
EFFLUENT	0821-801	3MCG-NCCW-IXR2-B-20210825	8/25/2021	14:00	PFAS 256	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IXR2-B-20210826	8/26/2021	8:00	PFAS 257	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-804	3MCG-NCCW-IXR2-B-20210826	8/26/2021	14:00	PFAS 258	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

Stream	Lab Report	Sample ID	Date	Time	ID in SAP	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
IXR LAG B	0921-700	3MCG-NCCW-IXR2-B-20210827	8/27/2021	8:00	PFAS 259	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210827	8/27/2021	14:00	PFAS 260	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210828	8/28/2021	8:00	PFAS 261	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210828	8/28/2021	14:00	PFAS 262	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210829	8/29/2021	8:00	PFAS 263	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210830	8/30/2021	8:00	PFAS 264	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**953**	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IXR2-B-20210830	8/30/2021	14:00	PFAS 265	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,010**	< 1000	< 700	< 700	< 1000
	0921-702	3MCG-NCCW-IXR2-B-20210831	8/31/2021	8:00	PFAS 266	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,030**	< 1000	< 700	< 700	< 1000
	0921-702	3MCG-NCCW-IXR2-B-20210831	8/31/2021	14:00	PFAS 267	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,160**	< 1000	< 700	< 700	< 1000
	0921-713	3MCG-NCCW-IXR2-B-20210901	9/1/2021	8:00	PFAS 268	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,080**	< 1000	**3,190**	< 700	< 1000
	0921-713	3MCG-NCCW-IXR2-B-20210901	9/1/2021	14:00	PFAS 269	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,210**	< 1000	**4,530**	< 700	< 1000
	0921-719	3MCG-NCCW-IXR2-B-20210902	9/2/2021	8:00	PFAS 270	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	**1,220**	< 1000	**6,630**	< 700	< 1000
	NCCW_D Phase																				
		3MCG-NCCW-IXR2-B	10/16/2021	8:00		< 383	< 425	< 483	< 305	< 443	< 888	< 61.9	< 478	< 338	< 400	< 5207	< 4712	< 7.3	< 11743	< 13871	< 1891
		3MCG-NCCW-IXR2-B	10/19/2021	8:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.5	< 239	< 169	< 200	< 2445	< 2140	< 4.4	< 4541	< 6989	< 798
		3MCG-NCCW-IXR2-B	10/20/2021	8:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 160	< 1194	< 844	< 1000	< 16427	< 14174	< 23.7	< 24179	< 50941	< 5301
		3MCG-NCCW-IXR2-B	10/21/2021	8:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 158	< 1194	< 844	< 1000	< 17897	< 14840	< 26.1	< 25421	< 63712	< 5468
PERMEATE IX TRAIN – IX LEAD EFFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-IX1-C-20210730	7/30/2021	12:00	PFAS 075	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-IX1-C-20210802	8/2/2021	12:00	PFAS 076	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	**730**	< 700	< 1000
	0821-730	3MCG-NCCW-IX1-C-20210804	8/4/2021	12:00	PFAS 077	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IX1-C-20210806	8/6/2021	12:00	PFAS 078	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-733	3MCG-NCCW-IX1-C-20210809	8/9/2021	12:00	PFAS 079	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-748	3MCG-NCCW-IX1-C-20210811	8/11/2021	12:00	PFAS 080	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-IX1-C-20210813	8/13/2021	12:00	PFAS 081	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-IX1-C-20210816	8/16/2021	12:00	PFAS 082	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-IX1-C-20210818	8/18/2021	12:00	PFAS 083	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-IX1-C-20210820	8/20/2021	12:00	PFAS 084	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-IX1-C-20210823	8/23/2021	12:00	PFAS 271	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IX1-C-20210825	8/25/2021	12:00	PFAS 272	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-C-20210827	8/27/2021	12:00	PFAS 273	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX1-C-20210830	8/30/2021	12:00	PFAS 274	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-713	3MCG-NCCW-IX1-C-20210901	9/1/2021	12:00	PFAS 275	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-IX1-C	10/16/2021	12:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.8	< 239	< 169	< 200	< 2532	< 2260	< 4.18	< 3634	< 8526	< 891
	1021-798	3MCG-NCCW-IX1-C	10/19/2021	12:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.1	< 239	< 169	< 200	< 2413	< 2424	< 3.88	< 2632	< 4953	< 623
	1021-798	3MCG-NCCW-IX1-C	10/20/2021	12:00		< 191	< 212	< 241	< 152	< 221	< 444	< 33	< 239	< 169	< 200	< 3227	< 2013	< 4.55	< 5994	< 2.84	< 939
	1021-798	3MCG-NCCW-IX1-C	10/21/2021	12:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.4	< 239	< 169	< 200	< 3717	< 2053	< 3.78	< 6584	< 10004	< 1032
	1021-837	3MCG-NCCW-IX1-C	10/23/2021	11:15		< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
PERMEATE IX TRAIN – IX LAG EFFLUENT	NCCW_A Phase																				
	0821-705	3MCG-NCCW-IX2-C-20210730	7/30/2021	12:00	PFAS 085	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-705	3MCG-NCCW-IX2-C-20210802	8/2/2021	12:00	PFAS 086	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IX2-C-20210804	8/4/2021	12:00	PFAS 087	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-730	3MCG-NCCW-IX2-C-20210806	8/6/2021	12:00	PFAS 088	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-733	3MCG-NCCW-IX2-C-20210809	8/9/2021	12:00	PFAS 089	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-748	3MCG-NCCW-IX2-C-20210811	8/11/2021	12:00	PFAS 090	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-IX2-C-20210813	8/13/2021	12:00	PFAS 091	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-763	3MCG-NCCW-IX2-C-20210816	8/16/2021	12:00	PFAS 092	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-IX2-C-20210818	8/18/2021	12:00	PFAS 093	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-791	3MCG-NCCW-IX2-C-20210820	8/20/2021	12:00	PFAS 094	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_B Phase																				
	0821-791	3MCG-NCCW-IX2-C-20210823	8/23/2021	12:00	PFAS 276	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0821-801	3MCG-NCCW-IX2-C-20210825	8/25/2021	12:00	PFAS 277	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX2-C-20210827	8/27/2021	12:00	PFAS 278	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	0921-700	3MCG-NCCW-IX2-C-20210830	8/30/2021	12:00	PFAS 279	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000

Large Table 3: Enthalpy PFAS data for NCCW/SW test phases

					Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3-TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream	Lab Report	Sample ID	Date	Time	ID in SAP																
	0921-713	3MCG-NCCW-IX2-C-20210901	9/1/2021	12:00	PFAS 280	< 191	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1000	< 752	< 1000	< 700	< 700	< 1000
	NCCW_D Phase																				
	1021-784	3MCG-NCCW-IX2-C	10/16/2021	12:00		< 383	< 425	< 483	< 305	< 443	< 888	< 61.9	< 478	< 338	< 400	< 5207	< 4712	< 7.3	< 11743	< 13871	< 1891
	1021-798	3MCG-NCCW-IX2-C	10/19/2021	12:00		< 191	< 212	< 241	< 152	< 221	< 444	< 32.5	< 239	< 169	< 200	< 2445	< 2140	< 4.4	< 4541	< 6989	< 798
	1021-798	3MCG-NCCW-IX2-C	10/20/2021	12:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 160	< 1194	< 844	< 1000	< 16427	< 14174	< 23.7	< 24179	< 50941	< 5301
	1021-798	3MCG-NCCW-IX2-C	10/21/2021	12:00		< 956	< 1062	< 1206	< 762	< 1106	< 2219	< 158	< 1194	< 844	< 1000	< 17897	< 14840	< 26.1	< 25421	< 63712	< 5468
	1021-837	3MCG-NCCW-IX2-C	10/23/2021	11:15		< 956	< 1060	< 1210	< 762	< 1110	< 2220	< 1290	< 1190	< 844	< 1000	< 5000	< 3760	< 5000	< 3500	< 3500	< 5000

Large Table 4: UF and RO CIP schedule

UF CIP Events						
Date	Test Phase	pH[1]	Citric Acid	NaOCl	NaOH	Notes
		S.U.	mg/L	mg/L	mL	
8/24/2021	NCCW_A	2	500	0	0	
8/24/2021	NCCW_A	10	0	750	30	
9/13/2021	WW	NA	0	250	0	15 minutes per flush, 6 flushes
9/14/2021	WW	NA	0	250	0	
9/15/2021	WW	NA	0	250	0	
9/16/2021	WW	NA	0	250	0	
9/17/2021	WW	NA	0	250	0	
9/18/2021	WW	NA	0	250	0	
9/19/2021	WW	NA	0	250	0	
9/20/2021	WW	NA	0	250	0	
9/21/2021	WW	NA	0	250	0	
9/22/2021	WW	NA	0	250	0	
9/23/2021	WW	NA	0	250	0	
9/24/2021	WW	2	250	0	0	
9/25/2021	WW	10	0	750	30	Recirculate and soak overnight
9/25/2021	WW	10	0	750	30	Recirculate and soak overnight
9/26/2021	WW	NA	0	250	0	
9/27/2021	WW	NA	0	250	0	
9/28/2021	WW	NA	0	250	0	
9/29/2021	WW	NA	0	250	0	
9/30/2021	WW	NA	0	250	0	
10/1/2021	WW	NA	0	250	0	
10/2/2021	WW	NA	0	250	0	
10/3/2021	WW	NA	0	250	0	
10/4/2021	WW	NA	0	250	0	
10/19/2021	NCCW_D	NA	0	250	0	
10/22/2021	NCCW_D	NA	0	250	0	
RO CIP Events						
Date	Test #	pH[1]	Citric Acid	NaOCl	NaOH	Notes
		S.U.	mg/L	mg/L	mL	
9/11/2021			250			
10/19/2021			500			Flush and soak overnight
10/22/2021			250			Flush and soak overnight

NA – pH not analyzed

[1] pH for acidic PIC solutions were achieved using sulfuric acid.

Large Table 5: Enthalpy PFAS data for WW test phase

Stream	Lab Report	Sample ID	Date	Time	ID in SAP	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3 TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
					CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
UF INFLUENT	0921-777	3MCG-WW-UF-INF-20210914	9/14/2021	12:00	PFAS 281	2,340	< 1062	< 1206	< 762	< 1106	16,200	< 1288	< 1194	< 844	204	< 12161	< 8517	17,000	< 39382	< 50322	166,000
	0921-777	3MCG-WW-UF-INF-20210916	9/16/2021	12:00	PFAS 282	3,160	< 1062	< 1206	< 762	< 1106	2,870	< 1288	< 1194	< 844	1,360	< 18780	< 18966	18,400	1,510	< 22854	112,000
	0921-783	3MCG-WW-UF-INF-20210920	9/20/2021	12:00	PFAS 283	1,500	< 175	< 61.6	< 47.7	< 318	4,240	< 37.7	< 287	< 72.2	< 469	< 4310	< 1594	24,100	2,420	< 7000	137,000
	0921-803	3MCG-WW-UF-INF-20210923	9/23/2021	12:00	PFAS 284	2,760	< 126	< 31.8	< 171	< 434	11,100	< 112	< 716	< 69.1	808	< 4447	< 1194	17,200	< 6797	< 7000	65,900
UF PERMEATE	0921-777	3MCG-WW-UF-PERM-20210914	9/14/2021	12:00	PFAS 285	2,080	< 212	< 241	< 152	< 221	15,200	< 258	< 239	< 169	< 200	< 2281	1,610	15,000	< 5772	< 4886	101,000
	0921-777	3MCG-WW-UF-PERM-20210916	9/16/2021	12:00	PFAS 286	2,450	24	< 241	< 152	< 221	3,570	< 258	< 239	< 169	< 200	< 2910	< 4422	19,800	10,100	< 22060	145,000
	0921-783	3MCG-WW-UF-PERM-20210920	9/20/2021	12:00	PFAS 287	1,740	9	< 16.8	< 6.90	34	3,700	< 3.33	< 2.35	< 8.35	< 9.08	< 820	< 242	20,800	1,430	< 700	106,000
	0921-803	3MCG-WW-UF-PERM-20210923	9/23/2021	12:00	PFAS 288	2,960	111	< 33.7	< 16.8	< 19.4	9,540	< 22.2	33	< 96.3	< 119	< 655	< 209	13,400	1,880	< 700	46,900
TRAIN C – RO PERMEATE	0921-777	3MCG-WW-F.0-INF-(RO PERM)-20210914	9/14/2021	12:00	PFAS 289	< 325	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 16601	< 19247	92	< 82.1	< 59415	3,090
	0921-783	3MCG-WW-F.0-INF (RO PERM)-20210917	9/17/2021	12:00	PFAS 290	< 11.8	< 13.2	< 1.51	< 10.3	< 45.7	< 6.25	< 4.02	< 3.49		< 4.71	< 556	< 131	124	< 700	< 700	2,150
	0921-783	3MCG-WW-F.0-INF (RO PERM)-20210920	9/20/2021	12:00	PFAS 291	< 191	< 16.2	< 1.99	< 26.7	< 15.1	< 9.46	< 2.19	< 3.12	< 5.48	< 2.30	< 509	< 122	154	< 700	< 700	1,970
	0921-803	3MCG-WW-F.0-INF (RO PERM)-20210923	9/23/2021	12:00	PFAS 292	10	5	< 2.01	< 55.8	< 2.31	84	80	< 131	< 82.6	< 75	< 429	< 136	157	34	< 700	1,050
TRAIN C – IX1	0921-777	3MCG-WW-F.1-IX1-20210914	9/14/2021	12:00	PFAS 293	< 298	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 15439	< 19805	< 31.9	< 34405	< 30961	< 605
	0921-783	3MCG-WW-F.1-IX1-20210917	9/17/2021	12:00	PFAS 294	< 11.6	< 20.3	< 2.24	< 17.5	< 12.0	< 5.42	< 4.94	< 6.89	< 3.60	< 2.74	< 485	< 170	< 0.734	< 700	< 700	43
	0921-783	3MCG-WW-F.1-IX1-20210920	9/20/2021	12:00	PFAS 295	< 17.5	< 27.5	< 1.63	< 13.6	< 27.7	< 7.16	< 6.69	< 1.93	< 3.98	< 9.62	< 538	< 154	< 1.14	< 700	< 700	< 36.7
	0921-803	3MCG-WW-F.1-IX1-20210923	9/23/2021	12:00	PFAS 296	< 191	< 36	< 18.9	< 13.2	< 27.9	< 32.6	< 20	< 8.64	< 13	< 29.3	< 507	< 131	< 1.01	93	< 700	< 18.4
TRAIN C – IX2	0921-777	3MCG-WW-F.2-IX2-20210914	9/14/2021	12:00	PFAS 297	< 422	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 18454	< 31656	< 36.7	< 63771	< 233046	< 728
	0921-783	3MCG-WW-F.2-IX2-20210917	9/17/2021	12:00	PFAS 298	< 169	< 121	< 89.9	< 235	< 669	< 99.1	< 7.99	< 43.8	< 41.9	< 64.1	< 5338	< 1212	< 7.21	< 7000	< 7000	< 188
	0921-783	3MCG-WW-F.2-IX2-20210920	9/20/2021	12:00	PFAS 299	< 13.9	< 19.4	< 9.43	< 14.1	< 22.9	< 6.20	< 5.47	< 4.59	< 6.25	< 20.1	< 577	< 168	< 1.04	< 700	< 700	< 19.5
	0921-803	3MCG-WW-F.2-IX2-20210923	9/23/2021	12:00	PFAS 300	< 8.17	< 20	< 1.17	< 0.948	< 35.7	< 60.7	< 8.27	< 30.4	< 8.15	< 9.95	< 373	< 129	< 1.45	< 350	< 700	157
RO REJECT	0921-777	3MCG-WW-D.0-INF (RO-REJ)-20210914	9/14/2021	12:00	PFAS 301	14,500	40	< 1206	< 762	320	136,000	< 1288	91	< 844	< 1000	< 15037	7,300	133,000	< 16207	< 74293	843,000
	0921-777	3MCG-WW-D.0-INF (RO REJ)-20210915-1300	9/15/2021	12:00	PFAS 302	16,100	< 1062	< 1206	< 762	614	143,000	< 1288	295	< 844	< 1000	< 16105	6,880	146,000	14,200	< 24.2	933,000
	0921-777	3MCG-WW-D.0-INF (RO REJ)-20210915-1645	9/15/2021	16:00	PFAS 303	14,500	92	< 1206	< 762	< 1106	94,000	< 1288	< 1194	< 844	< 1000	< 18334	< 15723	128,000	< 28416	< 109136	827,000
	0921-777	3MCG-WW-D.0-INF (RO-REJ)-20210916-0936	9/16/2021	9:00	PFAS 304	20,600	218	< 1206	< 762	1,150	133,000	< 1288	1,210	< 844	< 1000	< 12988	< 18111	257,000	44,000	< 106061	1,850,000
	0921-777	3MCG-WW-D.0-INF (RO-REJ)-20210916-1628	9/16/2021	16:00	PFAS 305	18,700	267	< 1206	< 762	< 1106	96,100	< 1288	524	< 844	< 1000	< 13926	< 15284	191,000	39,700	< 55825	1,340,000
	0921-783	3MCG-WW-D.0-INF (RO REJ)-20210917	9/17/2021	9:00	PFAS 306	22,400	604	< 59.6	< 329	2,450	104,000	< 245	2,600	< 1392	452	< 8334	< 2396	208,000	18,000	< 7000	1,660,000
	0921-783	3MCG-WW-D.0-INF (RO REJ) [2]-20210917	9/17/2021	16:00	PFAS 307	16,700	295	< 712	< 86.5	1,430	75,800	< 42.2	956	< 553	< 869	< 5692	< 2299	151,000	13,900	< 7000	1,410,000
	0921-783	3MCG-WW-D.0-INF (RO REJ)-20210918	9/18/2021	9:00	PFAS 308	15,300	399	< 12.4	< 127	681	63,400	< 37.0	110	< 41.8	< 172	< 7318	< 2055	130,000	2,780	< 7000	1,330,000
	0921-783	3MCG-WW-D.0-INF (RO REJ) [2]-20210918	9/18/2021	16:00	PFAS 309	18,700	424	< 41.0	< 73.4	1,390	78,700	< 61.2	1,660	< 458	< 431	< 7834	< 2429	151,000	9,210	< 7000	1,270,000
	0921-783	3MCG-WW-D.0-INF (RO REJ)-20210919	9/19/2021	9:00	PFAS 310	17,900	253	< 685	< 159	1,790	69,500	< 480	1,760	< 1454	42	< 7256	< 2528	129,000	8,510	< 7000	1,150,000
	0921-783	3MCG-WW-D.0-INF (RO REJ) [2]-20210919	9/19/2021	16:00	PFAS 311	20,800	543	< 34.0	< 152	5,080	72,900	< 24.7	5,540	53	1,270	< 6883	< 2446	186,000	10,100	< 7000	1,350,000
	0921-783	3MCG-WW-D.0-INF (RO REJ)-20210920	9/20/2021	9:00	PFAS 312	23,000	583	127	< 42.6	2,400	69,600	< 208	2,840	< 738	603	< 7837	< 2946	209,000	18,800	< 7000	1,550,000
	0921-783	3MCG-WW-D.0-INF (RO REJ) [2]-20210920	9/20/2021	16:00	PFAS 313	19,900	419	< 2087	< 276	3,550	58,000	< 289	3,710	< 94.2	894	< 8517	< 2320	188,000	12,100	< 7000	1,240,000
	0921-803	3MCG-WW-D.0-INF (RO-REJ)-20210921	9/21/2021	12:00	PFAS 314	17,400	680	< 113	< 1056	874	40,500	848	852	< 209	< 2598	< 7126	< 9089	161,000	10,100	< 23490	1,140,000
	0921-803	3MCG-WW-D.0-INF (RO-REJ)-20210922	9/22/2021	9:00	PFAS 315	15,500	< 279	< 255	< 136	86	38,600	< 131	91	< 795	< 1273	< 8197	< 9123	147,000	11,000	< 8.72	989,000
	0921-803	3MCG-WW-D.0-INF (RO-REJ)[2]-20210922	9/22/2021	16:00	PFAS 316	26,500	679	< 240	< 430	4,920	65,000	< 437	4,030	< 1515	8,940	< 8871	< 7517	259,000	5,540	< 8.81	1,590,000
	0921-803	3MCG-WW-D.0-INF (RO REJ)-20210923	9/23/2021	9:00	PFAS 317	18,900	147	< 336	< 204	1,120	49,500	< 417	936	< 639	< 7311	< 7861	< 1786	163,000	20,100	< 7000	1,060,000
	0921-803	3MCG-WW-D.0-INF (RO REJ) [2]-20210923	9/23/2021	16:00	PFAS 318	16,700	544	< 120	< 158	855	44,300	< 56.6	628	< 764	< 1138	< 5842	< 2463	160,000	9,090	< 7000	1,040,000
	1021-784	3MCG-Test 02-D.0-INF (RO-REJ)-20210924	9/24/2021	9:00	--	14,300	593	101	< 305	1,140	44,000	317	1,310	102	682	< 3471	< 3222	269,000	14,600	< 17975	1,670,000
	1021-784	3MCG-Test 02-D.0-INF (RO-REJ)[2]-20210924	9/24/2021	16:00	--	12,400	443	107	< 305	795	34,800	238	859	< 338	357	< 2802	< 3686	177,000	10,100	< 5053	981,000
GAC – GAC1 EFFLUENT	0921-777	3MCG-WW-D.1-GAC1-20210914	9/14/2021	12:00	PFAS 319	< 322	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 12960	7,640	< 41	< 45731	< 20	59,900
	0921-777	3MCG-WW-D.1-GAC1-20210915-1245	9/15/2021	12:00	PFAS 320	1,040	313	< 1206	186	755	< 2219	494	35	< 844	< 1000	< 13778	8,910	69	< 45881	< 99379	740,000
	0921-777	3MCG-WW-D.1-GAC1-20210915-1635	9/15/2021	16:00	PFAS 321	< 324	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 14923	< 16581	4	< 11724	< 18994	794,000
	0921-777	3MCG-WW-D.1-GAC1-20210916-0918	9/16/2021	9:00	PFAS 322	< 246	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 3375	< 4000	< 7828	< 3163	< 21.3	< 14000	< 14000	1,630,000
	0921-777	3MCG-WW-D.1-GAC1-20210916-1615	9/16/2021	16:00	PFAS 323	< 301	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 13029	< 24153	< 39	39,400	< 76674	1,120,000
	0921-783	3MCG-WW-D.1-GAC1-20210917	9/17/2021	9:00	PFAS 324	< 113	< 102	< 102	< 131	< 285	< 76.5	< 27.7	< 83.9	< 43.2	< 51.9	< 6513	< 2131	< 18.2	9,740	< 7000	1,220,000
	0921-783	3MCG-WW-D.1-GAC1 [2]-20210917	9/17/2021	16:00	PFAS 325	< 199	< 123	< 40.1	< 95.1	< 273	< 124	< 11.7	< 54.3	< 459	< 265	< 6901	< 2037	< 16.2	12,400	< 7000	1,420,000
	0921-783	3MCG-WW-D.1-GAC1-20210918	9/18/2021	9:00	PFAS 326	66	< 272	< 60.4	< 171	< 373	< 68.2	< 20.8	< 28.4	< 30.1	< 50.9	< 6046	< 2050	< 13.2	14,100	< 7000	1,420,000
	0921-783	3MCG-WW-D.1-GAC1 [2]-20210918	9/18/2021	16:00	PFAS 327	385	< 218	< 73.8	< 82.7	< 216	< 61.7	< 13.1	< 47.6	< 71.9	< 30.3	< 8451	< 2604	< 36.0	10,300	< 7000	1,220,000
	0921-783	3MCG-WW-D.1-GAC1-20210919	9/19/2021	9:00	PFAS 328	733	< 131	< 19.3	< 111	< 8.86	< 63.2	< 28.1	< 79.4	< 54.5	< 50.5	< 6583	< 2102	< 12.2	8,070	< 7000	1,020,000
	0921-783	3MCG-WW-D.1-GAC1 [2]-20210919	9/19/2021	16:00	PFAS 329	1,850	< 191	< 36.8	< 101	< 196	< 57.9	< 54.4	< 66.2	< 86.9	< 22.8	< 6651	< 2281	< 14.7	13,300	< 7000	1,430,000
	0921-783	3MCG-WW-D.1-GAC1-20210920	9/20/2021	9:00	PFAS 330	1,740	< 190	< 13.3	< 249	< 247	< 60.4	< 23.9	< 56.2	< 54.6	< 41.0	< 5963	< 1750	14	6,830	< 7000	1,120,000
	0921-783	3MCG-WW-D.1-GAC1 [2]-20210920	9/20/2021	16:00	PFAS 331	2,150	< 205	< 366	< 11.2	< 353	< 64.9	< 55.0	< 35.7	< 97.9	< 25.9	< 7921	< 2264	< 27.7	9,000	< 7000	1,150,000
	0921-803	3MCG-WW-D.1-GAC1-20210921	9/21/2021	12:00	PFAS 332	2,250	< 299	< 444	< 110	< 150	< 678	< 52.2	< 154	< 295	< 796	< 4944	< 6386	< 15.2	16,000	< 36825	973,000
	0921-803	3MCG-WW-D.1-GAC1-20210922	9/22/2021	9:00	PFAS 333	3,810	< 137	< 29.9	< 189	< 28.7	< 146	< 64.8	< 91.1	< 140	< 312	< 6471	< 6834	< 19.5	13,700	< 30495	1,140,000
	0921-803	3MCG-WW-D.1-GAC1[2]-20210922	9/22/2021	16:00	PFAS 334	4,670	< 362	< 192	< 70.4	< 268	< 489	< 85.2	< 74.8	< 115	< 183	< 6159	< 7116	< 17.1	14,000	< 7087	1,200,000
	0921-803	3MCG-WW-D.1-GAC1-20210923	9/23/2021	9:00	PFAS 335	7,450	< 180	< 66.3	< 90.1	< 53.7	< 601	< 81.9	< 102	< 137	< 432	< 6986	< 1802	< 13.5	16,200	< 7000	1,010,000
	0921-803	3MCG-WW-D.1-GAC1[2]-20210923	9/23/2021	16:00	PFAS 336	7,680	< 241	< 84.8	< 10.6	< 271	< 644	< 58.6	< 92.6	< 89	< 324	< 6612	< 2119	< 28.8	13,200	< 7000	1,010,000
	1021-784	3MCG-Test 02-D.1-GAC1-20210924	9/24/2021	9:00	--	9,450	< 425	< 483	< 305	< 443	< 888	< 66.7	< 478	< 338	< 400	< 3016	< 3300	< 10.4	16,400	< 18906	1,070,000
	1021-784	3MCG-Test 02-D.1-GAC1[2]-20210924	9/24/2021	16:00	--	10,700	< 425	< 483	< 305	< 443	< 888	< 63.4	< 478	< 338	< 400	< 3428	< 3594	< 7.63	12,100	< 13690	1,670,000
	0921-777	3MCG-WW-D.2-GAC2-20210914	9/14/2021	12:00	PFAS 337	< 336	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 15648	7,920	1	< 23723	< 56686	< 610

Large Table 5: Enthalpy PFAS data for WW test phase

Stream		Lab Report	Sample ID	Date	Time	Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3 TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
						CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream		Lab Report	Sample ID	Date	Time	ID in SAP																
	GAC2 EFFLUENT	0921-777	3MCG-WW-D.2-GAC2-20210915-1230	9/15/2021	12:00	PFAS 338	< 344	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 17411	**6,510**	**8**	< 18902	< 54923	**487,000**
		0921-777	3MCG-WW-D.2-GAC2-20210915-1625	9/15/2021	16:00	PFAS 339	< 309	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 17957	< 24748	**1**	< 15864	< 6328	**577,000**
		0921-777	3MCG-WW-D.2-GAC2-20210916-0849	9/16/2021	9:00	PFAS 340	< 410	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 16359	< 23011	< 29.3	**39,100**	< 72521	**1,120,000**
		0921-777	3MCG-WW-D.2-GAC2-20210916-1600	9/16/2021	16:00	PFAS 341	< 314	< 1062	< 1206	< 762	< 1106	< 2219	< 1288	< 1194	< 844	< 1000	< 15192	< 17999	< 33.2	**105,000**	< 132727	**1,090,000**
		0921-783	3MCG-WW-D.2-GAC2-20210917	9/17/2021	9:00	PFAS 342	< 201	< 144	< 22.0	< 101	< 645	< 67.4	< 26.9	< 22.6	< 67.0	< 21.6	< 7023	< 2414	< 11.7	**4,260**	< 7000	**1,190,000**
		0921-783	3MCG-WW-D.2-GAC2 [2]-20210917	9/17/2021	16:00	PFAS 343	< 158	< 84.7	< 51.5	< 162	< 395	< 57.3	< 37.0	< 28.8	< 51.9	< 21.2	< 7854	< 2177	< 9.97	**11,000**	< 7000	**1,190,000**
		0921-783	3MCG-WW-D.2-GAC2-20210918	9/18/2021	9:00	PFAS 344	< 272	< 88.6	< 14.6	< 90.8	< 191	< 51.7	< 36.9	< 25.5	< 28.0	< 36.5	< 7172	< 1914	< 16.0	**34,400**	< 7000	**1,280,000**
		0921-783	3MCG-WW-D.2-GAC2 [2]-20210918	9/18/2021	16:00	PFAS 345	< 230	< 176	< 181	< 306	< 335	< 72.0	< 30.7	< 267	< 37.2	< 53.5	< 7816	< 2501	< 13.9	**13,600**	< 7000	**1,220,000**
		0921-783	3MCG-WW-D.2-GAC2-20210919	9/19/2021	9:00	PFAS 346	< 240	< 132	< 128	< 49.4	< 358	< 58.4	< 29.9	< 58.0	< 41.6	< 75.4	< 6691	< 2122	< 16.3	**13,800**	< 7000	**1,080,000**
		0921-783	3MCG-WW-D.2-GAC2 [2]-20210919	9/19/2021	16:00	PFAS 347	< 172	< 84.7	< 128	< 143	< 362	< 55.7	< 67.4	< 33.3	< 84.2	< 234	< 7011	< 1749	< 11.8	**7,820**	< 7000	**1,200,000**
		0921-783	3MCG-WW-D.2-GAC2-20210920	9/20/2021	9:00	PFAS 348	< 194	< 115	< 63.5	< 145	< 535	< 45.0	< 30.8	< 39.7	< 68.6	< 44.8	< 8134	< 2075	< 12.3	**23,300**	< 7000	**1,170,000**
		0921-783	3MCG-WW-D.2-GAC2 [2]-20210920	9/20/2021	16:00	PFAS 349	< 256	< 189	< 108	< 18.8	< 461	< 75.9	< 35.3	< 120	< 77.6	< 44.0	< 7249	< 2225	< 11.7	**7,480**	< 7000	**1,060,000**
		0921-803	3MCG-WW-D.2-GAC2-20210921	9/21/2021	12:00	PFAS 350	< 111	< 371	< 46.3	< 258	< 13.3	< 180	< 84.6	< 73.3	< 164	< 95.6	< 5612	< 8720	< 12.1	**8,080**	< 14352	**877,000**
		0921-803	3MCG-WW-D.2-GAC2-20210922	9/22/2021	9:00	PFAS 351	< 137	< 330	< 96.1	< 478	< 177	< 872	< 150	< 97.6	< 190	< 261	< 5896	< 5844	< 18.5	**4,720**	< 34986	**1,140,000**
		0921-803	3MCG-WW-D.2-GAC2[2]-20210922	9/22/2021	16:00	PFAS 352	< 113	< 338	< 161	< 41.8	< 33.4	< 311	< 80.9	< 129	< 82	< 515	< 5724	< 7554	< 11.7	**6,040**	< 52204	**462**
		0921-803	3MCG-WW-D.2-GAC2-20210923	9/23/2021	9:00	PFAS 353	< 61.4	< 165	< 232	< 56.3	< 92.3	< 841	< 97.3	< 81.2	< 142	< 202	< 5354	< 1703	< 10.8	**3,950**	< 7000	**633,000**
		0921-803	3MCG-WW-D.2-GAC2[2]-20210923	9/23/2021	16:00	PFAS 354	< 75.8	< 287	< 19.6	< 190	< 21.4	< 558	< 106	< 290	< 124	< 247	< 6573	< 1839	< 16	**10,300**	< 7000	**992,000**
		1021-784	3MCG-Test 02-D.2-GAC2-20210924	9/24/2021	9:00	--	< 383	< 425	< 483	< 305	< 443	< 888	< 63.1	< 478	< 338	< 400	< 4002	< 3376	< 6.73	**8,830**	< 19592	**1,220,000**
		1021-784	3MCG-Test 02-D.2-GAC2[2]-20210924	9/24/2021	16:00	--	< 383	< 425	< 483	< 305	< 443	< 888	< 61.7	< 478	< 338	< 400	< 3965	< 2818	< 20.9	**9,820**	< 12524	**1,770,000**
CalRes Concentrate Train	IX1 EFFLUENT	0921-777	3MCG-WW-D.3-IX1-20210914	9/14/2021	12:00	PFAS 355	< 65.1	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2747	< 4507	**0**	**17,800**	< 24553	< 106
		0921-777	3MCG-WW-D.3-IX1-20210915-1155	9/15/2021	12:00	PFAS 356	< 71.7	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2327	< 4626	< 6.81	< 7094	< 13551	< 116
		0921-777	3MCG-WW-D.3-IX1-20210915-1610	9/15/2021	16:00	PFAS 357	< 71	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 3428	< 4046	**2**	< 6012	< 24487	< 132
		0921-777	3MCG-WW-D.3-IX1-20210916-0800	9/16/2021	9:00	PFAS 358	< 84.8	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1955	< 4131	< 8.47	< 6201	< 11396	< 162
		0921-777	3MCG-WW-D.3-IX1-20210916-1555	9/16/2021	16:00	PFAS 359	< 62.8	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1882	< 3390	< 6.63	**10,600**	< 19404	< 93.8
		0921-783	3MCG-WW-D.3-IX1-20210917	9/17/2021	9:00	PFAS 360	< 210	< 27.9	< 2.09	< 20.2	< 9.96	< 5.27	< 3.99	< 3.04	< 5.64	< 7.97	< 9951	< 3462	**10**	< 700	< 700	< 489
		0921-783	3MCG-WW-D.3-IX1 [2]-20210917	9/17/2021	16:00	PFAS 361	< 255	< 16.0	< 2.36	< 3.41	< 20.4	< 6.17	< 2.75	< 3.51	< 6.92	< 8.93	< 6774	< 3011	< 18.6	**93,200**	< 700	< 361
		0921-783	3MCG-WW-D.3-IX1-20210918	9/18/2021	9:00	PFAS 362	< 432	< 16.0	< 8.08	< 9.66	< 39.8	< 8.53	< 8.41	< 54.3	< 10.4	< 3.94	< 13696	< 3209	< 28.7	< 700	< 700	< 709
		0921-783	3MCG-WW-D.3-IX1 [2]-20210918	9/18/2021	16:00	PFAS 363	< 459	< 15.3	< 3.10	< 8.09	< 13.3	< 5.70	< 2.08	< 3.76	< 4.64	< 3.45	< 13103	< 3141	< 26.6	< 700	< 700	< 789
		0921-783	3MCG-WW-D.3-IX1-20210919	9/19/2021	9:00	PFAS 364	< 44.6	< 24.1	< 21.4	< 5.80	< 47.9	< 8.02	< 2.11	< 6.67	< 5.74	< 4.16	< 702	< 2586	< 2.50	< 700	< 700	< 46.8
		0921-783	3MCG-WW-D.3-IX1 [2]-20210919	9/19/2021	16:00	PFAS 365	< 294	< 15.1	< 1.73	< 1.49	< 3.67	< 5.53	< 4.38	< 5.92	< 3.20	< 4.15	< 8459	< 3311	< 21.0	< 700	< 700	< 510
		0921-783	3MCG-WW-D.3-IX1-20210920	9/20/2021	9:00	PFAS 366	< 334	< 23.0	< 23.3	< 0.612	< 26.4	< 7.59	< 26.3	< 46.9	< 51.8	< 27.2	< 9764	< 2174	< 26.0	< 700	< 700	< 432
		0921-783	3MCG-WW-D.3-IX1 [2]-20210920	9/20/2021	16:00	PFAS 367	< 419	< 17.6	< 12.1	< 2.78	< 0.122	< 5.43	< 3.15	< 18.0	< 6.49	< 9.28	< 6909	< 3269	**7**	< 700	< 700	< 492
		0921-803	3MCG-WW-D.3-IX1-20210921	9/21/2021	12:00	PFAS 368	< 91.4	< 39.7	< 15.5	< 9.19	< 19.9	< 35.4	< 8.55	< 8.92	< 18.5	< 110	< 3925	< 8246	< 11.7	**6,140**	< 14630	< 469
		0921-803	3MCG-WW-D.3-IX1-20210922	9/22/2021	9:00	PFAS 369	**111**	**119**	< 4.04	**111**	**80**	**111**	**163**	**63**	**18**	**56**	< 8230	< 4936	< 55.3	**4,630**	< 27667	< 593
		0921-803	3MCG-WW-D.3-IX1[2]-20210922	9/22/2021	16:00	PFAS 370	< 226	< 32.6	< 35.6	< 11.7	< 2.98	< 51.9	< 13.4	< 5.47	< 17.2	< 67.6	< 6611	< 6138	< 52.8	< 9368	< 27339	< 509
		0921-803	3MCG-WW-D.3-IX1-20210923	9/23/2021	9:00	PFAS 371	< 200	< 30	< 16.7	< 28.2	< 6.61	< 29.7	< 9.64	< 10.8	< 15.4	< 26.5	< 6466	< 1378	< 17.4	**11,100**	< 700	< 422
		0921-803	3MCG-WW-D.3-IX1[2]-20210923	9/23/2021	16:00	PFAS 372	< 141	< 21.3	< 21.5	< 35.8	< 3.21	< 50.8	< 7.25	< 6.57	< 11.2	< 30.9	< 5903	< 1353	< 18.1	**11,600**	< 700	< 390
		1021-784	3MCG-Test 02-D.3-IX1-20210924	9/24/2021	9:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 32.7	< 239	< 169	< 200	< 2049	< 1727	< 6.36	**4,180**	< 5646	< 605
		1021-784	3MCG-Test 02-D.3-IX1[2]-20210924	9/24/2021	16:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 31.2	< 239	< 169	< 200	< 2059	< 1758	< 8.04	**5,920**	< 11538	< 1000
	IX2 EFFLUENT	0921-777	3MCG-WW-D.4-IX2-20210914	9/14/2021	12:00	PFAS 373	< 68.3	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2462	< 4337	**1**	< 4864	< 7893	< 138
		0921-777	3MCG-WW-D.4-IX2-20210915-1055	9/15/2021	12:00	PFAS 374	< 68.6	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2785	< 4312	**0**	**11,000**	< 24871	< 135
		0921-777	3MCG-WW-D.4-IX2-20210915-1600	9/15/2021	16:00	PFAS 375	< 68.7	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2537	< 4363	< 18.6	**7,000**	< 9712	< 132
		0921-777	3MCG-WW-D.4-IX2-20210916-0731	9/16/2021	9:00	PFAS 376	< 70.6	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2642	< 4184	< 10.9	< 6204	< 4.28	< 86.7
		0921-777	3MCG-WW-D.4-IX2-20210916-1545	9/16/2021	16:00	PFAS 377	< 60.9	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2344	< 4340	< 16.3	< 1231	< 17168	< 102
		0921-783	3MCG-WW-D.4-IX2-20210917	9/17/2021	9:00	PFAS 378	< 222	< 18.3	< 8.40	< 5.25	< 8.27	< 6.25	< 3.82	< 5.00	< 5.89	< 7.20	< 8255	< 2255	< 20.9	< 700	< 700	< 390
		0921-783	3MCG-WW-D.4-IX2 [2]-20210917	9/17/2021	16:00	PFAS 379	< 388	< 24.8	< 22.2	< 17.4	< 13.1	< 7.51	< 2.57	< 3.22	< 8.76	< 5.88	< 8593	< 2944	< 16.5	< 700	< 700	< 409
		0921-783	3MCG-WW-D.4-IX2-20210918	9/18/2021	9:00	PFAS 380	< 408	< 23.2	< 23.7	< 5.22	< 29.1	< 5.70	< 1.75	< 7.19	< 6.46	< 3.64	< 14290	< 2902	< 32.2	< 700	< 700	< 625
		0921-783	3MCG-WW-D.4-IX2 [2]-20210918	9/18/2021	16:00	PFAS 381	< 478	< 25.0	< 2.08	< 13.5	< 23.1	< 7.56	< 3.15	< 5.11	< 3.80	< 4.00	< 9067	< 2696	**10**	< 700	< 700	< 568
		0921-783	3MCG-WW-D.4-IX2-20210919	9/19/2021	9:00	PFAS 382	< 359	< 19.2	< 0.718	< 7.09	< 7.11	< 6.41	< 2.08	< 2.54	< 5.96	< 4.65	< 9549	< 2528	**12**	< 700	< 700	< 460
		0921-783	3MCG-WW-D.4-IX2 [2]-20210919	9/19/2021	16:00	PFAS 383	< 275	< 12.5	< 5.86	< 8.52	< 15.5	< 5.07	< 1.87	< 7.08	< 4.79	< 2.79	< 9966	< 2928	**6**	< 700	< 700	< 385
		0921-783	3MCG-WW-D.4-IX2-20210920	9/20/2021	9:00	PFAS 384	< 326	< 13.1	< 13.2	< 14.9	< 27.8	< 4.43	< 3.07	< 5.38	< 7.47	< 1.41	< 7018	< 2658	< 18.4	< 700	< 700	**103**
		0921-783	3MCG-WW-D.4-IX2 [2]-20210920	9/20/2021	16:00	PFAS 385	< 237	< 34.3	< 26.9	< 1.05	< 11.5	< 4.76	< 2.95	< 2.03	< 7.53	< 4.50	< 8087	< 2744	< 15.9	< 700	< 700	**62**
		0921-803	3MCG-WW-D.4-IX2-20210921	9/21/2021	12:00	PFAS 386	< 135	< 37.8	< 3.2	< 36	< 3.68	< 36.4	< 7.73	< 10.7	< 15.9	< 18.4	< 5124	< 6868	< 19.4	< 18651	< 25641	< 347
		0921-803	3MCG-WW-D.4-IX2-20210922	9/22/2021	9:00	PFAS 387	< 111	< 19	< 70.9	< 11.5	< 0.9	< 19.6	**37**	< 5.89	< 28.5	< 50.5	< 4473	< 5548	< 13.9	< 7469	< 23231	< 306
		0921-803	3MCG-WW-D.4-IX2[2]-20210922	9/22/2021	16:00	PFAS 388	< 227	< 47.9	< 6.76	< 14.8	< 39	< 46.9	< 9.63	< 7.77	< 15.3	< 27.7	< 9151	< 5615	< 56.2	< 7761	< 33301	< 525
		0921-803	3MCG-WW-D.4-IX2-20210923	9/23/2021	9:00	PFAS 389	< 227	< 48.3	< 9.01	< 40.9	< 19.8	< 58.2	< 8.62	< 14.6	< 16.3	< 61	< 7215	< 1357	< 50.3	< 5467	< 700	< 719
		0921-803	3MCG-WW-D.4-IX2[2]-20210923	9/23/2021	16:00	PFAS 390	< 234	< 30.8	< 25.3	< 3.97	< 27.6	< 34.7	< 7.58	< 7.85	< 13.2	< 36.5	< 6661	< 1546	< 23.9	< 20.8	< 700	< 389
		1021-784	3MCG-Test 02-D.4-IX2-20210924	9/24/2021	9:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 31.1	< 239	< 169	< 200	< 1928	< 2278	< 6.48	**1,460**	< 9604	< 590

Large Table 5: Enthalpy PFAS data for WW test phase

						Compound	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	2,2,3,3 TFPA	2,3,3,3 TFPA	HQ-115	PFPA	TFA	TFMS
						CAS	375-22-4	2706-90-3	307-24-4	375-85-9	335-67-1	375-73-5	2706-91-4	355-46-4	375-92-8	1763-23-1	756-09-2	359-49-9	90076-65-6	422-64-0	76-05-1	1493-13-6
Stream		Lab Report	Sample ID	Date	Time	ID in SAP																
		1021-784	3MCG-Test 02-D.4-IX2[2]-20210924	9/24/2021	16:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 32.3	< 239	< 169	< 200	< 1570	< 1705	**20**	< 2031	< 8313	< 835
SORBIX Concentrate Train	IX1R EFFLUENT	0921-777	3MCG-WW-E.3-IXR1-20210914	9/14/2021	12:00	PFAS 391	< 75.3	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2592	< 3906	**2**	< 7593	< 16108	< 154
SORBIX Concentrate Train	IX1R EFFLUENT	0921-777	3MCG-WW-E.3-IXR1-20210915-1155	9/15/2021	12:00	PFAS 392	< 67	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2126	< 3464	**0**	**7,380**	< 14260	< 99
SORBIX Concentrate Train	IX1R EFFLUENT	0921-777	3MCG-WW-E.3-IXR1-20210915-1610	9/15/2021	16:00	PFAS 393	< 62.3	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2516	< 4142	< 5.97	< 6305	< 13578	< 110
SORBIX Concentrate Train	IX1R EFFLUENT	0921-777	3MCG-WW-E.3-IXR1-20210916-0800	9/16/2021	9:00	PFAS 394	< 59	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2549	< 4789	< 6.43	< 4287	< 19068	< 116
SORBIX Concentrate Train	IX1R EFFLUENT	0921-777	3MCG-WW-E.3-IXR1-20210916-1555	9/16/2021	16:00	PFAS 395	< 80.5	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2878	< 4556	< 6.92	< 9073	< 28609	< 84.2
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1-20210917	9/17/2021	9:00	PFAS 396	< 333	< 16.0	< 3.61	< 4.82	< 7.69	< 6.01	< 4.77	< 19.1	< 6.69	< 3.31	< 9670	< 2768	< 22.3	**13,100**	< 700	< 427
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1 [2]-20210917	9/17/2021	16:00	PFAS 397	< 280	< 23.1	< 7.85	< 36.7	< 38.3	< 4.84	< 2.85	< 2.67	< 5.85	< 6.93	< 10446	< 3699	< 24.4	< 700	< 700	< 588
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1-20210918	9/18/2021	9:00	PFAS 398	< 508	< 30.8	< 15.5	< 3.20	< 18.0	< 5.77	< 2.68	< 11.9	< 6.32	< 3.19	< 15814	< 3007	**7**	< 700	< 700	< 603
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1 [2]-20210918	9/18/2021	16:00	PFAS 399	< 601	< 18.6	< 1.81	< 9.47	< 6.93	< 5.48	< 4.10	< 3.94	< 8.70	< 4.53	< 14533	< 2540	**11**	< 700	< 700	< 657
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1-20210919	9/19/2021	9:00	PFAS 400	< 1053	< 23.0	< 1.02	< 7.63	< 19.6	< 5.47	< 3.74	< 10.8	< 6.09	< 5.19	< 11693	< 2689	**10**	**13,400**	< 700	< 506
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1 [2]-20210919	9/19/2021	16:00	PFAS 401	< 280	< 15.0	< 1.94	< 19.8	< 22.5	< 7.11	< 2.47	< 5.80	< 6.49	< 3.87	< 8252	< 2419	**11**	**9,780**	< 700	< 420
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1-20210920	9/20/2021	9:00	PFAS 402	< 223	< 14.2	< 1.20	< 2.77	< 18.9	< 6.87	< 3.84	< 6.14	< 4.42	< 3.65	< 8342	< 2132	< 26.7	**56,500**	< 700	< 421
SORBIX Concentrate Train	IX1R EFFLUENT	0921-783	3MCG-WW-E.3-IXR1 [2]-20210920	9/20/2021	16:00	PFAS 403	< 371	< 21.0	< 4.52	< 15.9	< 5.77	< 5.84	< 2.89	< 6.33	< 2.17	< 1.73	< 10384	< 2183	< 33.5	**13,900**	< 700	**30**
SORBIX Concentrate Train	IX1R EFFLUENT	0921-803	3MCG-WW-E.3-IXR1-20210921	9/21/2021	12:00	PFAS 404	< 240	< 38.9	< 10.5	< 18.1	< 1.88	< 32.4	< 4.38	< 20.2	< 7.77	< 82.6	< 8191	< 5276	< 27.3	**15,700**	< 18504	< 661
SORBIX Concentrate Train	IX1R EFFLUENT	0921-803	3MCG-WW-E.3-IXR1-20210922	9/22/2021	9:00	PFAS 405	< 203	< 36.8	< 10.2	< 7.96	< 15.2	< 29.5	< 7.41	< 19.1	< 12.9	< 26.7	< 7131	< 4870	< 36.2	**10,500**	< 37509	< 545
SORBIX Concentrate Train	IX1R EFFLUENT	0921-803	3MCG-WW-E.3-IXR1[2]-20210922	9/22/2021	16:00	PFAS 406	< 336	< 27.9	< 19.8	< 22.4	< 62.2	< 54.6	< 8.71	< 9.15	< 13.2	< 32.2	< 12152	< 4476	< 32.7	**6,280**	< 16799	< 745
SORBIX Concentrate Train	IX1R EFFLUENT	0921-803	3MCG-WW-E.3-IXR1-20210923	9/23/2021	9:00	PFAS 407	< 213	< 22.2	< 23.3	< 10.7	< 16.4	< 51.1	< 5.31	< 15.5	< 11.9	< 9.63	< 7644	< 1444	< 50.9	**5,970**	< 700	**2,340**
SORBIX Concentrate Train	IX1R EFFLUENT	0921-803	3MCG-WW-E.3-IXR1[2]-20210923	9/23/2021	16:00	PFAS 408	< 329	< 33.3	< 53.5	< 22.1	< 10.6	< 132	< 12	< 24.3	< 17.7	< 15.3	< 9726	< 1452	< 28.1	**6,760**	< 700	**5,460**
SORBIX Concentrate Train	IX1R EFFLUENT	1021-784	3MCG-Test 02-E.3-IXR1-20210924	9/24/2021	9:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 31.8	< 239	< 169	< 200	< 2182	< 2109	< 4.79	**35,400**	< 13549	**17,100**
SORBIX Concentrate Train	IX1R EFFLUENT	1021-784	3MCG-Test 02-E.3-IXR1[2]-20210924	9/24/2021	16:00	--	< 191	< 212	< 241	< 152	< 221	< 444	**33**	< 239	< 169	< 200	< 2003	< 2271	**101**	**8,570**	< 2.58	**8,830**
SORBIX Concentrate Train	IX2R EFFLUENT	0921-777	3MCG-WW-E.4-IXR2-20210914	9/14/2021	12:00	PFAS 409	< 74.6	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2474	< 4422	**0.1**	< 24948	< 25017	< 135
SORBIX Concentrate Train	IX2R EFFLUENT	0921-777	3MCG-WW-E.4-IXR2-20210915-1056	9/15/2021	12:00	PFAS 410	< 60.9	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2850	< 5051	**4.2**	**12,400**	< 19918	< 143
SORBIX Concentrate Train	IX2R EFFLUENT	0921-777	3MCG-WW-E.4-IXR2-20210915-1600	9/15/2021	16:00	PFAS 411	< 63.2	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2647	< 4932	< 9.2	**5,420**	< 13241	< 105
SORBIX Concentrate Train	IX2R EFFLUENT	0921-777	3MCG-WW-E.4-IXR2-20210916-0731	9/16/2021	9:00	PFAS 412	< 71.5	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 2269	< 3353	< 6.8	< 5043	< 12453	< 102
SORBIX Concentrate Train	IX2R EFFLUENT	0921-777	3MCG-WW-E.4-IXR2-20210916-1545	9/16/2021	16:00	PFAS 413	< 55.8	< 212	< 241	< 152	< 221	< 444	< 258	< 239	< 169	< 200	< 1726	< 3617	< 9.4	**8,760**	< 3.84	< 105
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2-20210917	9/17/2021	9:00	PFAS 414	< 311	< 20.9	< 13.5	< 7.39	< 21.8	< 5.88	< 3.69	< 4.46	< 7.78	< 3.71	< 9735	< 2937	**7.6**	< 700	< 700	< 454
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2 [2]-20210917	9/17/2021	16:00	PFAS 415	< 290	< 17.6	< 0.997	< 1.96	< 29.1	< 6.34	< 2.49	< 4.13	< 8.99	< 3.02	< 11231	< 4144	< 19.7	< 700	< 700	< 480
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2-20210918	9/18/2021	9:00	PFAS 416	< 649	< 20.4	< 3.75	< 11.1	< 12.0	< 5.75	< 2.67	< 18.1	< 8.62	< 11.5	< 13154	< 4244	**11.5**	< 700	< 700	< 907
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2 [2]-20210918	9/18/2021	16:00	PFAS 417	< 445	< 12.8	< 6.13	< 9.38	< 5.46	< 4.97	< 2.38	< 7.09	< 5.84	< 1.60	< 13087	< 3347	< 102	< 700	< 700	< 733
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2-20210919	9/19/2021	9:00	PFAS 418	< 588	< 20.1	< 25.0	< 5.56	< 7.49	< 5.40	< 3.30	< 4.78	< 7.17	< 3.55	< 19129	< 3223	**20.9**	< 700	< 700	< 665
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2 [2]-20210919	9/19/2021	16:00	PFAS 419	< 417	< 15.1	< 9.55	< 5.36	< 10.5	< 6.77	< 2.18	< 3.60	< 7.68	< 2.34	< 9332	< 2673	**7.4**	< 700	< 700	< 467
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2-20210920	9/20/2021	9:00	PFAS 420	< 276	< 30.5	< 7.30	< 14.6	< 11.3	< 7.62	< 3.98	< 5.78	< 4.70	< 4.28	< 8823	< 2318	< 54.6	< 700	< 700	< 390
SORBIX Concentrate Train	IX2R EFFLUENT	0921-783	3MCG-WW-E.4-IXR2 [2]-20210920	9/20/2021	16:00	PFAS 421	< 368	< 16.1	< 2.76	< 26.6	< 23.8	< 5.48	< 2.73	< 2.31	< 8.37	< 7.72	< 7254	< 2019	< 25.2	< 700	< 700	**25**
SORBIX Concentrate Train	IX2R EFFLUENT	0921-803	3MCG-WW-E.4-IXR2-20210921	9/21/2021	12:00	PFAS 422	< 281	< 31.5	< 15	< 17.7	< 31.1	< 15.4	< 9.43	< 11	< 10.4	< 24.6	< 9948	< 6566	< 27.2	< 7799	< 22978	< 511
SORBIX Concentrate Train	IX2R EFFLUENT	0921-803	3MCG-WW-E.4-IXR2-20210922	9/22/2021	9:00	PFAS 423	< 153	< 37.6	< 21.8	< 5.87	< 18.3	< 57.4	< 5.94	< 8.65	< 45.8	< 42.1	< 5267	< 4343	< 13	< 6609	< 25816	**290**
SORBIX Concentrate Train	IX2R EFFLUENT	0921-803	3MCG-WW-E.4-IXR2[2]-20210922	9/22/2021	16:00	PFAS 424	< 196	< 39.6	< 32.3	< 15.9	< 8.41	< 29.9	< 55.6	< 15.2	< 18.4	< 32.8	< 5882	< 1662	< 71.5	**6,160**	< 700	< 342
SORBIX Concentrate Train	IX2R EFFLUENT	0921-803	3MCG-WW-E.4-IXR2-20210923	9/23/2021	9:00	PFAS 425	< 316	< 28.3	< 9.03	< 8.66	< 39.3	< 91.7	< 5.34	< 8.14	< 12.2	< 39.6	< 11009	< 1464	< 26	**6,270**	< 700	< 578
SORBIX Concentrate Train	IX2R EFFLUENT	0921-803	3MCG-WW-E.4-IXR2[2]-20210923	9/23/2021	16:00	PFAS 426	< 247	< 39.6	< 20.5	< 13	< 82.1	< 64.3	< 7.34	< 10.7	< 17.2	< 40	< 9781	< 1399	< 41.3	**6,230**	< 700	< 620
SORBIX Concentrate Train	IX2R EFFLUENT	1021-784	3MCG-Test 02-E.4-IXR2-20210924	9/24/2021	9:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 32	< 239	< 169	< 200	< 1953	< 2241	< 3.78	**8,840**	< 6914	< 890
SORBIX Concentrate Train	IX2R EFFLUENT	1021-784	3MCG-Test 02-E.4-IXR2[2]-20210924	9/24/2021	16:00	--	< 191	< 212	< 241	< 152	< 221	< 444	< 34.7	< 239	< 169	< 200	< 1831	< 2357	< 3.06	**6,720**	< 12891	< 706

Large Table 6: AIX regeneration results

CalRes 2301 2320

Sample ID	Regen Step	BVs	Volume (L)	Time (hrs)	TFA	2,3,3,3 TFPA	2,2,3,3-TFPA	PFPA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	HQ-115	TFMS	SUM16
D.3-IX1-0	Initial Water Flush	0.36	1.81	0.18	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	24,400	< 4,440	< 2,580	19,900	< 1,690	33,100	< 10,000	179,000	256,400
D.3-IX1-1	Regen Fill	0.61	3.06	0.31	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	103,000	103,000
D.3-IX1-2		0.86	4.31	0.43	< 7,000	< 7,520	< 10,000	11,400	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	320,000	331,400
D.3-IX1-3	Regen Flush	1.11	5.56	0.56	< 7,000	< 7,520	< 10,000	11,300	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	354,000	365,300
D.3-IX1-4		1.36	6.81	0.68	< 7,000	< 7,520	< 10,000	60,400	7,820	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	1,450,000	1,518,220
D.3-IX1-5		1.61	8.06	0.81	80,100	< 7,520	< 10,000	365,000	60,400	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	3,480,000	3,985,500
D.3-IX1-6		1.86	9.31	0.93	423,000	< 7,520	< 10,000	1,330,000	186,000	< 2,120	< 2,410	< 1,520	< 2,210	9,910	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	8,230,000	10,178,910
D.3-IX1-7		2.11	10.56	1.06	520,000	< 7,520	< 10,000	1,640,000	194,000	< 2,120	< 2,410	< 1,520	< 2,210	11,000	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,600,000	13,965,000
D.3-IX1-8		2.36	11.81	1.18	542,000	< 7,520	< 10,000	1,680,000	180,000	< 2,120	< 2,410	< 1,520	< 2,210	9,260	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	12,500,000	14,911,260
D.3-IX1-9		2.61	13.06	1.31	479,000	< 7,520	< 10,000	1,570,000	156,000	< 2,120	< 2,410	< 1,520	< 2,210	7,910	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	12,200,000	14,412,910
D.3-IX1-10		2.86	14.31	1.43	442,000	< 7,520	< 10,000	1,540,000	141,000	< 2,120	< 2,410	< 1,520	< 2,210	6,910	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,900,000	14,029,910
D.3-IX1-11		3.11	15.56	1.56	402,000	< 7,520	< 10,000	1,370,000	129,000	< 2,120	< 2,410	< 1,520	< 2,210	6,530	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,500,000	13,407,530
D.3-IX1-12		3.36	16.81	1.68	349,000	< 7,520	< 10,000	1,320,000	113,000	< 2,120	< 2,410	< 1,520	< 2,210	5,360	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,600,000	13,387,360
D.3-IX1-13		3.61	18.06	1.81	266,000	< 7,520	< 10,000	1,150,000	97,500	< 2,120	< 2,410	< 1,520	< 2,210	5,580	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	10,800,000	12,319,080
D.3-IX1-14		3.86	19.31	1.93	234,000	< 7,520	< 10,000	1,060,000	88,900	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	10,400,000	11,782,900
D.3-IX1-15		4.11	20.56	2.06	192,000	< 7,520	< 10,000	908,000	78,500	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	10,300,000	11,478,500
D.3-IX1-16		4.36	21.81	2.18	163,000	< 7,520	< 10,000	896,000	75,500	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,000,000	12,134,500
D.3-IX1-17		4.61	23.06	2.31	130,000	< 7,520	< 10,000	827,000	69,500	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	11,000,000	12,026,500
D.3-IX1-18		4.86	24.31	2.43	82,400	< 7,520	< 10,000	702,000	54,400	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,820,000	10,658,800
D.3-IX1-19		5.11	25.56	2.56	64,700	< 7,520	< 10,000	608,000	50,500	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,740,000	10,463,200
D.3-IX1-20		5.36	26.81	2.68	43,300	< 7,520	< 10,000	547,000	47,600	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,770,000	10,407,900
D.3-IX1-21		5.61	28.06	2.81	41,700	< 7,520	< 10,000	486,000	42,300	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,230,000	9,800,000
D.3-IX1-22		5.86	29.31	2.93	< 7,000	< 7,520	< 10,000	442,000	39,900	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,920,000	10,401,900
D.3-IX1-23		6.11	30.56	3.06	< 7,000	< 7,520	< 10,000	385,000	34,700	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	9,180,000	9,599,700
D.3-IX1-24		6.36	31.81	3.18	< 7,000	< 7,520	< 10,000	436,000	31,100	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	8,600,000	9,067,100
D.3-IX1-25		6.38	31.88	3.19			< 10,000	256,000	23,200	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	7,610,000	7,889,200
D.3-IX1-26	Water Flush	6.63	33.13	3.31	< 7,000	< 7,520	< 10,000	261,000	26,300	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	8,170,000	8,457,300
D.3-IX1-27		6.88	34.38	3.44	< 7,000	< 7,520	< 10,000	139,000	12,400	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	5,860,000	6,011,400
D.3-IX1-28	Slow Water Rinse	7.13	35.63	3.56	< 7,000	< 7,520	< 10,000	15,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	1,530,000	1,545,000
D.3-IX1-29		7.38	36.88	3.69	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	49,200	49,200
D.3-IX1-30	Fast Water Rinse	9.90	49.48	4.06	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	16,100	16,100
D.3-IX1-31		12.42	62.08	4.44	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	16,200	16,200

Large Table 6: AIX regeneration results

SORBIX A3F Regen Step

Sample ID	Regen Step	BVs	Volume (L)	Time (hrs)	TFA	2,3,3,3 TFPA	2,2,3,3-TFPA	PFPA	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	HQ-115	TFMS	SUM16
E.3-IXR1-0	Initial Water Flush	0.36	1.81	0.18	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**264,000**	264,000
E.3-IXR1-1	Regen Fill	0.61	3.06	0.31	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**136,000**	136,000
E.3-IXR1-2		0.86	4.31	0.43	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**230,000**	230,000
E.3-IXR1-3	Regen Flush	1.11	5.56	0.56	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**377,000**	377,000
E.3-IXR1-4		1.36	6.81	0.68	< 7,000	< 7,520	< 10,000	**63,100**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**1,920,000**	1,983,100
E.3-IXR1-5		1.61	8.06	0.81	**37,400**	< 7,520	< 10,000	**219,000**	**10,200**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,490,000**	3,756,600
E.3-IXR1-6		1.86	9.31	0.93	**103,000**	< 7,520	< 10,000	**528,000**	**35,400**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**6,080,000**	6,746,400
E.3-IXR1-7		2.11	10.56	1.06	**256,000**	< 7,520	< 10,000	**865,000**	**50,800**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**12,100,000**	13,271,800
E.3-IXR1-8		2.36	11.81	1.18	**427,000**	< 7,520	< 10,000	**987,000**	**58,400**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**30,700,000**	32,172,400
E.3-IXR1-9		2.61	13.06	1.31	**369,000**	< 7,520	< 10,000	**825,000**	**42,700**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**26,800,000**	28,036,700
E.3-IXR1-10		2.86	14.31	1.43	**393,000**	< 7,520	< 10,000	**788,000**	**34,200**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**29,700,000**	30,915,200
E.3-IXR1-11		3.11	15.56	1.56	**217,000**	< 7,520	< 10,000	**582,000**	**29,300**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**17,600,000**	18,428,300
E.3-IXR1-12		3.36	16.81	1.68	**170,000**	< 7,520	< 10,000	**493,000**	**23,300**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**14,600,000**	15,286,300
E.3-IXR1-13		3.61	18.06	1.81	**138,000**	< 7,520	< 10,000	**376,000**	**14,400**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**10,300,000**	10,828,400
E.3-IXR1-14		3.86	19.31	1.93	**122,000**	< 7,520	< 10,000	**340,000**	**13,700**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**10,100,000**	10,575,700
E.3-IXR1-15		4.11	20.56	2.06	**74,900**	< 7,520	< 10,000	**246,000**	**7,470**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**6,740,000**	7,068,370
E.3-IXR1-16		4.36	21.81	2.18	**62,700**	< 7,520	< 10,000	**220,000**	**5,640**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**6,260,000**	6,548,340
E.3-IXR1-17		4.61	23.06	2.31	**31,900**	< 7,520	< 10,000	**167,000**	**3,790**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**5,120,000**	5,322,690
E.3-IXR1-18		4.86	24.31	2.43	**17,900**	< 7,520	< 10,000	**107,000**	**2,910**	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,950,000**	4,077,810
E.3-IXR1-19		5.11	25.56	2.56	< 7,000	< 7,520	< 10,000	**84,900**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,310,000**	3,394,900
E.3-IXR1-20		5.36	26.81	2.68	< 7,000	< 7,520	< 10,000	**71,100**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**2,840,000**	2,911,100
E.3-IXR1-21		5.61	28.06	2.81	< 7,000	< 7,520	< 10,000	**49,600**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**2,270,000**	2,319,600
E.3-IXR1-22		5.86	29.31	2.93	< 7,000	< 7,520	< 10,000	**36,700**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**2,100,000**	2,136,700
E.3-IXR1-23		6.11	30.56	3.06	< 7,000	< 7,520	< 10,000	**37,400**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**1,910,000**	1,947,400
E.3-IXR1-24		6.36	31.81	3.18	< 7,000	< 7,520	< 10,000	**89,100**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**1,980,000**	2,069,100
E.3-IXR1-25		6.38	31.88	3.19	**13,200**	< 7,520	< 10,000	**84,600**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,650,000**	3,747,800
E.3-IXR1-26	Water Flush	6.63	33.13	3.31	< 7,000	< 7,520	< 10,000	**56,400**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,640,000**	3,696,400
E.3-IXR1-27		6.88	34.38	3.44	< 7,000	< 7,520	< 10,000	**62,100**	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,940,000**	4,002,100
E.3-IXR1-28	Slow Water Rinse	7.13	35.63	3.56	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**3,430,000**	3,430,000
E.3-IXR1-29		7.38	36.88	3.69	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**664,000**	664,000
E.3-IXR1-30	Fast Water Rinse	9.90	49.48	4.06	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**88,300**	88,300
E.3-IXR1-31		12.42	62.08	4.44	< 7,000	< 7,520	< 10,000	< 7,000	< 1,910	< 2,120	< 2,410	< 1,520	< 2,210	< 4,440	< 2,580	< 2,390	< 1,690	< 2,000	< 10,000	**88,100**	88,100

Large Table 7 - Comparison of estimated water quality to permit limits

NCCW/SW (SD002)

		SD002		Blended NCCW/SW Effluent[1]	
Parameter	Units	Permit Limit SD001 (bolded if also for SD001)	Limit type	CalRes	SORBIX
BOD, 5 day	mg/L	**25**	CMA	< 2	< 2
Oil and Grease	mg/L	**10**	DM	< 4.8	< 4.8
Total Suspended Solids	mg/L	**30**	CMA	<10	<10

Phase 1/2 Wastewater (SD001)

		SD001		Blended WW Effluent[1]	
Parameter[2]	Units	Permit Limit SD001 (bolded if also for SD002)	Limit type	CalRes	SORBIX
Aluminum	mg/L	0.458	DM	< 0.2	< 0.2
BOD, 5 day	mg/L	**25**	CMA	2.03	2.08
Copper	mg/L	0.068	DM	0.015	0.018
Nickel	mg/L	0.48	DM	< 0.02	< 0.02
Oil and Grease	mg/L	**10**	DM	5.0	5.0
pH at 25 Degrees C	Std. Units	6-9	CMM/M	6.5-8.5	6.5-8.5
Total Suspended Solids	mg/L	**30**	CMA	19.2	17.3
Zinc	mg/L	0.24	DM	0.034	0.032
1,1,1-Trichloroethane	ug/L	54	DM	< 1	< 1
1,1,2-Trichloroethane	ug/L	54	DM	< 1	< 1
1,1-Dichloroethane	ug/L	59	DM	< 1	< 1
1,1-Dichloroethene	ug/L	25	DM	< 1	< 1
1,2,4-Trichlorobenzene	ug/L	140	DM	< 25	< 25
1,2-Dichlorobenzene	ug/L	163	DM	< 1	< 1
1,2-Dichloroethane	ug/L	68	CMA	< 25	< 25
1,2-Dichloropropane	ug/L	230	DM	< 1	< 1
1,3-Dichlorobenzene	ug/L	44	DM	< 1	< 1
1,4-Dichlorobenzene	ug/L	28	DM	< 1	< 1
Acrylonitrile	ug/L	242	DM	< 10	< 10
Benzene	ug/L	136	DM	< 1.82	< 1.82
Carbon tetrachloride	ug/L	38	DM	< 1	< 1
Chlorobenzene	ug/L	28	DM	< 1	< 1
Chloroethane	ug/L	268	DM	< 5	< 5
Chloroform	ug/L	21	CMA	< 5	< 5
Chloromethane	ug/L	190	DM	< 2.5	< 2.5
Ethylbenzene	ug/L	32	CMA	< 1	< 1
Hexachloro-1,3-butadiene	ug/L	49	DM	< 25	< 25
Methylene Chloride	ug/L	40	CMA	< 39.8	< 39.8
Tetrachloroethene	ug/L	56	DM	< 1	< 1
Toluene	ug/L	26	CMA	< 1	< 1
Trichloroethene	ug/L	54	DM	< 1	< 1
Vinyl chloride	ug/L	268	DM	< 1	< 1

DM = daily maximum, CMA = calendar monthly average, CMM/M = calendar monthly minimum and maximum

[1] Effluent water quality calculation from weighted average of RO permeate and AIX effluent. If not measured there, it is shown as less than the value measured/LOD for pilot feed water.
[2] VOC concentrations were not collected for treated water. Values shown reflect influent concentration. The bulk of VOC mass is expected to be routed to RO concentrate and then removed through GAC adsorption.

Large Table 8 - Updated PFAS Treatment Alternatives Screening

Category	Criteria Weight	Ranking Key	Alternative 5[1] Reverse Osmosis (85% recovery) with Anion Exchange (Regenerable)	Alternative 6[1] Reverse Osmosis (95% recovery) with Anion Exchange (Regenerable)
Technical Feasibility			***17***	***14***
Group 1 PFAS removal efficiency[2]	3	1 - <50% removal efficiency 2 - >50% and <75% removal efficiency 3 - >75% removal efficiency	3	3
Group 2 PFAS removal efficiency[3]	0	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	3	Unable to estimate from pilot data based on laboratory LODs
Group 3 PFAS removal efficiency[3]	0	1 - <75% removal efficiency 2 - >75% and <90% removal efficiency 3 - >90% removal efficiency	3	Unable to estimate from pilot data based on laboratory LODs
General complexity of operation/ maintenance of primary technology	3	1 - complex 2 - simple	2	1
Operator and public health risks	1	1 - significant additional health risk 2 - no additional health risk	2	2
Economic Feasibility			***9***	***9***
Capital costs for primary technology (and secondary technology, where applicable)	3	1 - high relative capital cost 2 - low relative capital cost	1	2
O&M costs for primary technology (and secondary technology, where applicable)[4]	3	1 - high relative O&M cost 2 - low relative O&M cost	2	1
Energy Consumption			***4***	***2***
Energy consumption of primary technology (and secondary technology, where applicable)	2	1 - high relative energy consumption 2 - low relative energy consumption	2	1
Potential for Media Shifting of Pollutants			***4***	***2***
Relative quantity of residuals generated	2	1 - high 2 - low	2	1
		Total Score	**34**	**27**

[1] Based on NCCW_B and WW test phases for Alternative 5 and NCCW_D test phase for Alternative 6. Both assume an AIX EBCT of 30 minutes.

[2] Removal efficiency ratings for media technologies reflect anticipated removal at 220-250 bed volumes. This value is lower than the 5,000 BV used for the Treatability Plan, because the pilot was only run through 220 BV (for Alternative 5 treatment of NCCW/SW) or 250 BV (for Alternative 5 treatment of Phase 1/2 WW).

[3] Removal efficiency estimates are affected by relatively high LOD values for most PFAS (typically in the range of 200-10,000 ng/L). For example, no Group 3 PFAS were detected in pilot influent water for much of the test, so removal efficiency could not be reliably assessed. Group 2 and 3 PFAS were detected in Alternative 5 treatments (NCCW_B and WW phases) using 3M's analytical lab, but samples were not collected for Alternative 6 treatment (NCCW_D phase) for analysis by 3M's lab, and IX influent Group 2 and 3 PFAS were below Enthalpy's LOD. As a result, Alternative 6 removal could not be estimated, and criteria weights were adjusted for Group 2 and Group 3 PFAS to zero.

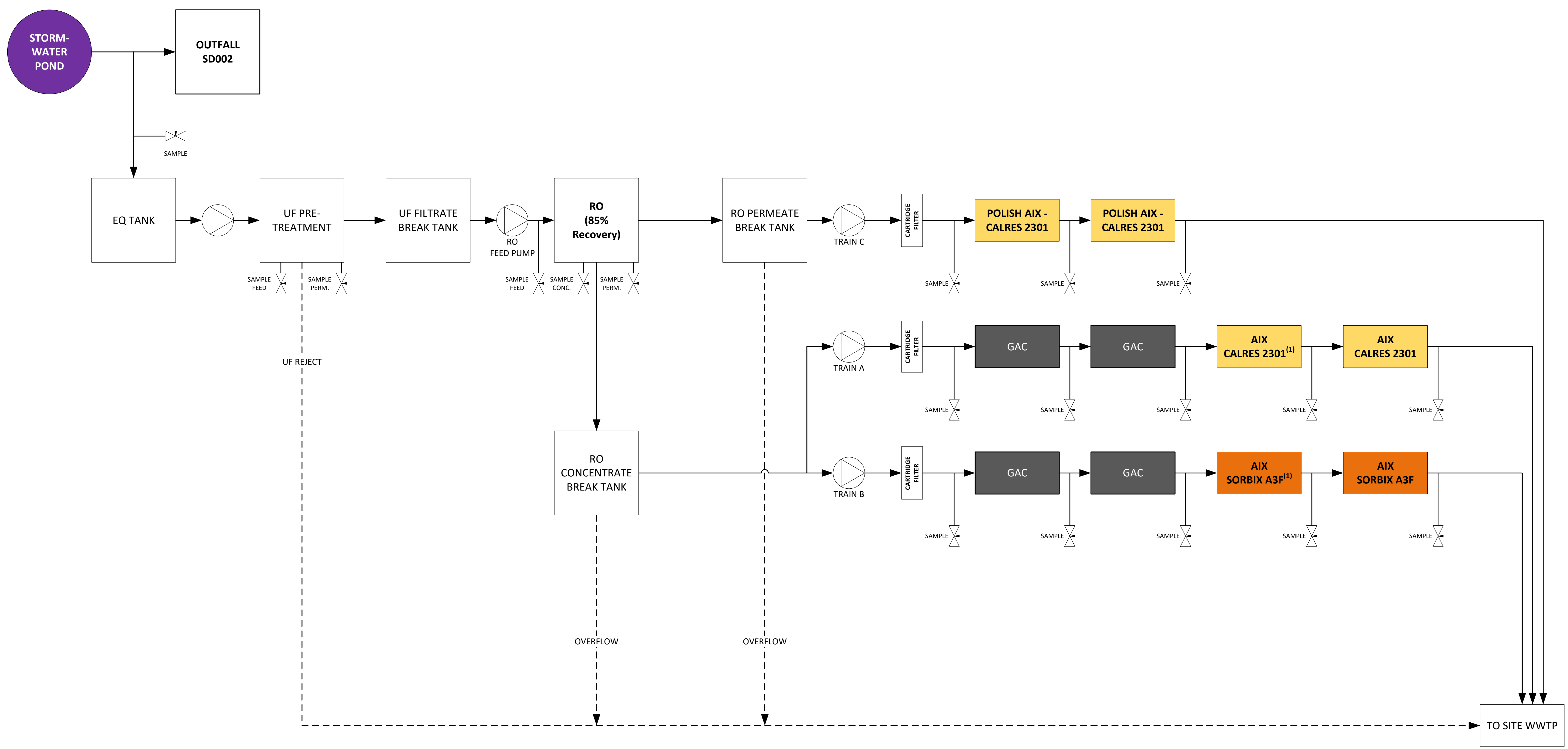
[4] Large differences in O&M costs are expected for membrane replacement and cleaning based on observations made during the 95% recovery pilot phase, NCCW_D.

Large Table 9 Comparison of full-scale treatment system design parameters to Treatability Plan Alternative 5 and pilot system

Unit Process	Design Parameter	Alternative 5 Conceptual Design from Treatability Plan		NCCW_B Treatability Study Pilot Test Phases	Modified Design for NCCW/SW			Phase 1/2 WW Treatability Study Pilot Test Phases	Modified Design for Phase 1/2 WW		
		Design Basis	Rationale	Design Basis	Average	Maximum	Rationale	Design Basis	Average	Maximum	Rationale
UF	Feed rate	Not included	NA	1.86 gpm 89.2 GFD	6.5 MGD (4,500 gpm)	8.9 MGD (6,200 gpm)	Design flux less than study value	1.49 gpm 71 GFD	2.2 MGD (1,500 gpm)	2.9 MGD (2,000 gpm)	Design flux less than study value
RO	Feed rate	8.3 MGD	Including 8.3 MGD feed flow plus stage-one concentrate	3 gpm feed 2.5 gpm permeate 14 GFD	6.5 MGD (4,500 gpm)	8.9 MGD (6,200 gpm)	Design flux less than study value	2.49 gpm feed 2.12 gpm permeate 12 GFD	2.2 MGD (1,500 gpm)	2.9 MGD (2,000 gpm)	Design flux less than study value
	Overall RO recovery	85%	Selected by 3M	85%	85%	85%	Limit driven by water quality data	85%	85%	85%	Limit driven by water quality data
GAC	Feed rate	Not included	NA	77 mL/min	0.97 MGD (675 gpm)	1.3 MGD (930 gpm)	Based on expected RO recovery	77 mL/min	0.32 MGD (225 gpm)	0.43 MGD (300 gpm)	Based on expected RO recovery
	EBCT	Not included	NA	60 minutes total across two vessels	26 min	19 min	Typical EBCT used for treatment of long chain PFAS	60 minutes total across two vessels	52 minutes total across two vessels	40 minutes total across two vessels	Typical EBCT used for treatment of long chain PFAS
	HLR	Not included	NA	0.9 gpm/SF	2.9 gpm/SF	3.8 gpm/SF	Typical HLR for this application	0.9 gpm/SF	2.9 gpm/SF	3.9 gpm/SF	Typical HLR for this application
AIX	Feed rate	1.2 MGD (max)	85% RO recovery	77 mL/min	0.97 MGD (675 gpm)	1.3 MGD (930 gpm)	85% RO Recovery	77 mL/min	0.32 MGD (225 gpm)	0.43 MGD (300 gpm)	85% RO Recovery
	EBCT	20 minutes total across two vessels	Typical for AIX PFAS removal applications	60 min total across two vessels	60 min total across three vessels	43 min total across three vessels	Balance between HLR and time between regenerations	60 min total across two vessels	72 min total across three vessels	54 min total across three vessels	Balance between HLR and time between regenerations
	HLR	7.0 gpm/SF	Maintain > 3 gpm/SF for good distribution within vessel	0.9 gpm/SF	4.8 gpm/SF	6.6 gpm/SF	Maintain > 3 gpm/SF for good distribution within vessel	0.9 gpm/SF	4.0 gpm/SF	5.3 gpm/SF	Maintain > 3 gpm/SF for good distribution within vessel

Large Figures

Large Figure 1 - Pilot Test Equipment Location



PILOT TESTING BLOCK FLOW DIAGRAM – NCCW/SW
3M COTTAGE GROVE PLANT
UPDATED 11/24/21

Large Figure 2 - Process Flow Diagram - NCCW/SW Test Phases

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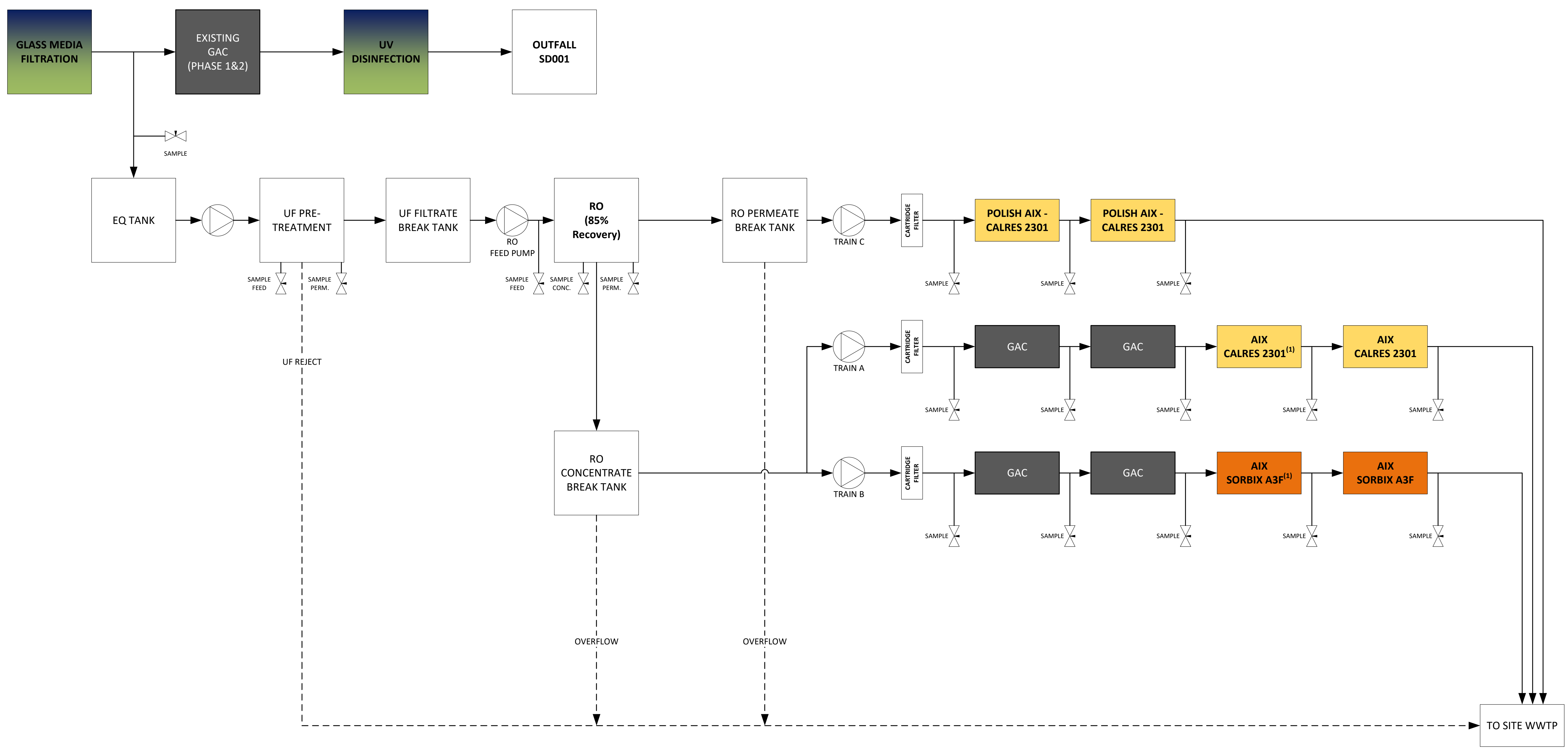

NOTES:
(1) At the end of the test, the lead AIX columns were sent to the ECT2 lab for regeneration

PILOT TESTING BLOCK FLOW DIAGRAM – PHASE 1 & 2 WASTEWATER
3M COTTAGE GROVE PLANT
UPDATED 11/24/21

Large Figure 3 - Process Flow Diagram - Phase 1/2 WW Test Phase

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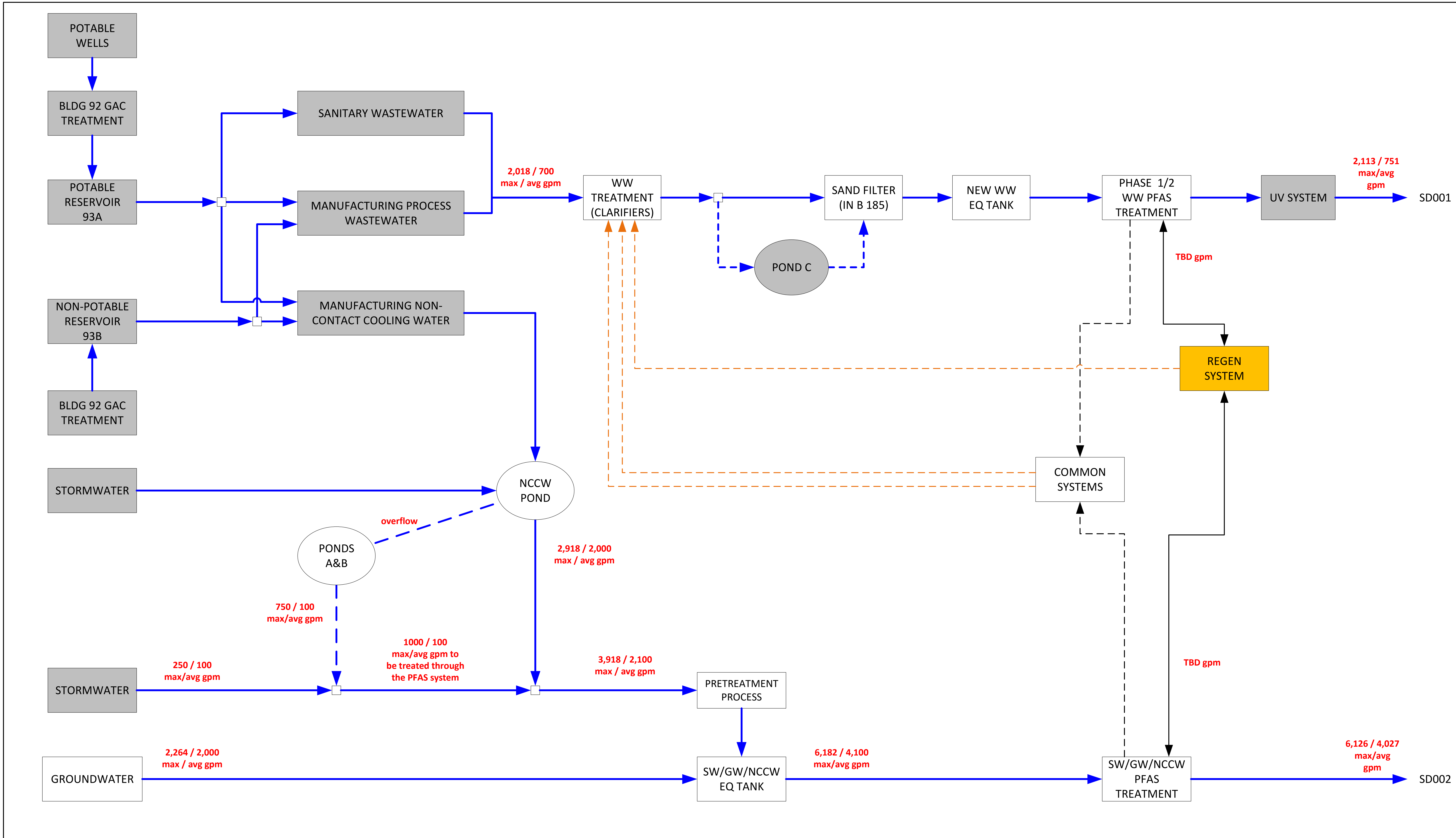

3M COTTAGE GROVE PLANT
SITE BLOCK DIAGRAM – STORM, WASTE AND PROCESS WATER SYSTEMS
3M FACILITY, COTTAGE GROVE, MINNESOTA
October 28, 2021

Large Figure 4

LEGEND

FORWARD FLOW	OVERFLOW/BYPASS
REGEN SYSTEM FLOW	NEW EQUIPMENT
RECYCLE STREAMS	REGEN SYSTEM
BACKWASH	EXISTING EQUIPMENT

ECT2
Portland, ME
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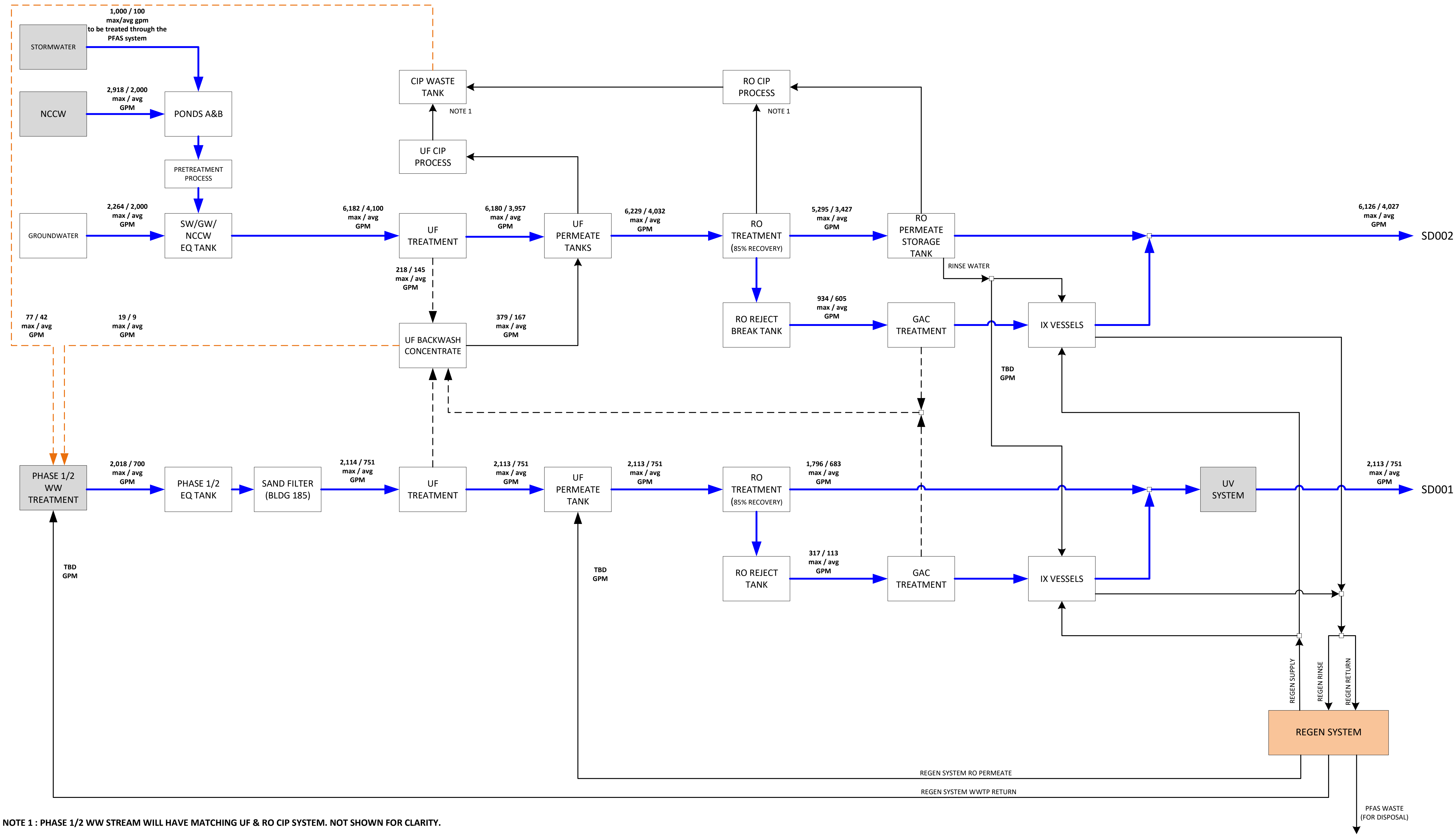


NOTE 1 : PHASE 1/2 WW STREAM WILL HAVE MATCHING UF & RO CIP SYSTEM. NOT SHOWN FOR CLARITY.

3M COTTAGE GROVE PLANT
PLANT BLOCK DIAGRAM – SW/GW/NCCW AND PHASE 1/2 WW SYSTEMS
3M FACILITY, COTTAGE GROVE, MINNESOTA
December 14, 2021

Large Figure 5

LEGEND

FORWARD FLOW	NEW EQUIPMENT
RECYCLE STREAMS	REGEN SYSTEM
BACKWASH	EXISTING EQUIPMENT

ECT2
Portland, ME
www.ect2.com

Appendices

Appendix A

Product Data Sheets

Emerging Compounds Treatment Technologies

Product Data Sheet
SORBIX A3F
PFAS Selective

SORBIX A3F is a strongly basic anion exchange resin, developed for selective poly- and per-fluorinated alkyl substance (PFAS) removal from water. SORBIX A3F resin removes PFAS preferentially to sulfate, bicarbonate/carbonate and other common groundwater anions, yielding an operating capacity higher than conventional resins. These characteristics make SORBIX A3F resin a great choice for a single, regenerable or disposable PFAS removal process for water treatment. Certified by the WQA to NSF/ANSI-61 Standard.

PROPERTIES

Matrix	Cross linked copolymer
Physical Form	White to cream spherical beads
Total Exchange Capacity	≥0.65 eq/L
Moisture Holding Capacity	58% (max.)
Shipping Weight	43 lb/ft^3
Particle Size	0.3- 1.2 mm

TYPICAL OPERATING CONDITIONS

Maximum Operating Temperature	75°C (167°F)
Minimum Bed Depth	30 inches
Service Flow Rate	5 - 40 BV/hr
EBCT	1.5 - 12 min
Flow Velocity	8 - 12 gpm/ft^2

CONDITIONING AND LIMITS OF USE

SORBIX A3F resin is suitable for use in potable water applications after soaking in soft, demineralized or drinking water for one hour. Following the resin soak, backwash for 30 minutes, followed by a forward flow rinse with 20 bed volumes (BV) of water at 4 BV/hr.

For non-potable applications, soak the water for 1 hr and backwash for 30 minutes before placing into service.

SORBIX A3F resin can be regenerated using a proprietary regeneration process. Contact ECT2 for more information.

Data Sheet

Calgon Carbon
A Kuraray Company

FILTRASORB® 400

Granular Activated Carbon

Applications

Industrial Wastewater	Groundwater	Surface Water
Pond/Aquarium/ Swim	Bottle & Brewing	Water Processing
Pharmaceuticals	Environmental Water	Food & Beverage
Drinking Water Industrial	Water Reuse	Drinking Water (Potable)
Granular Activated Carbon	Municipal	Reactivation

FILTRASORB 400 activated carbon can be used in a variety of liquid phase applications for the removal of dissolved organic compounds. FILTRASORB 400 has been successfully applied for over 40 years in applications such as drinking and process water purification, wastewater treatment, and food, pharmaceutical, and industrial purification.

Description

FILTRASORB 400 is a granular activated carbon for the removal of dissolved organic compounds from water and wastewater as well as industrial and food processing streams. These contaminants include taste and odor compounds, organic color, total organic carbon (TOC), industrial organic compounds such as TCE and PCE, and PFAS.

This activated carbon is made from select grades of bituminous coal through a process known as reagglomeration to produce a high activity, durable, granular product capable of withstanding the abrasion associated with repeated backwashing, hydraulic transport, and reactivation for reuse. The raw coal is mined and subsequently manufactured into GAC in the United States to ensure the highest quality and consistency in the finished product. Activation is carefully controlled to produce a significant volume of both low and high energy pores for effective adsorption of a broad range of high and low molecular weight organic contaminants.

FILTRASORB 400 is formulated to comply with all the applicable provisions of the AWWA Standard for Granular Activated Carbon (B604) and Food Chemicals Codex. This product may also be certified to the requirements of NSF/ANSI 61 for use in municipal water treatment facilities. Only products bearing the NSF Mark are certified to the NSF/ANSI 61 - Drinking Water System Components - Health Effects standard. Certified Products will bear the NSF Mark on packaging or documentation shipped with the product.

Features / Benefits

- Produced in the United States from a pulverized blend of high quality, domestically mined bituminous coals resulting in a consistent, high quality product.
- Carbon granules are uniformly activated through the whole granule, not just the outside, resulting in excellent adsorption properties and constant adsorption kinetics.
- The reagglomerated structure ensures proper wetting while also eliminating floating material.
- High mechanical strength relative to other raw materials, thereby reducing the generation of fines during backwashing and hydraulic transport.
- Carbon bed segregation is retained after repeated backwashing, ensuring the adsorption profile remains unchanged and therefore maximizing the bed life.
- Reagglomerated with a high abrasion resistance, which provides excellent reactivation performance.
- High density carbon resulting in a greater adsorption capacity per unit volume.

Specifications[1]	FILTRASORB 400
Iodine Number, mg/g	1000 (min)
Moisture by Weight	2% (max)
Effective Size	0.55–0.75 mm
Uniformity Coefficient	1.9 (max)
Abrasion Number	75 (min)
Screen Size by Weight, US Sieve Series	
On 12 mesh	5% (max)
Through 40 mesh	4% (max)

[1]Calgon Carbon test method

Typical Properties*	FILTRASORB 400
Apparent Density (tamped)	0.54 g/cc
Water Extractables	<1%
Non-Wettable	<1%

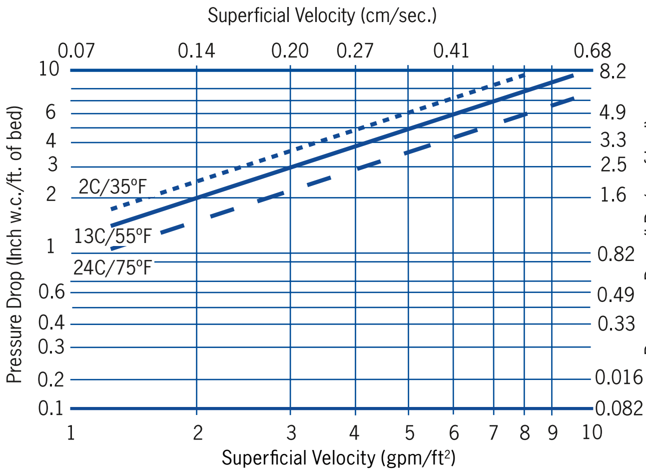
*For general information only, not to be used as purchase specifications.

Safety Message

Wet activated carbon can deplete oxygen from air in enclosed spaces. If use in an enclosed space is required, procedures for work in an oxygen deficient environment should be followed.

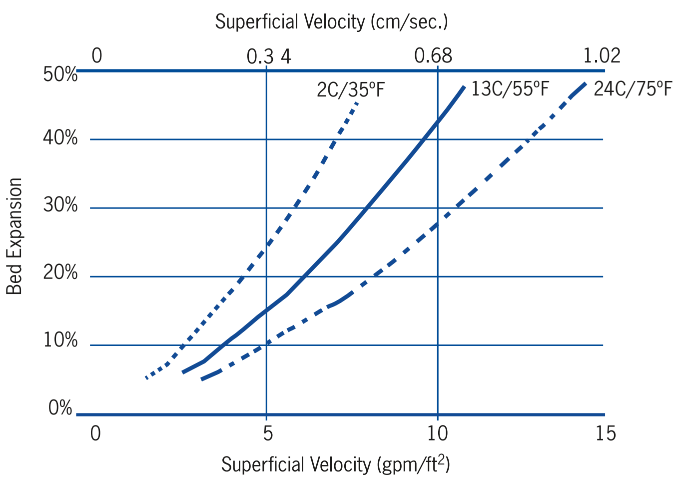
Typical Pressure Drop

Based on a backwashed and segregated bed



Typical Bed Expansion During Backwash

Based on a backwashed and segregated bed



Conditioning and Backwashing

Backwashing and conditioning fresh GAC before placing into operation is critical to GAC performance. The reasons for backwashing before placing fresh media online are to: (1) size segregate the media so subsequent backwashing will return the media to the same relative position in the bed, (2) remove any remaining air from the bed, and (3) remove media fines which can lead to excessive pressure drop and flow restriction. In addition, proper backwashing is a crucial step to collecting the most representative and meaningful post-start up data on compounds of interest, such as metals listed in the NSF/ANSI 61 standard.

Below are the recommended steps for proper conditioning and backwashing of GAC based on Filtrasorb 400 GAC being backwashed at 55°F:

1. Fully submerge GAC bed in clean, contaminant free water for at least 16 hours (overnight)
2. Open backwash inlet and begin up-flow at 3 gpm/ft^2 for 2 minutes
3. Increase flow to 5 gpm/ft^2 and maintain for 2 minutes
4. Increase flow to 7 gpm/ft^2 and maintain for 2 minutes
5. Increase flow to 8.5 gpm/ft^2 and maintain for 30 minutes*
6. Decrease flow to 7 gpm/ft^2 and maintain for 2 minutes
7. Decrease flow to 5 gpm/ft^2 and maintain for 2 minutes
8. Decrease flow to 3 gpm/ft^2 and maintain for 2 minutes
9. Close backwash inlet and stop flow

*Duration representative of initial backwash conditions. Required duration during operational backwashes can be shorter but will vary by utility, solids load, and GAC throughput. Contact Calgon Carbon for more information"

Design Considerations

FILTRASORB 400 activated carbon is typically applied in down-flow packed-bed operations using either pressure or gravity systems. Design considerations for a treatment system is based on the user's operating conditions, the treatment objectives desired, and the chemical nature of the compound(s) being adsorbed.

Safety Message

Wet activated carbon can deplete oxygen from air in enclosed spaces. If use in an enclosed space is required, procedures for work in an oxygen deficient environment should be followed.

Water Technologies & Solutions
fact sheet

ZeeWeed* 1500 Junior

Pressurized Ultrafiltration Model

Description and Use

SUEZ leverages decades of research, development and operational experience to develop one of the most advanced pressurized ultrafiltration membranes on the market, the ZeeWeed 1500.

Versatile and reliable, the ZeeWeed 1500 PVDF chemistry and outside/in flow path makes it ideally suited for turbid, chemically demanding applications in water and wastewater treatment.

Typical Applications

The ZeeWeed 1500 Junior (right) is an economical membrane module for small flows that is perfect for:

- Testing membrane compatibility with a water & wastewater stream with minimal investment.
- Running multiple lab or field experiments in parallel.
- Testing compatibility and suitability of a chemical or cleaning process on an existing membrane application.

General Properties

- 0.02 μm nominal pore diameter – for optimal rejection of suspended particles
- PVDF hollow fiber membrane - provides high mechanical strength and chemical resistance
- Outside-in filtration - provides uniform flow distribution and high solids tolerance
- Transparent shell - allows you to see the membrane while it's operating.

Storage and Handling

Modules must be stored between 5°C and 35°C (41°F to 95°F). Do not expose the membrane module to sources of heat, ignition, or direct sunlight (UV light).

Find a contact near you by visiting www.suezwatertechnologies.com and clicking on "Contact Us."

*Trademark of SUEZ; may be registered in one or more countries.

FSufZW1500_Junior_EN.docx Aug-21

Product Specifications

Model	ZeeWeed 1500 Junior
Nominal membrane surface area	1 m^2 (10 ft^2)
Weight	5 kg (10 lb)
Membrane material	PVDF
Nominal pore size	0.02 micron
Flow path	Outside-In
Housing material	Clear PVC housing with grey PVC tie-points
SUEZ Part Number	3172218

Module Dimensions & Connections	
Height	908 mm (35.7 in)
Diameter	50.8 mm (2")
Feed & Permeate	½" FNPT
Reject	¾" FNPT
System Integration	Bench top test apparatus

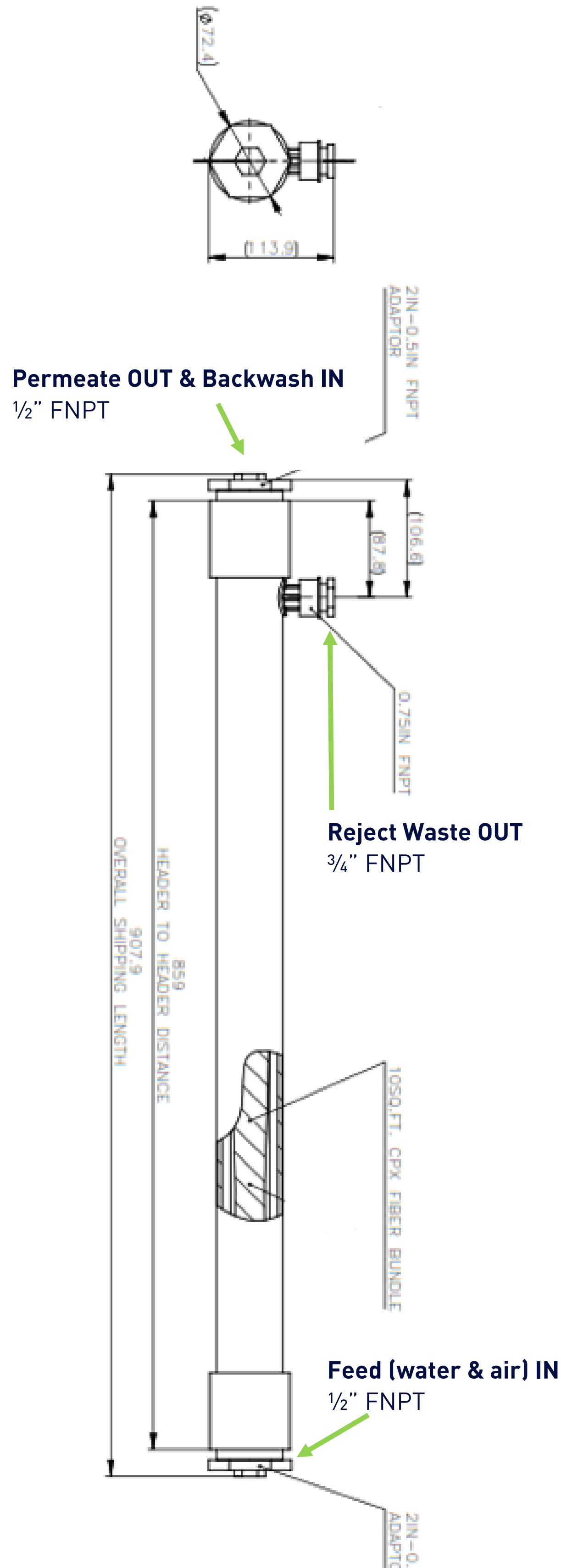


Figure 1 – ZeeWeed 1500 Junior
All dimensions in mm

Operating Parameters

Performance	
Flow range	0.4– 3.0 m^3/day (0.1 – 0.5 gpm)
Operating conditions	
Max shell inlet pressure	379 kPa (55 psi)
TMP range	0 - 276 kPa (0 - 40 psi)
Max temperature	40°C (104°F)
Operating pH	5.0 - 10.0
Backwash Frequency	Every ~30 min
Air scour flow	280 L/h (10 cfh)
Backwash flow	35 L/h (0.2 gpm)
Cleaning	
Cleaning pH range	2.0 - 12.0
Chlorine concentration	1,000 mg/L (as NaOCl)[1]

[1] Higher concentrations are possible depending on feedwater and pH.

Contact SUEZ for a sample Process Flow Diagram (schematic) if required.

Start-Up Procedure

The following procedure is required to prepare a new ZeeWeed 1500 Junior module prior to use. This procedure only needs to be conducted once for the life of the module.

This procedure is written for a single module. Volumes and flow rates can be scaled linearly with the number of modules being prepared.

Step 1 – install the module

Ensure that the feed, reject and permeate connections (Figure 1) are all completed.

Step 2 – prepare the activation solution

Wear appropriate personal protective equipment for the handling of sodium hypochlorite, such as chemical resistant gloves and safety glasses at a minimum.

> **WARNING**: Sodium Hypochlorite is corrosive chemical and an irritant if fumes are inhaled. Always handle in a well-ventilated area.

Prepare a 2000 mg/L (2000 ppm) solution of sodium hypochlorite in a suitable container at a temperature of 35°C to 40°C.

Ensure enough solution is prepared to fill the module and all associated tubing (approx. 3L for a single module set-up).

Step 3 – prepare the flow path to fill the module

Open any valves that allow the solution to enter the module via the feed (bottom) connection.

Open any valves that allow the solution to exit the module via the permeate (top) connection.

Open any valves that to allow the solution to exit the module via the reject (side) connection.

Direct all permeate and reject back to the feed tank to recirculate the hypochlorite solution.

Step 4 – fill the module.

Start the pump and begin the transfer of the hypochlorite solution prepared in step 2 from feed to reject and permeate of the module. Divert the cleaning solution back to the source container. Recommended flow rate for this activity is 35 L/h.

Continue the solution flow until the module is full of hypochlorite solution and the flow is leaving the reject port.

Close the reject (side connection) valve to direct all flow to the permeate.

Step 5 – recirculate solution and soak

Recirculate for 10 minutes.

After 10 minutes, turn off the feed pump and close all valve to isolate the module.

Allow the membrane to soak in the solution for 5 hours. Insulate the module to keep at 35°C to 40°C.

It is optional to recirculate solution for a few minutes every hour.

Step 6 – drain and rinse

Open all valves and pour the solution into a suitable container for disposal.

Using clean water, rinse the module housing and associated tubing by pumping 6 L of clean water into the feed port and exiting the reject and permeate ports. Repeat up to three times, if needed.

AK series

low energy brackish water RO elements

Water Technologies & Solutions
fact sheet

The A-Series, family of proprietary thin-film reverse osmosis membrane elements are characterized by high flux and high sodium chloride rejection. AK Low Pressure Brackish Water Elements are selected when high rejection and low operating pressures are desired. These elements allow significant energy savings since good rejection is achieved at operating pressures as low as 100 psi (689 kPa).

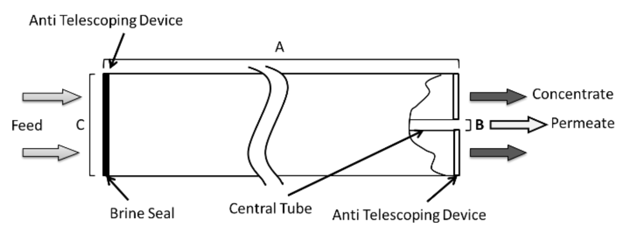
Table 1: Element Specification

Membrane	A-series, thin-film membrane (TFM*)

Model	Average permeate flow gpd (m³/day)(1)(2)	Average NaCl rejection(1)(2)	Minimum NaCl rejection(1)(2)
AK2540TM	750 (2.8)	99.0%	98.0%
AK4040C	2,300 (8.7)	99.0%	98.0%
AK4040FM	2,200 (8.3)	99.0%	98.0%
AK4040TM	2,200 (8.3)	99.0%	98.0%
AK8040C	10,000 (37.9)	99.0%	98.0%
AK8040F	10,000 (37.9)	99.0%	98.0%
AK8040F 400	11,000 (41.6)	99.0%	98.0%

(1) Average salt rejection after 24 hours operation. Individual flow rate may vary ±20%.
(2) Testing conditions: 500ppm NaCl solution at 115psi (793kPa) operating pressure, 77°F (25°C), pH7.5 and 15% recovery.

Model	Membrane area ft² (m²)	Outer wrap	Part Number
AK2540TM	27 (2.5)	Tape	1206802
AK4040C	90 (8.4)	Cage	1223696
AK4040FM	85 (7.9)	Fiberglass	3039082
AK4040TM	85 (7.9)	Tape	3039149
AK8040C	380 (35.3)	Cage	1206819
AK8040F	365 (33.9)	Fiberglass	3039160
AK8040F 400	400 (37.2)	Fiberglass	3039161



Note: **4040C elements do not feature brine seal.

Figure 1 : Element Dimensions Diagram – Female

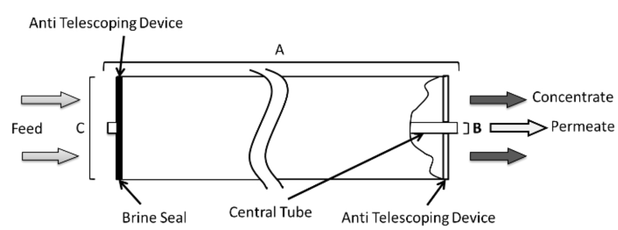


Figure 2: Element Dimensions Diagram – Male

Table 2: Dimensions and Weight

Model	Type	Dimensions, inches (cm) A	B	C	Boxed Weight lbs. (kg)
AK2540*	Male	40.0 (101.6)	0.75 (1.9)	2.4 (6.1)	5 (2.3)
AK4040C	Female	40.0 (101.6) (1)	0.625 (1.59)	3.9 (9.9)	9 (4)
AK4040FM	Male	40.0 (101.6)	0.75 (1.9)	3.9 (9.9)	9 (4)
AK4040TM	Male	40.0 (101.6)	0.75 (1.9)	3.9 (9.9)	9 (4)
AK8040*	Female	40.0 (101.6)	1.125 (2.86)	7.9 (20.1)	35 (16)

(1) Includes interconnector, refer to Technical Bulletin TB1206.

Table 3: Operating and CIP parameters

Typical Operating Pressure	100 psi (689 kPa)
Typical Operating Flux	10-20 GFD (15-35LMH)
Maximum Operating Pressure	600 psi (4,136 kPa)
Maximum Temperature	Continuous operation: 122°F (50°C), Clean In Place (CIP): 122°F (50°C)
pH Range	Optimum rejection: 7.0-7.5, Continuous operation: 2.0-11.0, Clean In Place (CIP): 1.0-13.0(1)
Maximum Pressure Drop	Over an element: 12 psi (83 kPa) Per housing: 50 psi (345 kPa)
Chlorine Tolerance	1,000+ ppm x hours, dechlorination recommended
Feedwater	NTU < 1 SDI_{15} < 5

(1) Refer to Cleaning Guidelines Technical Bulletin TB1194.

Water Technologies & Solutions
technical bulletin

cleaning guidelines

cleaning pure water membrane elements

These guidelines address when to clean and what cleaners or sanitizers to use for each type of SUEZ membrane element. The guidelines are based on technical information, which SUEZ believes to be accurate and reliable. They are intended for persons with technical skill to use at their own discretion and risk. Because of the conditions of use are outside our control, SUEZ does not assume liability for results obtained or damages incurred through the application of the cleaning solutions or procedures suggested.

When selecting a cleaner or sanitizer, several things must be considered, including the foulant to be removed, membrane element compatibility, and membrane type. Cleaning solutions must fall within pH ranges specified for the membrane element. In addition, the cleaner must not contain certain chemical substances incompatible with the membrane element, such as certain surface-active agents and, in some instances, oxidizing agents such as chlorine. Use of cleaning solutions other than those known to be compatible may reduce membrane life and void the SUEZ membrane element warranty.

why to clean

During the operation of a membrane separation system, the incoming water frequently brings suspended solids and organic materials to the membrane surface. The suspended solids might get stuck on the membrane surface, helped by the feed channel spacer that is in contact with the membrane. Dissolved organics might be adsorbed by the membrane, both on the outer surface and on the membrane pore walls. Dissolved species are concentrated in the elements, and it is possible that they reach saturation conditions and precipitate to form a scale on the membrane. Besides, microbes might settle down on the membrane surface and build a biofilm, which becomes thicker the higher the nutrients concentrations are in the feed solution.

The deposits including the precipitates, adsorbed organics and the biofilm are all called foulants, and they all impede the flow of water through the membrane. This can result in unacceptably low permeate flow rate, high operating pressure, and an excessive pressure drop in the system, which may lead to irreversible element damage. The foulants also increase the amount of dissolved material passing through the membrane, resulting in product water of unacceptable quality.

All foulants must be removed through a clean in place (CIP) process before irreversible membrane damage occurs. It is, however, much easier to remove foulants in the beginning of the fouling process than when a thick fouling layer has been formed, so a CIP should be performed when there are strong indications that the fouling process has started.

There are exceptions, for example many wastewater applications, where membrane fouling starts upon start of operation, and in such cases, the suitable cleaning frequency has to be determined case by case.

when to clean

Membrane elements should be cleaned if either of the following conditions occurs:

1. Normalized permeate flow drops 15% or greater after the initial flow stabilization.

   Note - In many cases, the operator may expect some irreversible loss of permeate flow due to system stabilization during the first 100 hours of initial use. This loss is usually normal flow loss and does not necessarily indicate a need for cleaning. However, the amount of lost flow should be carefully monitored in case it is the result of an RO pretreatment system malfunction or the existence of conditions not anticipated during system design.

2. Salt passage increases by 30 - 40%.

   Note - Abrupt and significant changes in permeate flow or salt passage can also be attributed to other factors, such as defective O-rings or flow by-pass around element brine seals.

3. An Increase in normalized pressure drop (ΔP) of 25% or greater.

   Membrane element ΔP increases when foulants or precipitates plug the feed spacers between the membranes in spiral-wound membrane elements. When the ΔP has increased markedly, a considerable amount of contaminants/sediment already has built up in the membrane element, so cleaning is required.

If element is too badly fouled, it is difficult to restore the membrane element's performance.

A spreadsheet for RO unit performance normalization is available upon request. Please contact your SUEZ representative.

recommended cleaner recirculation and soaking times

Most cleaning solutions should be circulated for 10-30 minutes, followed by a 10 to 30-minute soaking period and then a final 10-minute recirculation prior to discharging it. Chemical addition may be required during the recirculation to maintain the desired pH. The spent cleaning solution should be thoroughly flushed with RO quality water to drain or holding tank. Please refer to *Table 2* for recommended cleaning solutions.

Note - Enzyme cleaners require longer residence times to allow for complete reaction with the contaminate. Detergents containing enzymes should be allowed to recirculate and soak for at least 1-2 hours before flushing.

When contaminant removal is difficult, longer circulation and possibly additional soaking times may be useful. An additional cleaning cycle with fresh cleaning solution is usually more effective. A foulant may be composed of different types of materials, making different cleaners and/or multiple cleaning cycles necessary to increase cleaning effectiveness.

The circulation flow during cleaning should be in the same direction as during normal system operation. *Do not reverse flush from permeate manifolding through membrane element as damage will occur*.

cleaning solutions temperatures

The circulation of a heated cleaning solution through the membrane elements often proves advantageous because higher temperatures increase chemical reaction rates. Warm solutions often strip scale and/or contaminants faster than ambient temperature solutions. However, cleaning solution temperatures should be kept under the limits specified for each membrane element model. The operator risks damaging the membrane element if cleaning solution temperature goes above its maximum recommended cleaning temperature.

safety precautions

When using any cleaning chemical, follow accepted safety practices. Read the labels on cleaning chemical container and refer to the system operating manual. If in doubt about handling, safety or disposal procedures, contact the cleaning chemical supplier for detailed information before proceeding to prepare or use the products. Several cleaners contain surfactants. This may cause foaming during the CIP. It is recommended to have anti-foam on site. Consult with SUEZ Membrane Chemical specialist for further recommendations.

cleaning solution preparation

All solid cleaning chemicals should be fully dissolved and well mixed before the cleaning solution is introduced into the system. Use RO quality water or filtered, low hardness water (less than one grain per gallon or 17 mg/L as $CaCO_3$ of hardness to prepare cleaning solutions. Reuse of cleaning solutions is not recommended. Some cleaners have limited shelf life so check the age of cleaners before using them.

suggested cleaning equipment

A cleaning solution mixing tank with a cover and a temperature gauge is suggested. Appropriate valving, sample ports, flow meters, pH monitor, pressure gauges, recirculation pump and cartridge filter are also recommended. When selecting cleaning system equipment, the material of construction of the system's components should be chemically and physically compatible with the cleaners and temperatures to be used. A cartridge filter on the cleaning solution return-to-tank or feed line to the crossflow filtration machine will remove particles dislodged from the membrane elements.

amount of cleaning solution needed

To determine the amount of cleaning solution required, estimate the hold-up volume of the cleaning loop piping and membrane element housings. Then add sufficient water to the CIP tank to prevent it from emptying when filling the system. At the beginning of the cleaning cycle, the process water in the system should be discharged to drain as it is displaced by the cleaning solution. This process will prevent dilution of the cleaning solution.

To estimate the CIP tank recirculation dimension, calculate the hold-up volume of the system and then multiply it by 2. For the hold-up volume in the element housings, use the following estimate provided the housings are filled with maximum number of elements.

- 20 liters for every 8in element (5 gal/element)
- 4 liters for every 4in element (1 gal/element)

CIP protocol

In most cases, clean with a low pH cleaner first, except in cases where silica scale, sulfate scale or oil/grease fouling is suspected. Colloidal fouling can be covered by slow forming scale. It must be removed by a low pH cleaner first to uncover the silt and therefore make it available to be removed by a high pH cleaner.

The following general cleaning procedure can be followed. For the optimum cleaning procedure for your system, contact SUEZ representative.

1. Inspect cleaning tank, hoses, and cartridge filters. Clean tank and flush hoses if necessary. Install new cartridge filters. Use a 5-micron or tighter rating filter on the cleaning system.
2. Fill cleaning tank with RO permeate or DI water. Turn on agitator or tank recirculation pump.
3. Slowly add cleaner to cleaning tank and allow mixing thoroughly.
4. Check solution temperature. If solution temperature is lower than recommended level, adjust heating control to provide optimum temperature. If manufacturer's recommendation is not available, contact SUEZ representative. If a heater is not available, recirculate cleaning solution by using the membrane system's high-pressure pump. This may help to reach higher temperature.
5. Check solution pH. Allowable pH ranges are given in *Table 4*. If pH is too low, adjust pH upward with NaOH, or other chemical as recommended by the membrane manufacturer. If pH is too high, adjust with hydrochloric acid.
6. Circulate solution through one stage at a time in the direction of feed flow for 10 - 30 minutes. Recommended maximum recirculation flow rates are given in *Table 1*. To ensure that this maximum flow is not outside the limits, it is strongly advisable not to exceed 0.7 bar of pressure drop per element and 3 bar per pressure vessel. A too high flow, indeed, induces foam building that can make rinsing fastidious.

table 1: Recommended maximum cleaning flows

Size	Fiberglass or Tape m^3/hr (gpm)	Full-Fit or Net m^3/hr (gpm)
2.5"	1.2 (5.3)	1.8 (7.9)
4"	3 (13.2)	4.5 (19.8)
8"	12 (52.8)	18 (79.3)

Do not exceed 0.7 bar of pressure drop per element

7. Pressure should be low enough so that minimal permeate is produced during cleaning, but always less than 60 psig (4.2 bar); 2.5 - 4 bar for the reverse osmosis membranes and 1.5 - 2.5 for the other membrane types (nanofiltration, ultrafiltration and microfiltration). Higher pressure will cause increased permeation and hold foulant to the surface of the membrane. In cases of heavy fouling, the first return flow (up to 15% of the cleaning tank volume) should be diverted to drain to prevent redeposition of removed solids. For optimum results, each stage must be cleaned separately in a multistage system.
8. Soak the membrane during 25 min. This enhances cleaner efficiency.
9. If the first stage cleaning solution becomes turbid or discolored, dump the tank and prepare a fresh cleaning solution before proceeding. If solution pH or temperature moves out of the recommended range, a new solution should be prepared. In any event, a new cleaning solution should be prepared for each stage.
10. Rinse with RO permeate before returning system to service.
11. When returning unit to service, divert product water to drain until any residual cleaning solution has been rinsed from system.

If a second cleaning is necessary, always rinse your system up to get neutral pH in both permeate and concentrate. Redo the same procedure.

table 2: Recommended cleaning solutions - Example product selection

Foulant	A, D, G, H & S-series	P-series	C-series
Mineral scale and metal precipitates	• Kleen* MCT103 at 2-4 % • Kleen MCT882 at 2-10% • MemChem* MCT201 at 2-4%	• Kleen MCT103 at 2-4 % • Kleen MCT882 at 2-10% • MemChem MCT201 at 2-4%	• Kleen MCT103 at 2-4 % • Kleen MCT882 at 2-10% • MemChem MCT201 at 2% • Kleen MCT403 at 2-4% Adjust to pH 3 with NH_4OH if needed
Organics, silt, bacterial slime	• Kleen MCT 515 at 2-4 % [1] • Kleen MCT 404 surfactant at 0.1-0.2%, • Kleen MCT411 or MCT400 at 1-3% • Kleen MCT524 as high pH at 0.2-0.5% Products are buffered but if needed pH adjustment either sodium hydroxide or hydrochloric acid can be used	• Kleen MCT 515 at 2-4 % [1] • Kleen MCT 404 surfactant at 0.1-0.2% • Kleen MCT411 or MCT400 at 1-3% • Kleen MCT524 as high pH at 0.2-0.5% Products are buffered but if needed pH adjustment either sodium hydroxide or hydrochloric acid can be used	• Kleen ENV907 at 1-3% • Kleen MCT404 at 0.1-0.2% Adjust to pH 8.0 with HCl if needed Frequent cleaning will cause premature hydrolyzing of the membrane.

[1] Use Kleen MCT515E in Europe

table 3: Recommended sanitizing solutions - Example product selection

A, D, G, H & S-series	P-series	C-series
• BetzDearborn* DCL30 or BetzDearborn DCL32 at 0.1% • BioMate* MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100–200 ppm [2] • Chlorine dioxide at 30 ppm only pure not having chlorine by-products • Peracetic acid: ask SUEZ representative	• BetzDearborn DCL30 or BetzDearborn DCL32 at 0.1% • BioMate MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100-200 ppm [2] • Hydrogen peroxide at 5-10% • Chlorine at 5-10 ppm	• BetzDearborn DCL30 or BetzDearborn DCL32 at 0.1% • BioMate MBC781 at 200-400 ppm • BioMate MBC2881 at 100-200 ppm • BioMate MBC2881E at 100-200 ppm [2] • Chlorine at 30 ppm for 30 minutes

[2] NSF/ANSI Standard 60 Approved. This product is designed to be used off-line and flushed out prior to using the system for drinking water.

table 4: pH range during a 30-min cleaning - Refer to the element product fact sheet for further data

Element type	Max temp > 50°C (122°F)	50°C > Temp > 35°C	35°C > Temp > 20°C	Max Temp < 20°C
AC, AD, AE	Contact SUEZ for assistance	1.0-12.0	1.0 – 12.0	1.0 – 12.0
AG, AK, AP, MUNI RO, Industrial RO5 & RO6 **J-Series, P-Series, BEV UF**	Contact SUEZ for assistance	1.0 – 10.5	1.0 – 12.0	1.0 - 13.0
S-Series, DuraSlick* RO, Industrial RO3	Contact SUEZ for assistance	1.0 - 10.5	1.0 – 11.0	1.0 – 11.5
D-Series, DuraSlick NF, Industrial NF1 **H-Series, MUNI NF**	Contact SUEZ for assistance	3.0 – 10.0	2.0 – 11.0	2.0 – 11.0
C-Series, BEV RO CA, BEV NF	Contact SUEZ for assistance	Not allowed	4.0 – 6.0	3.0 - 8.0
G-Series	Contact SUEZ for assistance	2.0 – 11.0	1.0 – 12.0	1.0 – 13.0
M-Series	Contact SUEZ for assistance	3.0 - 10.0	2.0 – 11.0	2.0 – 11.0

table 5: Chlorine tolerances - Refer to the element product fact sheet for further data

Element type	Chlorine tolerance
A-series, MUNI RO, Industrial RO5 & RO6	< 1000 ppm x hours, dechlorination recommended
H-Series, MUNI NF	< 1000 ppm x hours, dechlorination recommended
C-Series, BEV RO CA, BEV NF	1ppm maximum continuous 30ppm for 30 min. during sanitization
D-Series, DuraSlick NF, Industrial NF1	500 ppm x hours, dechlorination recommended
G-series	20-50 ppm x days
M-series	8,000 ppm x days
J-Series, P-series, BEV UF	5,000+ ppm x days
S-Series, DuraSlick RO, Industrial RO3	500 ppm x hours, dechlorination recommended

Water Technologies & Solutions
fact sheet

Hypersperse* MDC775

antiscalant/antifoulant

- Effectively controls scales including calcium carbonate, calcium sulfate, barium sulfate, and strontium sulfate
- Maintains cleaner membrane surfaces by dispersing particulate foulants
- Effective over a wide pH range
- May be fed neat or diluted
- Coagulant compatible and can be used with any SoliSep* MPT series product

description and use

Hypersperse MDC775 is a highly effective liquid antiscalant/antifoulant developed to control scale precipitates and reduce particulate fouling within membrane separation systems.

This superior product has the ability to treat $CaCO_3$ at very low dosages and improve operating limits for calcium phosphate scale, resulting in reduced operating and capital costs. Use in industrial applications shows excellent results in membrane separation processes including reverse osmosis, nanofiltration and electrodialysis reversal (EDR).

application

For maximum effectiveness, Hypersperse MDC775 should be added upstream of the static mixer or cartridge filter housing.

dosing

Typical dosage range is between 2 and 6 mg/L. To determine the adequate dose rate for a certain system it is recommended to use the Argo Analyzer* 4.0 simulation software. It will provide the best application dosage linked to the specific water chemistry and system design.

Please contact your SUEZ sales representative for details at www.suezwatertechnologies.com.

Please contact your local SUEZ representative to define the optimal feed point and dosage rate.

Dilution Guidelines: On-site dilution of Hypersperse MDC775 is possible; however, product dilution to concentrations below 10% is generally not recommended. When diluting, use high quality water such as permeate or deionized water. When feeding diluted product, examine the make-down tank for evidence of microbiological (MB) growth. If MB growth is observed, sanitize the tank and reduce the batch size. For best results, Hypersperse MDC775 should be fed neat.

Maximum Dilutions: Maximum dilution is temperature related as shown below.

Temperature	Maximum Dilution, %
<30°C (86°F)	10
30-35°C (86-95°F)	25
>35°C (95°F)	50

packaging and storage information

Hypersperse MDC775 is a liquid material, available in a wide variety of customized containers and delivery methods. Protect from freezing. Contact your SUEZ sales representative for details.

safety precautions

A Material Safety Data Sheet containing detailed information about this product is available on request.

Kleen* MCT113

membrane cleaner for inorganics

description and use

Kleen MCT113 is a unique and superior low pH liquid formulation designed specifically to remove Fe, Al, Mn metal hydroxides, calcium carbonate, and calcium phosphate other similar scales from reverse osmosis (RO), nanofiltration (NF) and ultrafiltration (UF) membranes. This highly effective product provides superior cleaning resulting in longer system running time.

Kleen MCT113 offers the following features:

- Suitable for use with all thin film composite or cellulose acetate membranes.
- Buffered to maintain a pH of 3.0 ± 0.5 over a range of dilutions.
- Best use concentration is at 2% solution strength
- Liquid cleaner, which allows shorter mixing time.
- No adverse effects with repeated use.
- Non-foaming formulation.

typical applications

Kleen MCT113 should be used in combination with high pH cleaning step products for example, MCT515(liquid) or Kleen MCT411(Powder) for optimum results.

treatment and feeding requirements

Dilution

The typical dilution ratio for Kleen MCT113 is in the range of 1-3% in proportion to the total volume of the cleaning system inclusive of:

- Cleaning tank and all interconnecting pipe work
- Filtration and membrane pressure vessels and membrane elements.

Table 1 represents the relationship between Kleen MCT113 % concentration, pH and conductivity. Please notes these are guidelines and may slightly differ when made down at the site due to product mixing, water source used in the CIP make down process.

Table 1

Conc (%)	pH	Conductivity	Units
1	2.98	1088	µS
2	2.93	1837	µS
3	2.91	2435	µS
4	2.89	3084	µS
Neat	2.52	27.62	mS

Cleaning Instructions

Specific instructions are described in the use instructions for membrane cleaning below.

Use Instructions for Membrane Cleaning

1. Inspect cleaning tank, hoses, and cartridge filters. Clean tank and flush hoses as necessary and install new filter elements if required.
2. Fill cleaning tank with RO permeate or deionised water.
3. Slowly add the calculated quantity of Kleen MCT113 to the cleaning tank and mix thoroughly by recirculating the solution through the cleaning pump.
4. Check cleaning solution temperature and pH and adjust as necessary to provide the optimum cleaning temperature and pH (2.5 – 3.5). Do not exceed membrane manufacturers specifications.

5. Circulate the cleaning solution through each membrane array in the feed direction for 30 minutes. Circulate at the flow rate recommended by the membrane or system manufacture. If the manufacturers recommendations are not available, reference table 2 as guidelines. Pressure should be maintained low enough (less than 60psig, 4.2 bars) not to produce any permeate during the cleaning process.
6. In cases of heavy fouling, the first return flow to the tank (up to 15% of the cleaning tank volume) should be diverted to drain to prevent re-deposition of removed solids. For optimum results, each array must be cleaned separately in a multi array system.
7. If solution becomes turbid, discolored from removed material, or the pH moves outside the range recommended by for cleaning, then dump the cleaning tank and prepare a fresh batch of cleaning solution as indicated in sections 2 – 4 above, before cleaning additional passes.
8. Using RO permeate (if possible), rinse thoroughly, before returning the system to service. Ensure that the brine flush water exhibits the same characteristics as the feed flush water, e.g. temperature, pH and conductivity. When feed and brine water characteristics are equal or very close, the cleaning solution will have been displaced from the elements.

packaging information

Kleen MCT113 is supplied as a liquid and is available in a wide variety of customized containers and delivery methods. Standard pack types include pails (5 gallons), drums, custom bulk and non-returnable totes among other container types available in each region.

storage and handling

Precautions should be taken to prevent the liquid from freezing as it may crystalize. Product integrity may be restored by slowly warming and then agitating.

safety precautions

A Safety Data Sheet containing detailed information about this product is available on request.

Table 2

Membrane Type	Membrane Diameter	Recommended Flow Rate Per Vessel lpm (US gpm)
Spiral Wound	4"	38 (10)
Spiral Wound	6"	87 (23)
Spiral Wound	8"	151 (40)
Hollow Fiber	4"	Per manufacture specs.
Hollow Fiber	8"	Per manufacture specs
Hollow Fiber	10"	Per manufacture specs

Water Technologies & Solutions
fact sheet

Kleen* MCT515

liquid alkaline membrane cleaner

- Cost effective membrane cleaner
- Specially formulated to provide superior cleaning of organics, biofilm, colloidal and iron materials from membrane surfaces
- Buffered to maintain desired pH over a range of dilutions.
- Enhanced performance at elevated temperatures.
- For use on PA membrane elements. Do not use on CA membranes.

description and use

Kleen MCT515 is a proprietary buffered alkaline liquid cleaner formulation containing detergent surface active agents with wetting and emulsifying activities. It is recommended for use in removing organic foulants such as oils and bioproteins from membrane elements. This highly effective product provides superior cleanings, resulting in longer system running times.

typical applications

During the operation of a membrane separation system, organic materials and suspended solids in the incoming water can accumulate on the membrane surface. Fouling from these species impedes the flow of water through the membrane. This can result in unacceptably low production, high operating pressure, or an excessive pressure drop in the system, which may lead to irreversible membrane damage. Additionally, the accumulation of deposit next to the membrane surface can increase the amount of dissolved material passing through the membrane, resulting in product water of unacceptable quality.

Before the deposit accumulates to a level where permeate water flow or quality declines, or membrane damage occurs, it should be removed through a clean-in-place (CIP) off-line cleaning. Indications of the need for cleaning include a significant decrease in normalized permeate flow, a significant increase in pressure drop across the system (or individual stage), or an increase in the normalized salt passage such that product quality is unacceptable. Your SUEZ representative can assist you with monitoring your system and determining when cleaning is advised.

treatment and feeding requirements

Do not use on CA membranes.

Feed System - This product should be used in conjunction with membrane cleaning equipment supplied by the manufacturer of the membrane/ RO system. If such a system is not present, contact your SUEZ representative for information on fabricating or obtaining a cleaning system.

Dilution - The product must be diluted prior to introduction into the membrane system. The recommended dilution for this product is one pound (0.45 kg) of Kleen MCT515 per 5 gallons (19 L) of water [approximately one gallon (3.8 L) of Kleen MCT515 for each 50 gallons (189 L) of water].

The target conductivity range for this dilution of Kleen MCT515 is based on the % product strength as shown in the following table:

Concentration %	pH	Conductivity (µS)
0.5	11.34	2,032
1	11.51	3,590
1.5	11.62	5,063
2	11.70	6,549
2.5	11.75	7,974
3	11.79	9,327

general cleaning instructions

The following general cleaning procedure can be followed. For the optimum cleaning procedure for your system, contact your SUEZ representative.

1. Inspect cleaning tank, hoses, and cartridge filters. Clean tank and flush hoses if necessary. Install new cartridge filters.
2. Fill cleaning tank with RO permeate or DI water. Turn on agitator or tank recirculation pump.
3. Slowly add the recommended amount of Kleen MCT515 to the cleaning tank and allow to mix thoroughly.
4. Check solution temperature. If solution temperature is lower than recommended level, adjust heating control to provide optimum temperature. If manufacturer's recommendation is not available, contact your SUEZ representative. Do not allow the temperature to exceed 104°F (40°C).
5. Check solution pH. The solution pH should be 11.0 to 12.0, or as recommended by the membrane manufacturer. If pH is too low, adjust pH upward with NaOH, or other chemical as recommended by the membrane manufacturer. If pH is too high, adjust with hydrochloric acid.
6. Circulate solution in the direction of feed flow for 30 minutes. Circulate at the flow rate recommended by the membrane or system manufacturer. If manufacturer's recommendation is not available, contact your SUEZ representative. Pressure should be low enough so that minimal permeate is produced during cleaning, but always less than 60 psig (4.2 kg/cm^2). In cases of heavy fouling, the first return flow (up to 15% of the cleaning tank volume) should be diverted to drain to prevent redeposition of removed solids. For optimum results, each stage must be cleaned separately in a multistage system.
7. This product is a moderate foamer. Minimize foaming in the CIP tank by placing the permeate and concentrate return lines under the liquid level in the CIP tank. A spray-hose may be used for periodic knocking-down of the foam. DO NOT apply an antifoam; most antifoams are not compatible with PA membranes.
8. If the first stage cleaning solution becomes turbid or discolored, dump the tank and prepare a fresh cleaning solution before proceeding. If solution pH or temperature moves out of the recommended range, a new solution should be prepared.
9. Rinse with RO permeate water before returning system to service.
10. When returning the unit to service, divert product water to drain until any residual cleaning solution has been rinsed from system. Depending on the nature of the fouling, a soak period may be necessary for optimum results.

storage and handling

Corrosion-resistant materials should be used for the storage and handling of this product. Discuss recommended materials of construction with your SUEZ representative.

safety precautions

A Material Safety Data Sheet containing detailed information about this product is available on request.

Corporate Office
2381 Rosegate
Roseville, Minnesota 55113
Phone: (612) 331-6910
Fax: (612) 331-5304

PRODUCT DATA SHEET

Sodium Hydroxide 50%
Diaphragm Grade

PDS – 1066; REVISION 06

EFFECTIVE DATE: 30 AUG 18

General Characteristics:

Appearance:	Clear, colorless solution
Synonyms:	Caustic soda
Chemical Formula:	NaOH
Molecular Weight:	40.00
CAS#:	1310-73-2
Shelf Life:	730 days
Storage Recommendations:	65 – 95° F

Standard Specifications:

COMPONENT	SPECIFICATION
Sodium Hydroxide (as NaOH), wt.%	48.50 – 51.5
Sodium Oxide (as Na_2O), wt.%	38.00 – 39.63
Sodium Carbonate (as Na_2CO_3), wt.%	$\leq$ 0.2
Sodium Chloride (as NaCl), wt.%	$\leq$ 1.1
Sodium Chlorate (as $NaClO_3$), wt.%	$\leq$ 0.35
Sodium Sulfate (as Na_2SO_4), wt.%	$\leq$ 0.075
Iron (as Fe), ppm	$\leq$ 9
Arsenic (as As), ppm	$\leq$ 3
Lead (as Pb), ppm	$\leq$ 2
Mercury (as Hg), ppm	$\leq$ 0.1
Identification (Sodium)	Passes Test

Meets the current edition requirements of the *Food Chemicals Codex*.

PHYSICAL PROPERTIES	
Specific Gravity, 60° F	1.521 – 1.540

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Roseville, Minnesota 55113
Phone: (612) 331-6910
Fax: (612) 331-5304

PRODUCT DATA SHEET

Sodium Hydroxide 50%
Diaphragm Grade

PDS – 1066; REVISION 06

EFFECTIVE DATE: 30 AUG 18

Additional Information:

Allergen Status: Product does not contain any of the known allergens including dairy, egg, wheat, soy, peanuts, tree nuts, fish, and shellfish.

Bioterrorism Act of 2002: All appropriate Hawkins, Inc. facilities are registered with the FDA per the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

Country of Origin: Product is manufactured in the United States.

GMO Status: Product does not contain genetically-modified organisms nor are genetically-modified organisms used in its manufacture.

GRAS Status: Product is considered "GRAS" (Generally Recognized as Safe) under FDA's Code of Federal Regulation (CFR) Title 21, Section §184.1763 for Sodium Hydroxide. Please reference FDA's CFR Title 21 for conditions of use.

Halal Status: Product is certified Halal.

Kosher Status: Product is certified Kosher-Pareve.

NSF Certification: Certified to NSF ANSI/Std. 60 with a maximum use level of 100 mg/L.

Nutritional Information (per 100 grams):

Calories (kcal)	0
Total Fat (g)	0
Saturated Fat (g)	0
Trans Fat (g)	0
Cholesterol (mg)	0
Sodium (mg)	28,750
Total Carbohydrate (g)	0
Dietary Fiber (g)	0
Total Sugars (g)	0
Added Sugars (g)	0
Protein (g)	0
Vitamin D (mcg)	0
Calcium (mg)	< 0.5
Iron (mg)	< 1
Potassium (mg)	< 10

Notice for Product Numbers: 13691, 13692, 13699, 13700, 13750, 13760, 13800, 13900, 14001, 14025, 37240, 54571, 813654, 813655, 813657, 813658, 813660, 55971, 56052 ("Product(s)")

Corporate Office
2381 Rosegate
Roseville, Minnesota 55113
Phone: (612) 331-6910
Fax: (612) 331-5304

PRODUCT DATA SHEET

Citric Acid 50%
Food Grade

PDS-1077; REVISION 06
EFFECTIVE DATE: 16 NOV 18

General Characteristics:

Appearance:	Clear, colorless to pale yellow liquid
Chemical Formula:	$C_6H_8O_7$
Molecular Weight:	192.13
CAS#:	77-92-9
Shelf Life:	365 days
Storage Recommendations:	55 - 95˚ F

Standard Specifications:

COMPONENT	SPECIFICATION
Assay, wt.%	49.0 – 51.0
Water	Balance

Raw materials used in manufacturing this product meet the current requirements of the *Food Chemicals Codex*.

PHYSICAL PROPERTIES	
Specific Gravity, 20° C	1.239 – 1.251

Additional Information:

Allergen Status: Product does not contain any of the known allergens including dairy, egg, wheat, soy, peanuts, tree nuts, fish and shellfish.

Bioterrorism Act of 2002: All appropriate Hawkins, Inc. facilities are registered with the FDA per the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

BSE/TSE Status: Product does not contain, nor is produced with any animal products or any material of animal origin, and does not contain BSE/TSE.

Country of Origin: Product is manufactured in the United States.

Gluten Status: Product is gluten-free.

GMO Status: Product is manufactured with materials that are derived from genetically modified crops but are highly refined. During the course of processing, any genetically modified DNA is denatured, degraded, or removed and cannot be detected in measurable amounts.

GRAS Status: Product is considered "GRAS" (Generally Recognized as Safe) under FDA's Code of Federal Regulation (CFR) Title 21, Section §184.1033 for Citric Acid. Please reference FDA's CFR Title 21 for conditions of use.

Corporate Office
2381 Rosegate
Roseville, Minnesota 55113
Phone: (612) 331-6910
Fax: (612) 331-5304

PRODUCT DATA SHEET

Citric Acid 50%
Food Grade

PDS-1077; REVISION 06
EFFECTIVE DATE: 16 NOV 18

Halal Status: Product is certified Halal.

Kosher Status: Product is certified Kosher-Pareve.

NSF Certification: Certified to NSF ANSI/Std. 60 with no maximum use level.

Nutritional Information (per 100 grams):

Calories (kcal)	**150**
Total Fat (g)	**0**
Saturated Fat (g)	**0**
Trans Fat (g)	**0**
Cholesterol (mg)	**0**
Sodium (mg)	**< 0.15**
Total Carbohydrate (g)	**0**
Dietary Fiber (g)	**0**
Total Sugars (g)	**0**
Added Sugars (g)	**0**
Protein (g)	**0**
Vitamin D (mcg)	**0**
Calcium (mg)	**< 0.1**
Iron (mg)	**< 0.005**
Potassium (mg)	**< 0.15**

Notice for Product Numbers: 900723, 900725, 900727, 900728, 900729, 900730, 900733, 35145, 39680, 44864, 45702, 58438 (“Product(s)”)

Corporate Office
2381 Rosegate
Roseville, Minnesota 55113
Phone: (612) 331-6910
Fax: (612) 331-5304

PRODUCT DATA SHEET

Sulfuric Acid 66º Baume
Smelter Grade

PDS – 1245; REVISION 09
EFFECTIVE DATE: 06 JAN 20

General Characteristics:

Appearance:	Clear, colorless to pale yellow solution
Odor:	Odorless
Synonyms:	Oil of Vitriol
Chemical Formula:	H_2SO_4
Molecular Weight:	98.08
CAS #:	7664-93-9
Shelf Life:	730 days
Storage Recommendation:	55 – 95º F

Standard Specifications:

COMPONENT	SPECIFICATION
Sulfuric Acid (H_2SO_4), wt.%	93.0 – 95.0
Sulfur Dioxide (as SO_2), ppm	$\leq$ 50
Iron (as Fe), ppm	$\leq$ 50
Mercury (as Hg), ppm	$\leq$ 2

Physical Properties:

COMPONENT	SPECIFICATION
Specific Gravity (60° F)	$\geq$ 1.8354

Additional Information:

Bioterrorism Act of 2002: All appropriate Hawkins, Inc. facilities are registered with the FDA per the Public Health Security and Bioterrorism Preparedness and Response Act of 2002.

NSF Certification: Certified to NSF ANSI/Std. 60 with a maximum use level of 50 mg/L.

Notice for Product Numbers: 32297, 51364, 54744 ("Product(s)")

Appendix B

Executed Sampling and Analysis Plan

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

KEY:

Enthaply Sample
3M Sample
Pace Sample
Field Sample
(H) = Hold
BC XX = Background chemistry sample, XX is sample designation in Table 4: Background Water Chemistry Data
PFAS XXX = PFAS sample, XXX is sample designation in Table 5: PFAS Data - NCCW

Flow Rate - RO Influent	mL/min	10,882
	gpd	4,140
	gpm	2.88
Flow Rate - RO Permeate	mL/min	9,463
	gpd	3,600
	gpm	2.50
Flow Rate - RO Reject	mL/min	1,419
	gpd	540
	gpm	0.38

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	15.0	15.0
Flow Rate	mL/min	154.0	154.0
Daily Flow Rate	gpd	58.6	58.6

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

NCCW_A

Start Date/Time: 7/30/21 10:15

Date	Day	Time	Date/Time	Daily Flows: RO Influent	RO Permeate	RO Reject	Cumulative Flows: RO Influent	RO Permeate	RO Reject	RO STREAMS: UF INFLUENT	UF EFFLUENT	RO PERMEATE	RO REJECT
				gal	gal	gal	gal	gal	gal				
7/11/2021	SUN												
7/12/2021	MON												
7/13/2021	TUE												
7/14/2021	WED			System Setup/Commissioning						System setup and commissioning			
7/15/2021	THU												
7/16/2021	FRI												
7/17/2021	SAT												
7/18/2021	SUN												
7/19/2021	MON												
7/20/2021	TUE												
7/21/2021	WED			UF/RO Initial Operations Only						UF/RO Initial Operations Only			
7/22/2021	THU												
7/23/2021	FRI												
7/24/2021	SAT												
7/25/2021	SUN												
7/26/2021	MON												
7/27/2021	TUE												
7/28/2021	WED												
7/29/2021	THU												
7/30/2021	FRI	10:15	7/30/21 10:15	690	600	90	690	600	90		PFAS 003	PFAS 010	PFAS 019
7/31/2021	SAT	12:00	7/31/21 12:00	4,442	3,862	579	5,132	4,462	669		PFAS (H)		
8/1/2021	SUN	12:00	8/1/21 12:00	4,140	3,600	540	9,272	8,062	1,209		PFAS (H)		
8/2/2021	MON	12:00	8/2/21 12:00	4,140	3,600	540	13,412	11,662	1,749	PFAS 001	PFAS 004	PFAS 011	PFAS 020
8/3/2021	TUE	12:00	8/3/21 12:00	4,140	3,600	540	17,552	15,262	2,289	BC 01	BC 03	BC 05	BC 07
8/4/2021	WED	12:00	8/4/21 12:00	4,140	3,600	540	21,692	18,862	2,829				PFAS 021
8/5/2021	THU	12:00	8/5/21 12:00	4,140	3,600	540	25,832	22,462	3,369				
8/6/2021	FRI	12:00	8/6/21 12:00	4,140	3,600	540	29,972	26,062	3,909		PFAS 005	PFAS 012	PFAS 022
8/7/2021	SAT	12:00	8/7/21 12:00	4,140	3,600	540	34,112	29,662	4,449		PFAS (H)		
8/8/2021	SUN	12:00	8/8/21 12:00	4,140	3,600	540	38,252	33,262	4,989		PFAS (H)		
8/9/2021	MON	12:00	8/9/21 12:00	4,140	3,600	540	42,392	36,862	5,529		PFAS 006	PFAS 013	PFAS 023
8/10/2021	TUE	12:00	8/10/21 12:00	4,140	3,600	540	46,532	40,462	6,069	BC 02	BC 04	BC 06	BC 08
8/11/2021	WED	12:00	8/11/21 12:00	4,140	3,600	540	50,672	44,062	6,609		PFAS 007	PFAS 014	PFAS 024
8/12/2021	THU	12:00	8/12/21 12:00	4,140	3,600	540	54,812	47,662	7,149		PFAS (H)		
8/13/2021	FRI	12:00	8/13/21 12:00	4,140	3,600	540	58,952	51,262	7,689	PFAS 002	PFAS 008	PFAS 015	PFAS 025
8/14/2021	SAT	12:00	8/14/21 12:00	4,140	3,600	540	63,092	54,862	8,229		PFAS (H)		
8/15/2021	SUN	12:00	8/15/21 12:00	4,140	3,600	540	67,232	58,462	8,769		PFAS (H)		
8/16/2021	MON	12:00	8/16/21 12:00	4,140	3,600	540	71,372	62,062	9,309		PFAS 009	PFAS 016	PFAS 026
8/17/2021	TUE	12:00	8/17/21 12:00	4,140	3,600	540	75,512	65,662	9,849		PFAS (H)		
8/18/2021	WED	12:00	8/18/21 12:00	Setup on Resin Reload / Data Review								PFAS 017	
8/19/2021	THU	12:00	8/19/21 12:00										
8/20/2021	FRI	12:00	8/20/21 12:00									PFAS 018	

Date	Cumulative Flows (Trains A & B): To TRAINS A & B	GAC1	GAC2	IX1	IX2	TRAIN A: GAC1-A	GAC2-A	IX1-A	IX2-A	FP	TRAIN B: IXR1-B	IXR2-B	FP
	gal	BVs	BVs	BVs	BVs	(PRETREATMENT)		(SINGLE-USE IX)			(REGENERABLE IX)		
7/14/2021	System setup and commissioning										System setup and commissioning		
7/21/2021	UF/RO Initial Operations Only										UF/RO Initial Operations Only		
7/30/2021	10	16	8	16	8	PFAS 027	PFAS 035	PFAS 043	PFAS 051	FP	PFAS 059	PFAS 067	FP
7/31/2021	68	112	56	112	56	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/1/2021	127	208	104	208	104	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/2/2021	185	304	152	304	152	PFAS 028	PFAS 036	PFAS 044	PFAS 052	FP	PFAS 060	PFAS 068	FP
8/3/2021	244	400	200	400	200	BC 09	PFAS (H)	BC 11	PFAS (H)	FP	BC 13	PFAS (H)	FP
8/4/2021	303	496	248	496	248	PFAS 029	PFAS 037	PFAS 045	PFAS 053	FP	PFAS 061	PFAS 069	FP
8/5/2021	361	592	296	592	296	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/6/2021	420	688	344	688	344	PFAS 030	PFAS 038	PFAS 046	PFAS 054	FP	PFAS 062	PFAS 070	FP
8/7/2021	478	784	392	784	392	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/8/2021	537	880	440	880	440	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/9/2021	596	976	488	976	488	PFAS 031	PFAS 039	PFAS 047	PFAS 055	FP	PFAS 063	PFAS 071	FP
8/10/2021	654	1,072	536	1,072	536	BC 10	PFAS (H)	BC 12	PFAS (H)	FP	BC 14	PFAS (H)	FP
8/11/2021	713	1,168	584	1,168	584	PFAS 032	PFAS 040	PFAS 048	PFAS 056	FP	PFAS 064	PFAS 072	FP
8/12/2021	771	1,264	632	1,264	632	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/13/2021	830	1,360	680	1,360	680	PFAS 033	PFAS 041	PFAS 049	PFAS 057	FP	PFAS 065	PFAS 073	FP
8/14/2021	888	1,456	728	1,456	728	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/15/2021	947	1,552	776	1,552	776	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/16/2021	1,006	1,648	824	1,648	824	PFAS 034	PFAS 042	PFAS 050	PFAS 058	FP	PFAS 066	PFAS 074	FP
8/17/2021	1,064	1,744	872	1,744	872	PFAS (H)	PFAS (H)	PFAS (H)	PFAS (H)	FP	PFAS (H)	PFAS (H)	FP
8/18/2021													
8/19/2021													
8/20/2021													

Date	Cumulative Flows (Train C): To TRAIN C	IX1	IX2	TRAIN C: IX1-C	IX2-C	FP
	gal	BVs	BVs	(SINGLE-USE IX)		
7/14/2021	System setup and commissioning					
7/21/2021	UF/RO Initial Operations Only					
7/30/2021	49	80	40	PFAS 075	PFAS 085	FP
7/31/2021	342	560	280	PFAS (H)	PFAS (H)	FP
8/1/2021	635	1,040	520	PFAS (H)	PFAS (H)	FP
8/2/2021	927	1,520	760	PFAS 076	PFAS 086	FP
8/3/2021	1,220	2,000	1,000	BC 15	PFAS (H)	FP
8/4/2021	1,513	2,480	1,240	PFAS 077	PFAS 087	FP
8/5/2021	1,806	2,960	1,480	PFAS (H)	PFAS (H)	FP
8/6/2021	2,099	3,440	1,720	PFAS 078	PFAS 088	FP
8/7/2021	2,392	3,920	1,960	PFAS (H)	PFAS (H)	FP
8/8/2021	2,685	4,400	2,200	PFAS (H)	PFAS (H)	FP
8/9/2021	2,978	4,880	2,440	PFAS 079	PFAS 089	FP
8/10/2021	3,271	5,360	2,680	BC 16	PFAS (H)	FP
8/11/2021	3,563	5,840	2,920	PFAS 080	PFAS 090	FP
8/12/2021	3,856	6,320	3,160	PFAS (H)	PFAS (H)	FP
8/13/2021	4,149	6,800	3,400	PFAS 081	PFAS 091	FP
8/14/2021	4,442	7,280	3,640	PFAS (H)	PFAS (H)	FP
8/15/2021	4,735	7,760	3,880	PFAS (H)	PFAS (H)	FP
8/16/2021	5,028	8,240	4,120	PFAS 082	PFAS 092	FP
8/17/2021	5,321	8,720	4,360	PFAS (H)	PFAS (H)	FP
8/18/2021	5,614	9,200	4,600	PFAS 083	PFAS 093	FP
8/19/2021	5,906	9,680	4,840	PFAS (H)	PFAS (H)	FP
8/20/2021				PFAS 084	PFAS 094	

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

KEY:

Enthaply Sample
3M Sample
Pace Sample
Field Sample
(H) = Hold

BC XX	= Background chemistry sample, XX is sample designation in Table 4: Background Water Chemistry Data
PFAS XXX	= PFAS sample, XXX is sample designation in Table 5: PFAS Data - NCCW

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	30.0	30.0
Flow Rate	mL/min	77.0	77.0
Daily Flow Rate	gpd	29.3	29.3
BV Goal (LOW)	#	152	152
BV Goal (HIGH)	#	496	496

NCCW_B

Start Date/Time: 8/23/21 12:22

Date	Day	Time	Date/Time	Daily Flows: RO Influent (gal)	Daily Flows: RO Permeate (gal)	Daily Flows: RO Reject (gal)	Cumulative Flows: RO Influent (gal)	Cumulative Flows: RO Permeate (gal)	Cumulative Flows: RO Reject (gal)	RO STREAMS: UF INFLUENT	UF EFFLUEN	RO PERMEATE	RO REJECT	FP
8/23/2021	MON	12:22	8/23/21 12:22							PFAS 095	PFAS 114	PFAS 133	PFAS 138	FP
8/24/2021	TUE	8:00	8/24/21 8:00							PFAS 096	PFAS 115		PFAS 139	FP
8/24/2021	TUE	14:00	8/24/21 14:00							PFAS 097	PFAS 116		PFAS 140	
8/25/2021	WED	8:00	8/25/21 8:00							PFAS 098	PFAS 117		PFAS 141	FP
8/25/2021	WED	14:00	8/25/21 14:00							PFAS 099	PFAS 118	PFAS 134	PFAS 142	
8/26/2021	THU	8:00	8/26/21 8:00							PFAS 100	PFAS 119		PFAS 143	FP
8/26/2021	THU	14:00	8/26/21 14:00							PFAS 101	PFAS 120		PFAS 144	
8/27/2021	FRI	8:00	8/27/21 8:00							PFAS 102	PFAS 121		PFAS 145	FP
8/27/2021	FRI	14:00	8/27/21 14:00							PFAS 103	PFAS 122	PFAS 135	PFAS 146	
8/28/2021	SAT	8:00	8/28/21 8:00							PFAS 104	PFAS 123		PFAS 147	FP
8/28/2021	SAT	14:00	8/28/21 14:00							PFAS 105	PFAS 124		PFAS 148	
8/29/2021	SUN	8:00	8/29/21 8:00							PFAS 106	PFAS 125		PFAS 149	FP
8/30/2021	MON	8:00	8/30/21 8:00							PFAS 107	PFAS 126		PFAS 150	FP
8/30/2021	MON	14:00	8/30/21 14:00							PFAS 108	PFAS 127	PFAS 136	PFAS 151	
8/31/2021	TUE	8:00	8/31/21 8:00							PFAS 109	PFAS 128		PFAS 152	FP
8/31/2021	TUE	14:00	8/31/21 14:00							PFAS 110	PFAS 129		PFAS 153	
9/1/2021	WED	8:00	9/1/21 8:00							PFAS 111	PFAS 130		PFAS 154	FP
9/1/2021	WED	14:00	9/1/21 14:00							PFAS 112	PFAS 131	PFAS 137	PFAS 155	
9/2/2021	THU	8:00	9/2/21 8:00							PFAS 113	PFAS 132		PFAS 156	FP
9/3/2021	FRI	8:00	9/3/21 8:00							PFAS (H)				
9/3/2021	FRI	14:00	9/3/21 14:00											
9/4/2021	SAT	8:00	9/4/21 8:00											
9/4/2021	SAT	14:00	9/4/21 14:00											
9/5/2021	SUN	8:00	9/5/21 8:00											
9/5/2021	SUN	14:00	9/5/21 14:00											
9/6/2021	MON	8:00	9/6/21 8:00							PFAS (H)				
9/6/2021	MON	14:00	9/6/21 14:00											
9/7/2021	TUE	8:00	9/7/21 8:00											
9/8/2021	WED	14:00	9/8/21 14:00											
9/9/2021	THU													
9/10/2021	FRI													
9/11/2021	SAT													
9/12/2021	SUN													
9/13/2021	MON													

Date/Time	Cumulative Flows (Trains A & B): To TRAINS A & B (gal)	GAC1 (BVs)	GAC2 (BVs)	IX1 (BVs)	IX2 (BVs)	TRAIN A: GAC1-A	GAC2-A	IX1-A	IX2-A	FP	TRAIN B: IXR1-B	IXR2-B	FP
8/23/21 12:22	5	16	8	8	4	PFAS 157	PFAS 176	PFAS 195	PFAS 214	FP	PFAS 233	PFAS 252	FP
8/24/21 8:00	63	104	52	104	52	PFAS 158	PFAS 177	PFAS 196	PFAS 215	FP	PFAS 234	PFAS 253	FP
8/24/21 14:00	93	152	76	152	76	PFAS 159	PFAS 178	PFAS 197	PFAS 216		PFAS 235	PFAS 254	
8/25/21 8:00	122	200	100	200	100	PFAS 160	PFAS 179	PFAS 198	PFAS 217	FP	PFAS 236	PFAS 255	FP
8/25/21 14:00	151	248	124	248	124	PFAS 161	PFAS 180	PFAS 199	PFAS 218		PFAS 237	PFAS 256	
8/26/21 8:00	181	296	148	296	148	PFAS 162	PFAS 181	PFAS 200	PFAS 219	FP	PFAS 238	PFAS 257	FP
8/26/21 14:00	210	344	172	344	172	PFAS 163	PFAS 182	PFAS 201	PFAS 220		PFAS 239	PFAS 258	
8/27/21 8:00	239	392	196	392	196	PFAS 164	PFAS 183	PFAS 202	PFAS 221	FP	PFAS 240	PFAS 259	FP
8/27/21 14:00	268	440	220	440	220	PFAS 165	PFAS 184	PFAS 203	PFAS 222		PFAS 241	PFAS 260	
8/28/21 8:00	298	488	244	488	244	PFAS 166	PFAS 185	PFAS 204	PFAS 223	FP	PFAS 242	PFAS 261	FP
8/28/21 14:00	327	536	268	536	268	PFAS 167	PFAS 186	PFAS 205	PFAS 224		PFAS 243	PFAS 262	
8/29/21 8:00	356	584	292	584	292	PFAS 168	PFAS 187	PFAS 206	PFAS 225	FP	PFAS 244	PFAS 263	FP
8/30/21 8:00	415	680	340	680	340	PFAS 169	PFAS 188	PFAS 207	PFAS 226	FP	PFAS 245	PFAS 264	FP
8/30/21 14:00	444	728	364	728	364	PFAS 170	PFAS 189	PFAS 208	PFAS 227		PFAS 246	PFAS 265	
8/31/21 8:00	473	776	388	776	388	PFAS 171	PFAS 190	PFAS 209	PFAS 228	FP	PFAS 247	PFAS 266	FP
8/31/21 14:00	503	824	412	824	412	PFAS 172	PFAS 191	PFAS 210	PFAS 229		PFAS 248	PFAS 267	
9/1/21 8:00	532	872	436	872	436	PFAS 173	PFAS 192	PFAS 211	PFAS 230	FP	PFAS 249	PFAS 268	FP
9/1/21 14:00	561	920	460	920	460	PFAS 174	PFAS 193	PFAS 212	PFAS 231		PFAS 250	PFAS 269	
9/2/21 8:00	591	968	484	968	484	PFAS 175	PFAS 194	PFAS 213	PFAS 232	FP	PFAS 251	PFAS 270	FP
9/3/21 8:00	649	1064	532	1064	532	PFAS (H)				FP			FP
9/3/21 14:00	679	1112	556	1112	556								
9/4/21 8:00	708	1160	580	1160	580								
9/4/21 14:00	737	1208	604	1208	604								
9/5/21 8:00	766	1256	628	1256	628								
9/5/21 14:00	796	1304	652	1304	652								
9/6/21 8:00	825	1352	676	1352	676	PFAS (H)							
9/6/21 14:00	854	1400	700	1400	700								
9/7/21 8:00	884	1448	724	1448	724								
9/8/21 14:00	913	1496	748	1496	748								

Date/Time	Cumulative Flows (Train C): To TRAIN C (gal)	IX1 (BVs)	IX2 (BVs)	TRAIN C: IX1-C	IX2-C	FP
8/23/21 12:22	6,199	10,160	5,080	PFAS 271	PFAS 276	FP
8/24/21 8:00	6,785	11,120	5,560	PFAS (H)		FP
8/24/21 14:00	7,078	11,600	5,800			
8/25/21 8:00	7,371	12,080	6,040			FP
8/25/21 14:00	7,664	12,560	6,280	PFAS 272	PFAS 277	
8/26/21 8:00	7,957	13,040	6,520			FP
8/26/21 14:00	8,250	13,520	6,760			
8/27/21 8:00	8,542	14,000	7,000			FP
8/27/21 14:00	8,835	14,480	7,240	PFAS 273	PFAS 278	
8/28/21 8:00	9,128	14,960	7,480	PFAS (H)		FP
8/28/21 14:00	9,421	15,440	7,720			
8/29/21 8:00	9,714	15,920	7,960	PFAS (H)		FP
8/30/21 8:00	10,300	16,880	8,440			FP
8/30/21 14:00	10,593	17,360	8,680	PFAS 274	PFAS 279	
8/31/21 8:00	10,886	17,840	8,920	PFAS (H)		FP
8/31/21 14:00	11,178	18,320	9,160			
9/1/21 8:00	11,471	18,800	9,400			FP
9/1/21 14:00	11,764	19,280	9,640	PFAS 275	PFAS 280	
9/2/21 8:00	12,057	19,760	9,880	PFAS (H)		FP
9/3/21 8:00	12,643	20,720	10,360	PFAS (H)		FP
9/3/21 14:00	12,936	21,200	10,600			
9/4/21 8:00	13,229	21,680	10,840			
9/4/21 14:00	13,521	22,160	11,080			
9/5/21 8:00	13,814	22,640	11,320			
9/5/21 14:00	14,107	23,120	11,560			
9/6/21 8:00	14,400	23,600	11,800			
9/6/21 14:00	14,693	24,080	12,040			
9/7/21 8:00	14,986	24,560	12,280			
9/8/21 14:00	15,279	25,040	12,520			
(9/9/2021)	15,572	25,520	12,760			
(9/10/2021)	15,865	26,000	13,000			
(9/11/2021)	16,157	26,480	13,240			
(9/12/2021)	16,450	26,960	13,480			

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

KEY:

Enthaply Sample
3M Sample
Pace Sample
Field Sample
(H) = Hold

BC XX = Background chemistry sample, XX is sample designation in Table 4: Background Water Chemistry Data
PFAS XXX = PFAS sample, XXX is sample designation in Table 5: PFAS Data - NCCW

		GAC	IX
Media Volume	L		
	gal		
EBCT	min		
Flow Rate	mL/min		
Daily Flow Rate	gpd		
BV Goal (LOW)	#		
BV Goal (HIGH)	#		

NCCW_D

Start Date/Time: 10/21/21 13:30

				Daily Flows			Cumulative Flows			RO STREAMS					Cumulative Flows (Trains A & B)					TRAIN A					TRAIN B			Cumulative Flows (Train C)			TRAIN C		
Date	Day	Time	Date/Time	RO Influent	RO Permeate	RO Reject	RO Influent	RO Permeate	RO Reject	UF INFLUENT	UF EFFLUEN	RO PERMEATE	RO REJECT	FP	To TRAINS A & B	GAC1	GAC2	IX1	IX2	GAC1-A	GAC2-A	IX1-A	IX2-A	FP	IXR1-B	IXR2-B	FP	To TRAIN C	IX1	IX2	IX1-C	IX2-C	FP
				gal	gal	gal	gal	gal	gal						gal	BVs	BVs	BVs	BVs									gal	BVs	BVs			
10/21/2021	THU	13:30	10/21/21 13:30							BC25	BC26	BC27	BC28																				
10/21/2021	THU	16:01	10/21/21 16:01																	BC29		BC30									BC31		

ON-SITE PILOT TEST
3M COTTAGE GROVE, MN

KEY:

Enthaply Sample
3M Sample
Pace Sample
Field Sample
(H) = Hold
BC XX = Background chemistry sample, XX is sample designation in Table 4: Background Water Chemistry Data
PFAS XXX = PFAS sample, XXX is sample designation in Table 6: PFAS Data - WW

		GAC	IX
Media Volume	L	2.3	2.3
	gal	0.61	0.61
EBCT	min	30.0	30.0
Flow Rate	mL/min	77.0	77.0
Daily Flow Rate	gpd	29.3	29.3
BV Goal (LOW)	#	152	152
BV Goal (HIGH)	#	496	496

		IX
Media Volume	L	2.3
	gal	0.61
EBCT	min	3.0
Flow Rate	mL/min	769.8
Daily Flow Rate	gpd	292.9

WW

Start Date/Time: 9/14/21 12:00

Date	Day	Time	Date/Time	Daily Flows: RO Influent	RO Permeate	RO Reject	Cumulative Flows: RO Influent	RO Permeate	RO Reject	RO STREAMS: UF INFLUENT	UF PERMEATE	FP
				gal	gal	gal	gal	gal	gal			
9/14/2021	TUE	12:00	9/14/21 12:00							PFAS 281	PFAS 285	FP
9/14/2021	TUE	14:00	9/14/21 14:00									
9/15/2021	WED	8:00	9/15/21 8:00							PFAS (H)		FP
9/15/2021	WED	14:00	9/15/21 14:00									
9/16/2021	THU	12:00	9/16/21 12:00							PFAS 282	PFAS 286	FP
9/16/2021	THU	18:00	9/16/21 18:00									
9/17/2021	FRI	8:00	9/17/21 8:00							PFAS (H)		FP
9/17/2021	FRI	14:00	9/17/21 14:00									
9/18/2021	SAT	8:00	9/18/21 8:00							PFAS (H)		FP
9/18/2021	SAT	14:00	9/18/21 14:00									
9/19/2021	SUN	8:00	9/19/21 8:00									
9/19/2021	SUN	14:00	9/19/21 14:00									
9/20/2021	MON	8:00	9/20/21 8:00							PFAS 283	PFAS 287	FP
9/20/2021	MON	14:00	9/20/21 14:00									
9/21/2021	TUE	15:25	9/21/21 15:25									
9/21/2021	TUE	21:25	9/21/21 21:25							PFAS (H)		FP
9/22/2021	WED	16:30	9/22/21 16:30							BC 23	BC 24	FP
9/22/2021	WED	22:30	9/22/21 22:30									
9/23/2021	THU	8:00	9/23/21 8:00							PFAS 284	PFAS 288	FP
9/23/2021	THU	14:00	9/23/21 14:00									
9/24/2021	FRI	8:00	9/24/21 8:00									
9/24/2021	FRI	14:00	9/24/21 14:00							PFAS (H)		FP
9/25/2021	SAT	8:00	9/25/21 8:00									
9/25/2021	SAT	14:00	9/25/21 14:00									
9/26/2021	SUN	8:00	9/26/21 8:00									
9/26/2021	SUN	14:00	9/26/21 14:00									
9/27/2021	MON	8:00	9/27/21 8:00									
9/27/2021	MON	14:00	9/27/21 14:00									
9/28/2021	TUE	8:00	9/28/21 8:00									
9/28/2021	TUE	14:00	9/28/21 14:00									
9/29/2021	WED	8:00	9/29/21 8:00									
9/29/2021	WED	14:00	9/29/21 14:00									
9/30/2021	THU	20:00	9/30/21 20:00									
9/30/2021	THU	2:00	10/1/21 2:00									
10/1/2021	FRI	8:00	10/2/21 8:00									
10/1/2021	FRI	14:00	10/2/21 14:00									
10/2/2021	SAT	20:00	10/3/21 20:00									
10/2/2021	SAT	2:00	10/4/21 2:00									
10/3/2021	SUN	8:00	10/5/21 8:00									
10/3/2021	SUN	14:00	10/5/21 14:00									
10/4/2021	MON	20:00	10/6/21 20:00									
10/4/2021	MON	2:00	10/7/21 2:00									

Date/Time	Cumulative Flows (Trains D & E): To TRAINS D & E	GAC1	GAC2	IX1	IX2	TRAIN D: TRAIN D INFLUENT (RO REJECT)		D.1-GAC1 EFFLUENT		D.2-GAC2 EFFLUENT	D.3-IX1 EFFLUENT		D.4-IX2 EFFLUENT	FP	TRAIN E: E.3-IXR1 EFFLUENT		E.4-IXR2 EFFLUENT	FP
	gal	BVs	BVs	BVs	BVs													
9/14/21 12:00	5	8	4	8	4									FP				FP
9/14/21 14:00	7	12	6	12	6	PFAS 301		PFAS 319		PFAS 337	PFAS 355		PFAS 373		PFAS 391		PFAS 409	
9/15/21 8:00	29	48	24	48	24	PFAS 302		PFAS 320		PFAS 338	PFAS 356		PFAS 374	FP	PFAS 392		PFAS 410	FP
9/15/21 14:00	37	60	30	60	30	PFAS 303		PFAS 321		PFAS 339	PFAS 357		PFAS 375		PFAS 393		PFAS 411	
9/16/21 12:00	63	104	52	104	52	PFAS 304		PFAS 322		PFAS 340	PFAS 358		PFAS 376	FP	PFAS 394		PFAS 412	FP
9/16/21 18:00	71	116	58	116	58	PFAS 305		PFAS 323		PFAS 341	PFAS 359		PFAS 377		PFAS 395		PFAS 413	
9/17/21 8:00	88	144	72	144	72	PFAS 306		PFAS 324		PFAS 342	PFAS 360		PFAS 378	FP	PFAS 396		PFAS 414	FP
9/17/21 14:00	95	156	78	156	78	PFAS 307		PFAS 325		PFAS 343	PFAS 361		PFAS 379		PFAS 397		PFAS 415	
9/18/21 8:00	117	192	96	192	96	PFAS 308		PFAS 326		PFAS 344	PFAS 362		PFAS 380	FP	PFAS 398		PFAS 416	FP
9/18/21 14:00	124	204	102	204	102	PFAS 309		PFAS 327		PFAS 345	PFAS 363		PFAS 381		PFAS 399		PFAS 417	
9/19/21 8:00	146	240	120	240	120	PFAS 310		PFAS 328		PFAS 346	PFAS 364		PFAS 382	FP	PFAS 400		PFAS 418	FP
9/19/21 14:00	154	252	126	252	126	PFAS 311		PFAS 329		PFAS 347	PFAS 365		PFAS 383		PFAS 401		PFAS 419	
9/20/21 8:00	176	288	144	288	144	PFAS 312		PFAS 330		PFAS 348	PFAS 366		PFAS 384	FP	PFAS 402		PFAS 420	FP
9/20/21 14:00	183	300	150	300	150	PFAS 313		PFAS 331		PFAS 349	PFAS 367		PFAS 385		PFAS 403		PFAS 421	
9/21/21 15:25	214	351	175	351	175	PFAS 314		PFAS 332	BC 18	PFAS 350	PFAS 368	BC 19	PFAS 386	FP	PFAS 404	BC 20	PFAS 422	FP
9/21/21 21:25	221	363	181	363	181													
9/22/21 16:30	245	401	201	401	201	PFAS 315	BC 17	PFAS 333		PFAS 351	PFAS 369		PFAS 387	FP	PFAS 405		PFAS 423	FP
9/22/21 22:30	252	413	207	413	207	PFAS 316		PFAS 334		PFAS 352	PFAS 370		PFAS 388		PFAS 406		PFAS 424	
9/23/21 8:00	264	432	216	432	216	PFAS 317		PFAS 335		PFAS 353	PFAS 371		PFAS 389	FP	PFAS 407		PFAS 425	FP
9/23/21 14:00	271	444	222	444	222	PFAS 318		PFAS 336		PFAS 354	PFAS 372		PFAS 390		PFAS 408		PFAS 426	
9/24/21 8:00	293	480	240	480	240									FP				FP
9/24/21 14:00	300	492	246	492	246							PFAS-3M				PFAS-3M		
9/25/21 8:00	322	528	264	528	264	PFAS (H)								FP	PFAS (H)			FP
9/25/21 14:00	329	540	270	540	270													
9/26/21 8:00	351	576	288	576	288									FP				FP
9/26/21 14:00	359	588	294	588	294													
9/27/21 8:00	381	624	312	624	312									FP				FP
9/27/21 14:00	388	636	318	636	318													
9/28/21 8:00	410	672	336	672	336									FP				FP
9/28/21 14:00	417	684	342	684	342													
9/29/21 8:00	439	720	360	720	360									FP				FP
9/29/21 14:00	447	732	366	732	366													
9/30/21 20:00	483	792	396	792	396									FP				FP
10/1/21 2:00	491	804	402	804	402													
10/2/21 8:00	527	864	432	864	432									FP				FP
10/2/21 14:00	535	876	438	876	438													
10/3/21 20:00	571	936	468	936	468									FP				FP
10/4/21 2:00	578	948	474	948	474													
10/5/21 8:00	615	1008	504	1008	504									FP				FP
10/5/21 14:00	622	1020	510	1020	510													
10/6/21 20:00	659	1080	540	1080	540									FP				FP
10/7/21 2:00	666	1092	546	1092	546													

Date/Time	Cumulative Flows (Train F): To TRAIN C	IX1	IX2	TRAIN F: TRAIN F INFLUENT	F.1-IX1 EFFLUENT	F.2-IX2 EFFLUENT	FP
	gal	BVs	BVs				
9/14/21 12:00	293	480	240	PFAS 289	PFAS 293	PFAS 297	FP
9/14/21 14:00	586	960	480				
9/15/21 8:00	879	1,440	720	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/15/21 14:00	1,172	1,920	960				
9/16/21 12:00	1,464	2,400	1,200	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/16/21 18:00	1,757	2,880	1,440				
9/17/21 8:00	2,050	3,360	1,680	PFAS 290	PFAS 294	PFAS 298	FP
9/17/21 14:00	2,343	3,840	1,920				
9/18/21 8:00	2,636	4,320	2,160	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/18/21 14:00	2,929	4,800	2,400				
9/19/21 8:00	3,222	5,280	2,640	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/19/21 14:00	3,515	5,760	2,880				
9/20/21 8:00	3,807	6,240	3,120	PFAS 291	PFAS 295	PFAS 299	FP
9/20/21 14:00	4,100	6,720	3,360				
9/21/21 15:25	4,393	7,200	3,600	PFAS (H)	BC 22	PFAS (H)	FP
9/21/21 21:25	4,686	7,680	3,840				
9/22/21 16:30	4,979	8,160	4,080	BC 21	PFAS (H)	PFAS (H)	FP
9/22/21 22:30	5,272	8,640	4,320				
9/23/21 8:00	5,565	9,120	4,560	PFAS 292	PFAS 296	PFAS 300	FP
9/23/21 14:00	5,858	9,600	4,800				
9/24/21 8:00	6,151	10,080	5,040	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/24/21 14:00	6,443	10,560	5,280				
9/25/21 8:00	6,736	11,040	5,520	PFAS (H)	PFAS (H)	PFAS (H)	FP
9/25/21 14:00	7,029	11,520	5,760				
9/26/21 8:00	7,322	12,000	6,000				
9/26/21 14:00	7,615	12,480	6,240				
9/27/21 8:00	7,908	12,960	6,480				
9/27/21 14:00	8,201	13,440	6,720				
9/28/21 8:00	8,494	13,920	6,960				
9/28/21 14:00	8,787	14,400	7,200				
9/29/21 8:00	9,079	14,880	7,440				
9/29/21 14:00	9,372	15,360	7,680				
9/30/21 20:00	9,665	15,840	7,920				
10/1/21 2:00	9,958	16,320	8,160				
10/2/21 8:00	10,251	16,800	8,400				
10/2/21 14:00	10,544	17,280	8,640				
10/3/21 20:00	10,837	17,760	8,880				
10/4/21 2:00	11,130	18,240	9,120				
10/5/21 8:00	11,422	18,720	9,360				
10/5/21 14:00	11,715	19,200	9,600				
10/6/21 20:00	12,008	19,680	9,840				
10/7/21 2:00	12,301	20,160	10,080				

Appendix C

Laboratory Data Summary Tables – Enthalpy Analytical

Enthalpy Analytical

Job No.: 0721-816-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG, Cottage Grove, MN

QA'd 8/31/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-UF-INF-20210726 ng/L	3MCG-Test 02-UF-INF-20210726 ng/L	3MCG-Test 03-UF-INF-20210726 ng/L
Acids	PFBA	375-22-4	8030	4690	<LOD (19100) U
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	<LOD (21200) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (24100) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (15200) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (22100) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	645	<LOD (44400) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (25800) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (23900) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (16900) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (20000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (100000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (75200) U
	HQ-115	90076-65-6	<LOD (5000) U	25700	<LOD (100000) U
	PFPA	422-64-0	<LOD (3500) U	3680	<LOD (70000) U
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (70000) U
	TFMS	1493-13-6	11300	56600	<LOD (100000) U

QA Notes

Received one of two bottles for sample 3MCG-Test 02-UF-INF-20210726 broken. All contents of bottle emptied. The remaining bottle was in good condition.

Samples and QC were reinjected and processed for additional legacy compounds. No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.
QC passed all criteria.

Enthalpy Analytical

Job No.: 0821-705-1 PFAS by Direct Inject

ECT2 PROJ-009092 3M CG Cottage Grove, MN

QA'd 9/1/21 by JLT

Summary

	Compound	CAS	3MCG-Test01-UF-PERM-20210730 ng/L	3MCG-Test01-RO-REJ-20210730 ng/L	3MCG-Test01-GAC1-A-20210730 ng/L	3MCG-Test01-GAC2-A-20210730 ng/L	3MCG-Test01-IX1-A-20210730 ng/L
	PFBA	375-22-4	7370	21200	<LOD (1910) U	<LOD (1910) U	<LOD (191) U
	PFPeA	2706-90-3	432	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U
Acids	PFHxA	307-24-4	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U
	PFBS	375-73-5	<LOD (444) U	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U
Sulfonates	PFHxS	355-46-4	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U
	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	<LOD (752) U
other	HQ-115	90076-65-6	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	PFPA	422-64-0	2740	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U
	TFMS	1493-13-6	7890	26200	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U

QA Notes
Samples and QC were reinjected and processed for additional legacy compounds. No JS was added to these extracts, so the recoveries for the ES are showing as "0%".

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-705-1 PFAS by Direct Inject

ECT2 PROJ-009092 3M CG Cottage Grove, MN

QA'd 9/1/21 by JLT

Summary

	Compound	CAS	3MCG-Test01-IX2-A-20210730 ng/L	3MCG-Test01-IX1-B-20210730 ng/L	3MCG-Test01-IX2-B-20210730 ng/L	3MCG-Test01-RO-PERM-20210730 ng/L	3MCG-Test01-IX1-C-20210730 ng/L	3MCG-Test01-IX2-C-20210730 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

Samples and QC were reinjected and processed for additional legacy compounds. No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-705-1 PFAS by Direct Inject

ECT2 PROJ-009092 3M CG Cottage Grove, MN

QA'd 9/1/21 by JLT

Summary

	Compound	CAS	3MCG-Test01-UF-INF-20210802 ng/L	3MCG-Test01-UF-PERM-20210802 ng/L	3MCG-Test01-RO-REJ-20210802 ng/L	3MCG-Test01-GAC1-A-20210802 ng/L	3MCG-Test01-GAC2-A-20210802 ng/L	3MCG-Test01-IX1-A-20210802 ng/L
Acids	PFBA	375-22-4	8060	8450	32200	18400	4730	<LOD (191) U
	PFPeA	2706-90-3	561	562	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	PFPA	422-64-0	2750	2740	9200 J	10500 J	9100 J	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U
	TFMS	1493-13-6	8530	7860	36100	28200	31900	<LOD (1000) U

QA Notes
Samples and QC were reinjected and processed for additional legacy compounds. No JS was added to these extracts, so the recoveries for the ES are showing as "0%".

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-705-1 PFAS by Direct Inject

ECT2 PROJ-009092 3M CG Cottage Grove, MN

QA'd 9/1/21 by JLT

Summary

	Compound	CAS	3MCG-Test01-IX2-A-20210802 ng/L	3MCG-Test01-IXR1-B-20210802 ng/L	3MCG-Test01-IXR2-B-20210802 ng/L	3MCG-Test01-RO-PERM-20210802 ng/L	3MCG-Test01-IX1-C-20210802 ng/L	3MCG-Test01-IX2-C-20210802 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	25100	<LOD (700) U	730 J	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

Samples and QC were reinjected and processed for additional legacy compounds. No JS was added to these extracts, so the recoveries for the ES are showing as "0%".

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-730-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG Cottage Grove, MN

Summary

	Compound	CAS	3MCG-Test 01-GAC1-A-20210804 ng/L	3MCG-Test 01-GAC2-A-20210804 ng/L	3MCG-Test 01-IX1-A-20210804 ng/L	3MCG-Test 01-IX1-C-20210804 ng/L	3MCG-Test 01-IX2-A-20210804 ng/L	3MCG-Test 01-IX2-C-20210804 ng/L
Acids	PFBA	375-22-4	32600	23100	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (1060) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (3760) U	1680	<LOD (752) U	1550	<LOD (752) U
	HQ-115	90076-65-6	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	26700	33900	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (3500) U	<LOD (3500) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	30100	33300	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

There was contamination in the MB for PFPA and the following samples were sent back for a re-direct inject (Batch 12155).

3MCG-Test 01-GAC1-A-20210804
3MCG-Test 01-GAC2-A-20210804
3MCG-Test 01-RO-REJ-20210804
3MCG-Test 01-RO-REJ-20210806
3MCG-Test 01-UF-PERM-20210806
3MCG-Test 01-GAC1-A-20210806
3MCG-Test 01-GAC2-A-20210806
3MCG-Test 01-IX1-A-20210806
3MCG-Test 01-IX2-B-20210806
3MCG-Test 01-IX1-C-20210806

Enthalpy Analytical

Job No.: 0821-730-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG Cottage Grove, MN

Summary

	Compound	CAS	3MCG-Test 01-IXR1-B-20210804 ng/L	3MCG-Test 01-IXR2-B-20210804 ng/L	3MCG-Test 01-RO-REJ-20210804 ng/L	3MCG-Test 01-RO-REJ-20210806 ng/L	3MCG-Test 01-UF-PERM-20210806 ng/L	3MCG-Test 01-GAC1-A-20210806 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	48900	45500	8180	44400
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	3210	2880	664	<LOD (1060) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (1210) U	<LOD (1210) U	<LOD (241) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (762) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (444) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (200) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	1730	1720	<LOD (3760) U	<LOD (3760) U	<LOD (752) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	2850	<LOD (5000) U
	PFPA	422-64-0	17200	<LOD (700) U	22300	25800	1940	31400
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (700) U	<LOD (3500) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	31500	33500	6690	35900

QA Notes

There was contamination in the MB for PFPA and the follc
3MCG-Test 01-GAC1-A-20210804
3MCG-Test 01-GAC2-A-20210804
3MCG-Test 01-RO-REJ-20210804
3MCG-Test 01-RO-REJ-20210806
3MCG-Test 01-UF-PERM-20210806
3MCG-Test 01-GAC1-A-20210806
3MCG-Test 01-GAC2-A-20210806
3MCG-Test 01-IX1-A-20210806
3MCG-Test 01-IX2-B-20210806
3MCG-Test 01-IX1-C-20210806

Enthalpy Analytical

Job No.: 0821-730-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG Cottage Grove, MN

Summary

	Compound	CAS	3MCG-Test 01-GAC2-A-20210806 ng/L	3MCG-Test 01-IX1-A-20210806 ng/L	3MCG-Test 01-IX2-A-20210806 ng/L	3MCG-Test 01-IX1-B-20210806 ng/L	3MCG-Test 01-IX2-B-20210806 ng/L	3MCG-Test 01-RO-PERM-20210806 ng/L
Acids	PFBA	375-22-4	43800	<LOD (191) U	<LOD (191) U	3860	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	1560	1560	1470	1550	<LOD (752) U
	HQ-115	90076-65-6	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	27500	5170	<LOD (700) U	18300	13700	<LOD (700) U
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	35200	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

There was contamination in the MB for PFPA and the follc
3MCG-Test 01-GAC1-A-20210804
3MCG-Test 01-GAC2-A-20210804
3MCG-Test 01-RO-REJ-20210804
3MCG-Test 01-RO-REJ-20210806
3MCG-Test 01-UF-PERM-20210806
3MCG-Test 01-GAC1-A-20210806
3MCG-Test 01-GAC2-A-20210806
3MCG-Test 01-IX1-A-20210806
3MCG-Test 01-IX2-B-20210806
3MCG-Test 01-IX1-C-20210806

Enthalpy Analytical

Job No.: 0821-730-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG Cottage Grove, MN

Summary

	Compound	CAS	3MCG-Test 01-IX1-C-20210806 ng/L	3MCG-Test 01-IX2-C-20210806 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U

QA Notes

There was contamination in the MB for PFPA and the follc
3MCG-Test 01-GAC1-A-20210804
3MCG-Test 01-GAC2-A-20210804
3MCG-Test 01-RO-REJ-20210804
3MCG-Test 01-RO-REJ-20210806
3MCG-Test 01-UF-PERM-20210806
3MCG-Test 01-GAC1-A-20210806
3MCG-Test 01-GAC2-A-20210806
3MCG-Test 01-IX1-A-20210806
3MCG-Test 01-IX2-B-20210806
3MCG-Test 01-IX1-C-20210806

Enthalpy Analytical

Job No.: 0821-733-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M CG Cottge Grove, MN

QA'd 9/16/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-GAC1-A-20210809 ng/L	3MCG-Test 01-RO-REJ-20210809 ng/L	3MCG-Test 01-UF-PERM-20210809 ng/L	3MCG-Test 01-IX2-A-20210809 ng/L
Acids	PFBA	375-22-4	61200	43300	7810	<LOD (191) U
	PFPeA	2706-90-3	<LOD (1060) U	3240	717	<LOD (212) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (1210) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (1110) U	4360	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (2220) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (1190) U	1270 J	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (1000) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (3760) U	<LOD (752) U	2790
	HQ-115	90076-65-6	<LOD (5000) U	13500	10500	<LOD (1000) U
	PFPA	422-64-0	20600	12200	2860	<LOD (700) U
	TFA	76-05-1	<LOD (3500) U	<LOD (3500) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	78200	54900	11400	<LOD (1000) U

QA Notes

All method criteria met.

Enthalpy Analytical

Job No.: 0821-733-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M CG Cottge Grove, MN

QA'd 9/16/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-IX1-A-20210809 ng/L	3MCG-Test 01-GAC2-A-20210809 ng/L	3MCG-Test 01-IXR1-B-20210809 ng/L	3MCG-Test 01-IXR2-B-20210809 ng/L	3MCG-Test 01-RO-PERM-20210809 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	70100	28800	1010	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (1060) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	2560	<LOD (3760) U	2110	1890	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	26400	21000	18600	20000	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (3500) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	77100	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

All method criteria met.

Enthalpy Analytical

Job No.: 0821-733-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M CG Cottge Grove, MN

QA'd 9/16/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-IX1-C-20210809 ng/L	3MCG-Test 01-IX2-C-20210809 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U

QA Notes

All method criteria met.

Enthalpy Analytical

Job No.: 0821-748-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove, MN

QA'd JLT 9/17/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-UF-PERM-20210811 ng/L	3MCG-Test 01-RO-REJ-20210811 ng/L	3MCG-Test 01-GAC1-A-20210811 ng/L	3MCG-Test 01-GAC2-A-20210811 ng/L	3MCG-Test 01-IX1-A-20210811 ng/L
Acids	PFBA	375-22-4	6340	45500	67200	70800	370 J
	PFPeA	2706-90-3	523	3480	1410 J	<LOD (1060) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	1930
	HQ-115	90076-65-6	82700	91300	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	PFPA	422-64-0	1500 J	13900	16600	18200	22000
	TFA	76-05-1	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	<LOD (700) U
	TFMS	1493-13-6	7960	51800	62300	64300	<LOD (1000) U

QA Notes

Samples received with duplicate bottle exhibiting different sampling times than initial bottle. The lab confirmed that the times were in error and duplicate bottles were indeed sampled at the same time as the initial bottle.

% Recovery for PFBS did not meet method criteria in the OPR. However, it met marginal exceedance. Therefore, data is accepted.

Sample 3MCG-Test 01-IX1-A-20210811 (0821-748_005) was reinjected with a x5 dilution (20 µL sample diluted with 80 µL 50:50 methanol:water) due to acquisition issues for PFOS and PFHpS.

Enthalpy Analytical

Job No.: 0821-748-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove, MN

QA'd JLT 9/17/21 JLT

Summary

	Compound	CAS	3MCG-Test 01-IX2-A-20210811 ng/L	3MCG-Test 01-IXR1-B-20210811 ng/L	3MCG-Test 01-IXR2-B-20210811 ng/L	3MCG-Test 01-RO-PERM-20210811 ng/L	3MCG-Test 01-IX1-C-20210811 ng/L	3MCG-Test 01-IX2-C-20210811 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	49400	6560	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	1700	1950	1830	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	2630	19300	21200	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

Samples received with duplicate bottle exhibiting different sampling times than initial bottle. The lab confirmed that the times were in error and duplicate bottles were indeed sampled at the same time as the initial bottle.

% Recovery for PFBS did not meet method criteria in the OPR. However, it met marginal exceedance. Therefore, data is accepted.

Sample 3MCG-Test 01-IX1-A-20210811 (0821-748_005) was reinjected with a x5 dilution (20 µL sample diluted with 80 µL 50:50 methanol:water) due to acquisition issues for PFOS and PFHpS.

Enthalpy Analytical

Job No.: 0821-763-1 PFAS by Direct Inject
(non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10-5-21 JLT

Summary

	Compound	CAS	3MCG-Test 01-UF-INF-20210813 ng/L	3MCG-Test 01-UF-PERM-20210813 ng/L	3MCG-Test 01-INF-A (RO-REJ)-20210813 ng/L	3MCG-Test 01-GAC1-A-20210813 ng/L	3MCG-Test 01-GAC2-A-20210813 ng/L
Acids	PFBA	375-22-4	4080	3920	54100	56200	76100
	PFPeA	2706-90-3	<LOD (1060) U	281 J	2780	1420 J	<LOD (1060) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	1500 J	<LOD (1210) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	10900	13000	165000	<LOD (5000) U	<LOD (5000) U
	PFPA	422-64-0	<LOD (3500) U	1390 J	18900	17500	16700
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U
	TFMS	1493-13-6	<LOD (5000) U	2990	32400	29900	33700

QA Notes

All calibration met method criteria.

QC met method criteria with the exception of analyte PFBS % Recovery which fell outside the lower limit but met marginal exceedance limits. Therefore, data is accepted with no adverse impact.

Enthalpy Analytical

Job No.: 0821-763-1 PFAS by Direct Inject
(non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10-5-21 JLT

Summary

	Compound	CAS	3MCG-Test 01-IX1-A-20210813 ng/L	3MCG-Test 01-IX2-A-20210813 ng/L	3MCG-Test 01-IXR1-B-20210813 ng/L	3MCG-Test 01-IXR2-B-20210813 ng/L	3MCG-Test 01-INF-C (RO-PERM)-20210813 ng/L
Acids	PFBA	375-22-4	1610	<LOD (191) U	60500	20000	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	23000	9840	20000	18800	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

All calibration met method criteria.

QC met method criteria with the exception of analyte PFBS % Recovery which fell outside the lower limit but met marginal exceedance limits. Therefore, data is accepted with no adverse impact.

Enthalpy Analytical

Job No.: 0821-763-1 PFAS by Direct Inject
(non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10-5-21 JLT

Summary

	Compound	CAS	3MCG-Test 01-IX1-C-20210813 ng/L	3MCG-Test 01-IX2-C-20210813 ng/L	3MCG-Test 01-UF-PERM-20210816 ng/L	3MCG-Test 01-INF-A (RO-REJ)-20210816 ng/L	3MCG-Test 01-GAC1-A-20210816 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	3410	54200	49600
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	304 J	3390	1530 J
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	1620 J	<LOD (1210) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (2220) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	5190	171000	<LOD (5000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	1580	17600	16000
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	3210	31700	27400

QA Notes

All calibration met method criteria.

QC met method criteria with the exception of analyte PFBS % Recovery which fell outside the lower limit but met marginal exceedance limits. Therefore, data is accepted with no adverse impact.

Enthalpy Analytical

Job No.: 0821-763-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10-5-21 JLT

Summary

	Compound	CAS	3MCG-Test 01-GAC2-A-20210816 ng/L	3MCG-Test 01-IX1-A-20210816 ng/L	3MCG-Test 01-IX2-A-20210816 ng/L	3MCG-Test 01-IXR1-B-20210816 ng/L	3MCG-Test 01-IXR2-B-20210816 ng/L
Acids	PFBA	375-22-4	43800	5580	<LOD (191) U	58100	38100
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	14500	18600	16000	14000	13900
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	26600	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

All calibration met method criteria.

QC met method criteria with the exception of analyte PFBS % Recovery which fell outside the lower limit but met marginal exceedance limits. Therefore, data is accepted with no adverse impact.

Enthalpy Analytical

Job No.: 0821-763-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10-5-21 JLT

Summary

	Compound	CAS	3MCG-Test 01-INF-C (RO PERM)-20210816 ng/L	3MCG-Test 01-IX1-C-20210816 ng/L	3MCG-Test 01-IX2-C-20210816 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

All calibration met method criteria.

QC met method criteria with the exception of analyte PFBS % Recovery which fell outside the lower limit but met marginal exceedance limits. Therefore, data is accepted with no adverse impact.

Enthalpy Analytical

Job No.: 0821-791-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10/20/2021 LKB

Summary

	Compound	CAS	3MCG-Test-01_B-UF-INF-20210823 ng/L	3MCG-Test-01_B-UF-PERM-20210823 ng/L	3MCG-Test-01_B-INF-A (RO-REJ)-20210823 ng/L	3MCG-Test-01_B-GAC1-A-20210823 ng/L	3MCG-Test-01_B-GAC2-A-20210823 ng/L	3MCG-Test-01_B-IX1-A-20210823 ng/L
Acids	PFBA	375-22-4	<LOD (956) U	398	16500	30000	29300	<LOD (191) U
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	1310 J	1560 J	<LOD (1060) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (152) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (5000) U	4370	71000	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (3500) U	1420 J	7670	15000	13000	<LOD (700) U
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (5000) U	1600	14900	21400	24200	<LOD (1000) U

QA Notes:

Revised COC received on 8/24 to clarify sample IDs.

The low recoveries for target analytes in the OPR appear to be due to a likely underspike of Ax or possibly an ES over spike.

EDLs in the samples indicate that non-detects are not due to elevated detection limits, and, thus, the low OPR recoveries are not a concern from the perspective of possible false negatives in the samples. Since the low recoveries affect undetected analytes, with the exception of PFPeA, which met marginal exceedance criteria, the data are accepted and reported as-is.

Enthalpy Analytical

Job No.: 0821-791-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10/20/2021 LKB

Summary

	Compound	CAS	3MCG-Test-01_B-IX2-A-20210823 ng/L	3MCG-Test-01_B-IXR1-B-20210823 ng/L	3MCG-Test-01_B-IXR2-B-20210823 ng/L	3MCG-Test-01_B-INF-C (RO PERM)-20210823	3MCG-Test-01_B-IX1-C-20210823 ng/L	3MCG-Test-01_B-IX2-C-20210823 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Revised COC received on 8/24 to clarify sample

The low recoveries for target analytes in the OPR appear to be due to a likely underspike of Ax or possibly an ES over spike.

EDLs in the samples indicate that non-detects are not due to elevated detection limits, and, thus, the low OPR recoveries are not a concern from the perspective of possible false negatives in the samples. Since the low recoveries affect undetected analytes, with the exception of PFPeA, which met marginal exceedance criteria, the data are accepted and reported as-is.

Enthalpy Analytical

Job No.: 0821-791-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA'd 10/20/2021 LKB

Summary

	Compound	CAS	3MCG-Test-01-INF-C (RO PERM)-20210820 ng/L	3MCG-Test-01-IX1-C-20210820 ng/L	3MCG-Test-01-IX2-C-20210820 ng/L	3MCG-Test-01-INF-C (RO PERM)-20210818 ng/L	3MCG-Test-01-IX1-C-20210818 ng/L	3MCG-Test-01-IX2-C-20210818 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Revised COC received on 8/24 to clarify sample

The low recoveries for target analytes in the OPR appear to be due to a likely underspike of Ax or possibly an ES over spike.

EDLs in the samples indicate that non-detects are not due to elevated detection limits, and, thus, the low OPR recoveries are not a concern from the perspective of possible false negatives in the samples. Since the low recoveries affect undetected analytes, with the exception of PFPeA, which met marginal exceedance criteria, the data are accepted and reported as-is.

Enthalpy Analytical

Job No.: 0821-797-1 PFAS by Isotope Dilution (non-potable water)

ECT2 Client No.: PROJ-009092 Site: 3M CG

QA 10/21/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210824 ng/L	3MCG-Test 01_B-UF-INF-2-20210824 ng/L	3MCG-Test 01_B-UF-PERM-20210824 ng/L	3MCG-Test 01_B-UF-PERM-2-20210824 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210824 ng/L
Acids	PFBA	375-22-4	<LOD (1910) U	<LOD (1910) U	601	552	23100
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (7520) U	<LOD (752) U	<LOD (752) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (10000) U	26600	5070	7480	127000
	PFPA	422-64-0	<LOD (7000) U	<LOD (7000) U	1960	1990	16800
	TFA	76-05-1	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (10000) U	<LOD (10000) U	4680	3830	44600

QA Notes

Client confirmed naming convention on bottle labels is to be used for reporting.

No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.

QC passed all criteria.

Enthalpy Analytical

Job No.: 0821-797-1 PFAS by Isotope Dilution (non-potable water)

ECT2 Client No.: PROJ-009092 Site: 3M CG

QA 10/21/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-INF-A (RO-REJ)-2-20210824	3MCG-Test 01_B-GAC1-A-20210824 ng/L	3MCG-Test 01_B-GAC1-A-2-20210824 ng/L	3MCG-Test 01_B-GAC2-A-20210824 ng/L	3MCG-Test 01_B-GAC2-A-2-20210824 ng/L
Acids	PFBA	375-22-4	17600	31200	30600	31700	28900
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U
	HQ-115	90076-65-6	103000	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U
	PFPA	422-64-0	14700 J	14900 J	15600	11200 J	10900 J
	TFA	76-05-1	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U
	TFMS	1493-13-6	41300	42200	43400	40600	39900

QA Notes

Client confirmed naming convention on bottle labels is to be used for reporting.

No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.

QC passed all criteria.

Enthalpy Analytical

Job No.: 0821-797-1 PFAS by Isotope Dilution (non-potable water)

ECT2 Client No.: PROJ-009092 Site: 3M CG

QA 10/21/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX1-A-20210824 ng/L	3MCG-Test 01_B-IX1-A-2-20210824 ng/L	3MCG-Test 01_B-IX2-A-20210824 ng/L	3MCG-Test 01_B-IX2-A-2-20210824 ng/L	3MCG-Test 01_B-IXR1-B-20210824 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

Client confirmed naming convention on bottle labels is to be used for reporting.

No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.

QC passed all criteria.

Enthalpy Analytical

Job No.: 0821-797-1 PFAS by Isotope Dilution (non-potable water)

ECT2 Client No.: PROJ-009092 Site: 3M CG

QA 10/21/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR1-B-2-20210824 ng/L	3MCG-Test 01_B-IXR2-B-20210824 ng/L	3MCG-Test 01_B-IXR2-B-2-20210824 ng/L
	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U
Acids	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U
	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U
Sulfonates	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U
	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
other	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes

Client confirmed naming convention on bottle labels is to be used for reporting.
No JS was added to these extracts, so the recoveries for the ES are showing as “0%”.
QC passed all criteria.

Enthalpy Analytical

Job No.: 0821-801-1 PFAS by Isotope Dilution
(non-potable water)

ECT2   3M CG

QA 10-22-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210825 ng/L	3MCG-Test 01_B-UF-INF-2-20210825 ng/L	3MCG-Test 01_B-UF-PERM-20210825 ng/L	3MCG-Test 01_B-UF-PERM-2-20210825 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210825 ng/L
	PFBA	375-22-4	<LOD (956) U	<LOD (956) U	475	527	18500
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (1060) U	<LOD (212) U	<LOD (212) U	1390 J
Acids	PFHxA	307-24-4	<LOD (1210) U	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (1110) U
	PFBS	375-73-5	<LOD (2220) U	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (1290) U
Sulfonates	PFHxS	355-46-4	<LOD (1190) U	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (1000) U
	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (3760) U	<LOD (752) U	<LOD (752) U	<LOD (3760) U
other	HQ-115	90076-65-6	18400	8100	16200	11600	114000
	PFPA	422-64-0	<LOD (3500) U	<LOD (3500) U	1960	1610	10500
	TFA	76-05-1	<LOD (3500) U	<LOD (3500) U	<LOD (700) U	<LOD (700) U	<LOD (3500) U
	TFMS	1493-13-6	5660	6050	4960	4930	39200

QA Notes:

Initial COC detailed 18 of the 21 samples received. Suppplemental COC received to document the additional 3 samples.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

Enthalpy Analytical

Job No.: 0821-801-1 PFAS by Isotope Dilution
(non-potable water)

ECT2   3M CG

QA 10-22-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-INF-A (RO-REJ)-2-20210825	3MCG-Test 01_B-GAC1-A-20210825 ng/L	3MCG-Test 01_B-GAC1-A-2-20210825 ng/L	3MCG-Test 01_B-GAC2-A-20210825 ng/L	3MCG-Test 01_B-GAC2-A-2-20210825 ng/L
Acids	PFBA	375-22-4	16900	29200	34500	32600	34200
	PFPeA	2706-90-3	1240 J	1390 J	2090	<LOD (1060) U	<LOD (1060) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	105000	<LOD (5000) U	5650	<LOD (5000) U	<LOD (5000) U
	PFPA	422-64-0	11800	10600	10900	13200	9490
	TFA	76-05-1	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U
	TFMS	1493-13-6	37000	33900	41000	40600	40800

QA Notes:

Initial COC detailed 18 of the 21 samples received. Suppplemental COC received to document the additional 3 samples.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

Enthalpy Analytical

Job No.: 0821-801-1 PFAS by Isotope Dilution (non-potable water)

ECT2   3M CG

QA 10-22-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX1-A-20210825 ng/L	3MCG-Test 01_B-IX1-A-2-20210825 ng/L	3MCG-Test 01_B-IX2-A-20210825 ng/L	3MCG-Test 01_B-IX2-A-2-20210825 ng/L	3MCG-Test 01_B-IXR1-B-20210825 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Initial COC detailed 18 of the 21 samples received. Suppplemental COC received to document the additional 3 samples.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

Enthalpy Analytical

Job No.: 0821-801-1 PFAS by Isotope Dilution
(non-potable water)

ECT2   3M CG

QA 10-22-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR1-B-2-20210825 ng/L	3MCG-Test 01_B-IXR2-B-20210825 ng/L	3MCG-Test 01_B-IXR2-B-2-20210825 ng/L	3MCG-Test 01_B-INF-C (RO PERM)-20210825	3MCG-Test 01_B-IX1-C-20210825 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Initial COC detailed 18 of the 21 samples received. Suppplemental COC received to document the additional 3 samples.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

Enthalpy Analytical

Job No.: 0821-801-1 PFAS by Isotope Dilution
(non-potable water)

ECT2   3M CG

QA 10-22-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX2-C-20210825 ng/L
Acids	PFBA	375-22-4	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U
	TFA	76-05-1	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U

QA Notes:

Initial COC detailed 18 of the 21 samples received. Suppplemental COC received to document the additional 3 samples.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

Enthalpy Analytical

Job No.: 0821-804-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG- Cottage Grove, MN

QA 10-22-2021 - LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210826 ng/L	3MCG-Test 01_B-UF-PERM-20210826 ng/L	3MCG-Test 01_B-INF-A (RO REJ)-20210826 ng/L	3MCG-Test 01_B-GAC1-A-20210826 ng/L	3MCG-Test 01_B-GAC2-A-20210826 ng/L
Acids	PFBA	375-22-4	<LOD (956) U	565	15800	29600	29800
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	1320 J	1890 J	<LOD (1060) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (5000) U	5700	104000	5270	<LOD (5000) U
	PFPA	422-64-0	<LOD (3500) U	2370	10800	14600	9000
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U
	TFMS	1493-13-6	6670	5570	38400	37400	35300

QA NOTES:

Legacy compounds reported from two batches, sample 007 required re-DJ for ES label detection.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-804-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG- Cottage Grove, MN

QA 10-22-2021 - LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX1-A-20210826 ng/L	3MCG-Test 01_B-IX2-A-20210826 ng/L	3MCG-Test 01_B-IXR1-B-20210826 ng/L	3MCG-Test 01_B-IXR2-B-20210826 ng/L	3MCG-Test 01_B-UF-INF-2-20210826 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (956) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (1060) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (1210) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (762) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (1190) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	1230	<LOD (752) U	1220	<LOD (752) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (3500) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (3500) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	6910

QA NOTES:

Legacy compounds reported from two batches, sample 007 required re-DJ for ES label detection.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-804-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG- Cottage Grove, MN

QA 10-22-2021 - LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-PERM-2-20210826 ng/L	3MCG-Test 01_B-INF-A (RO REJ)-2-20210826	3MCG-Test 01_B-GAC1-A-2-20210826 ng/L	3MCG-Test 01_B-GAC2-A-2-20210826 ng/L	3MCG-Test 01_B-IX1-A-2-20210826 ng/L
Acids	PFBA	375-22-4	626	13400	26600	32600	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (1060) U	1860 J	<LOD (1060) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (1210) U	<LOD (1210) U	<LOD (1210) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (2220) U	<LOD (2220) U	<LOD (2220) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	1300
	HQ-115	90076-65-6	3340	91100	5160	<LOD (5000) U	<LOD (1000) U
	PFPA	422-64-0	2370	11700	10800	16500	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	<LOD (700) U
	TFMS	1493-13-6	6180	35900	34500	38400	<LOD (1000) U

QA NOTES:

Legacy compounds reported from two batches, sample 007 required re-DJ for ES label detection.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

QC passed all criteria

Enthalpy Analytical

Job No.: 0821-804-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG- Cottage Grove, MN

QA 10-22-2021 - LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX2-A-2-20210826 ng/L	3MCG-Test 01_B-IXR1-B-2-20210826 ng/L	3MCG-Test 01_B-IXR2-B-2-20210826 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	1350	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	12100	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA NOTES:

Legacy compounds reported from two batches, sample 007 required re-DJ for ES label detection.

JS is not spiked into the 3M direct injects, therefore the ES recoveries are zero in the report.

QC passed all criteria

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210827 ng/L	3MCG-Test 01_B-UF-PERM-20210827 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210827	3MCG-Test 01_B-GAC1-A-20210827 ng/L	3MCG-Test 01_B-GAC2-A-20210827 ng/L	3MCG-Test 01_B-IX1-A-20210827 ng/L	3MCG-Test 01_B-IX2-A-20210827 ng/L
Acids	PFBA	375-22-4	<LOD (1910) U	570	13200	19300	26100	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	752	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	1260	<LOD (752) U
	HQ-115	90076-65-6	27000	5530	81800	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (7000) U	1470 J	10200 J	9210 J	12200 J	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (10000) U	4140	28600	26000	23500	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR1-B-20210827 ng/L	3MCG-Test 01_B-IXR2-B-20210827 ng/L	3MCG-Test 01_B-INF-C (RO PERM)-20210827	3MCG-Test 01_B-IX1-C-20210827 ng/L	3MCG-Test 01_B-IX2-C-20210827 ng/L	3MCG-Test 01_B-UF-INF-2-20210827 ng/L	3MCG-Test 01_B-UF-PERM-2-20210827 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (1910) U	756
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	12900	17700 IR
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	1320	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (7520) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	10700	11700
	PFPA	422-64-0	2950	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	2060
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	4310

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

other	Compound	CAS	3MCG-Test 01_B-INF-A (RO-REJ)-2-20210827	3MCG-Test 01_B-GAC1-A-2-20210827 ng/L	3MCG-Test 01_B-GAC2-A-2-20210827 ng/L	3MCG-Test 01_B-IX1-A-2-20210827 ng/L	3MCG-Test 01_B-IX2-A-2-20210827 ng/L	3MCG-Test 01_B-IXR1-B-2-20210827 ng/L	3MCG-Test 01_B-IXR2-B-2-20210827 ng/L
Acids	PFBA	375-22-4	12800	19200	26500	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	1300	<LOD (752) U	1130	<LOD (752) U
	HQ-115	90076-65-6	78600	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (7000) U	8290 J	11000 J	<LOD (700) U	<LOD (700) U	1830	<LOD (700) U
	TFA	76-05-1	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	25500	22800	26000	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210828 ng/L	3MCG-Test 01_B-UF-PERM-20210828 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210828	3MCG-Test 01_B-GAC1-A-20210828 ng/L	3MCG-Test 01_B-GAC2-A-20210828 ng/L	3MCG-Test 01_B-IX1-A-20210828 ng/L	3MCG-Test 01_B-IX2-A-20210828 ng/L
Acids	PFBA	375-22-4	<LOD (1910) U	753	11200	15600	18700	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	3100	<LOD (4440) U	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	1040	1690
	HQ-115	90076-65-6	<LOD (10000) U	5760	79300	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (7000) U	2250	8120 J	8430 J	<LOD (7000) U	<LOD (700) U	<LOD (700) U
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (10000) U	6060	31900	32200	28600	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR1-B-20210828 ng/L	3MCG-Test 01_B-IXR2-B-20210828 ng/L	3MCG-Test 01_B-UF-INF-2-20210828 ng/L	3MCG-Test 01_B-UF-PERM-2-20210828 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-2-20210828	3MCG-Test 01_B-GAC1-A-2-20210828 ng/L	3MCG-Test 01_B-GAC2-A-2-20210828 ng/L
Acids	PFBA	375-22-4	643	<LOD (191) U	<LOD (1910) U	767	11700	13600	20100
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (4440) U	4230	<LOD (4440) U-IR	<LOD (4440) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	1100	<LOD (752) U	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	7150	82800	<LOD (10000) U	<LOD (10000) U
	PFPA	422-64-0	7030	<LOD (700) U	<LOD (7000) U	2010	<LOD (7000) U	34300	9100 J
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	5650	32200	30800	36400

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX1-A-2-20210828 ng/L	3MCG-Test 01_B-IX2-A-2-20210828 ng/L	3MCG-Test 01_B-IXR1-B-2-20210828 ng/L	3MCG-Test 01_B-IXR2-B-2-20210828 ng/L	3MCG-Test 01_B-UF-INF-20210829 ng/L	3MCG-Test 01_B-UF-PERM-20210829 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210829
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	961	<LOD (191) U	<LOD (1910) U	1250	15600
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U	3280	5010
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	970	1060	1140	<LOD (752) U	<LOD (7520) U	<LOD (752) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	6180	102000
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	7690	<LOD (700) U	<LOD (7000) U	3570	9480 J
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	8180	41900

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-GAC1-A-20210829 ng/L	3MCG-Test 01_B-GAC2-A-20210829 ng/L	3MCG-Test 01_B-IX1-A-20210829 ng/L	3MCG-Test 01_B-IX2-A-20210829 ng/L	3MCG-Test 01_B-IXR1-B-20210829 ng/L	3MCG-Test 01_B-IXR2-B-20210829 ng/L	3MCG-Test 01_B-UF-INF-20210830 ng/L
	PFBA	375-22-4	16000	17300	<LOD (191) U	<LOD (191) U	2510	<LOD (191) U	<LOD (1910) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U
Acids	PFHxA	307-24-4	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U
	PFBS	375-73-5	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U
Sulfonates	PFHxS	355-46-4	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U
	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (7520) U	1170	1060	1150	<LOD (752) U	<LOD (7520) U
other	HQ-115	90076-65-6	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U
	PFPA	422-64-0	10100 J	10800 J	<LOD (700) U	<LOD (700) U	11000	<LOD (700) U	<LOD (7000) U
	TFA	76-05-1	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	35700	36500	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-PERM-20210830 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210830	3MCG-Test 01_B-GAC1-A-20210830 ng/L	3MCG-Test 01_B-GAC2-A-20210830 ng/L	3MCG-Test 01_B-IX1-A-20210830 ng/L	3MCG-Test 01_B-IX2-A-20210830 ng/L	3MCG-Test 01_B-IXR1-B-20210830 ng/L
Acids	PFBA	375-22-4	1320	10800	16100	16400	<LOD (191) U	<LOD (191) U	5000
	PFPeA	2706-90-3	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U-IR	<LOD (221) U
Sulfonates	PFBS	375-73-5	1120	11400	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	1110	961	1170
	HQ-115	90076-65-6	5550	81400	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	3430	8420 J	13900 J	13000 J	<LOD (700) U	<LOD (700) U	11200
	TFA	76-05-1	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	7860	33900	35100	35900	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR2-B-20210830 ng/L	3MCG-Test 01_B-INF-C (RO PERM)-20210830	3MCG-Test 01_B-IX1-C-20210830 ng/L	3MCG-Test 01_B-IX2-C-20210830 ng/L	3MCG-Test 01_B-UF-INF-2-20210830 ng/L	3MCG-Test 01_B-UF-PERM-2-20210830 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-2-20210830
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (1910) U	1340	9530
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U	<LOD (444) U-IR	15300
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	953	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (7520) U	<LOD (752) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	1720	74400
	PFPA	422-64-0	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	2690	17300
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	7140	38200

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-700-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA completed 11-5-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-GAC1-A-2-20210830 ng/L	3MCG-Test 01_B-GAC2-A-2-20210830 ng/L	3MCG-Test 01_B-IX1-A-2-20210830 ng/L	3MCG-Test 01_B-IX2-A-2-20210830 ng/L	3MCG-Test 01_B-IXR1-B-2-20210830 ng/L	3MCG-Test 01_B-IXR2-B-2-20210830 ng/L
Acids	PFBA	375-22-4	15500	16600	<LOD (191) U	<LOD (191) U	4880	<LOD (191) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (7520) U	1130	1030	1180	1010
	HQ-115	90076-65-6	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	12100 J	15400	<LOD (700) U	<LOD (700) U	9570	<LOD (700) U
	TFA	76-05-1	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	31500	38200	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Samples: 3MCG-Test 01_B-IX1-A-20210829 (045), 3MCG-Test 01_B-IXR2-B-20210829 (48), and 3MCG-Test 01_B-IX2-A-20210830 (55) were vortexed and reinjected due to ES recoveries outside method criteria for the legacy analytes. All legacy analytes reported from the reinjection.

Enthalpy Analytical

Job No.: 0921-702-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA date: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-INF-A (RO REJ)-20210831 ng/L	3MCG-Test 01_B-UF-PERM-20210831 ng/L	3MCG-Test 01_B-UF-INF-20210831 ng/L	3MCG-Test 01_B-IX1-A-20210831 ng/L	3MCG-Test 01_B-GAC2-A-20210831 ng/L
Acids	PFBA	375-22-4	11500	1300	<LOD (1910) U	<LOD (191) U	12100
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	17100	<LOD (444) U	<LOD (4440) U	<LOD (444) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	1020	<LOD (7520) U
	HQ-115	90076-65-6	84900	1310	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U
	PFPA	422-64-0	19700	2590	7520 J	<LOD (700) U	23000
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	40600	6690	<LOD (10000) U	<LOD (1000) U	31500

QA NOTES:

Samples 001-011 in prep batch 12246; samples 012 -018 in prep batch 12247. Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Sample 16 experienced insufficient ES recoveries and was vortex, then re-injected to report the Legacy compounds.

Enthalpy Analytical

Job No.: 0921-702-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA date: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-GAC1-A-20210831 ng/L	3MCG-Test 01_B-IX2-A-20210831 ng/L	3MCG-Test 01_B-IXR1-B-20210831 ng/L	3MCG-Test 01_B-IXR2-B-20210831 ng/L	3MCG-Test 01_B-UF-INF-2-20210831 ng/L
Acids	PFBA	375-22-4	12000	<LOD (191) U	8170	<LOD (191) U	<LOD (1910) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	1150	1250	1030	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U
	PFPA	422-64-0	11000 J	<LOD (700) U	11100	<LOD (700) U	<LOD (7000) U
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U
	TFMS	1493-13-6	34700	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U

QA NOTES:

Samples 001-011 in prep batch 12246; samples 012 -018 in prep batch 12247. Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Sample 16 experienced insufficient ES recoveries and was vortex, then re-injected to report the Legacy compounds.

Enthalpy Analytical

Job No.: 0921-702-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA date: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-PERM-2-20210831 ng/L	3MCG-Test 01_B-INF-A (RO REJ)-2-20210831	3MCG-Test 01_B-GAC1-A-2-20210831 ng/L	3MCG-Test 01_B-GAC2-A-2-20210831 ng/L	3MCG-Test 01_B-IX1-A-2-20210831 ng/L
Acids	PFBA	375-22-4	1640	10900	10900	<LOD (1910) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	16900	<LOD (4440) U	<LOD (4440) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	1120
	HQ-115	90076-65-6	1050	76500	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U
	PFPA	422-64-0	2670	17000	11300 J	<LOD (7000) U	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U
	TFMS	1493-13-6	8040	43400	31500	<LOD (10000) U	<LOD (1000) U

QA NOTES:

Samples 001-011 in prep batch 12246; samples 012 -018 in prep batch 12247. Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Sample 16 experienced insufficient ES recoveries and was vortex, then re-injected to report the Legacy compounds.

Enthalpy Analytical

Job No.: 0921-702-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA date: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX2-A-2-20210831 ng/L	3MCG-Test 01_B-IXR1-B-2-20210831 ng/L	3MCG-Test 01_B-IXR2-B-2-20210831 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	8580	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	1170	1170	1160
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (700) U	10900	<LOD (700) U
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA NOTES:

Samples 001-011 in prep batch 12246; samples 012 -018 in prep batch 12247. Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Sample 16 experienced insufficient ES recoveries and was vortex, then re-injected to report the Legacy compounds.

Enthalpy Analytical

Job No.: 0921-713-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove

QA complete: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210901 ng/L	3MCG-Test 01_B-UF-PERM-20210901 ng/L	3MCG-Test 01_B-INF-A (RO REJ)-20210901 ng/L	3MCG-Test 01_B-GAC1-A-20210901 ng/L	3MCG-Test 01_B-GAC2-A-20210901 ng/L	3MCG-Test 01_B-IX1-A-20210901 ng/L	3MCG-Test 01_B-IX2-A-20210901 ng/L	3MCG-Test 01_B-IXR1-B-20210901 ng/L
Acids	PFBA	375-22-4	<LOD (1910) U	1590	8180	9730	11400	<LOD (191) U	<LOD (191) U	11500
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	1020	12900	<LOD (4440) U	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U	983	1270	1270
	HQ-115	90076-65-6	<LOD (10000) U	2040	60600	<LOD (10000) U	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	<LOD (7000) U	2570	8820 J	8770 J	13600 J	<LOD (700) U	<LOD (700) U	10300
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (10000) U	6530	29100	30100	27500	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Initial prep batch ID: 12252

Samples 007 and 008 showed decreased recovery for ES compounds and were re-direct injected in Batch 12291.

Reinject batch 12294: PFBS, PFHpS, and PFOS fell above method recovery criteria but samples 007 and 008 were non-detect for these compounds.

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Enthalpy Analytical

Job No.: 0921-713-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove

QA complete: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IXR2-B-20210901 ng/L	3MCG-Test 01_B-INF-C (RO PERM)-20210901	3MCG-Test 01_B-IX1-C-20210901 ng/L	3MCG-Test 01_B-IX2-C-20210901 ng/L	3MCG-Test 01_B-UF-INF-2-20210901 ng/L	3MCG-Test 01_B-UF-PERM-2-20210901 ng/L	3MCG-Test 01_B-INF-A (RO REJ)-2-20210901	3MCG-Test 01_B-GAC1-A-2-20210901 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (191) U	<LOD (1910) U	1460	8530	11300
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (4440) U	<LOD (444) U	14700	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	1080	<LOD (752) U	<LOD (752) U	<LOD (752) U	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	1560	57100	<LOD (10000) U
	PFPA	422-64-0	3190	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	2670	11100 J	10200 J
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (10000) U	6310	29700	31300

QA Notes:

Initial prep batch ID: 12252

Samples 007 and 008 showed decreased recovery for ES compounds and were re-direct injected in Batch 12291.

Reinject batch 12294: PFBS, PFHpS, and PFOS fell above method recovery criteria but samples 007 and 008 were non-detect for these compounds.

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Enthalpy Analytical

Job No.: 0921-713-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove

QA complete: 11-9-2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-GAC2-A-2-20210901 ng/L	3MCG-Test 01_B-IX1-A-2-20210901 ng/L	3MCG-Test 01_B-IX2-A-2-20210901 ng/L	3MCG-Test 01_B-IXR1-B-2-20210901 ng/L	3MCG-Test 01_B-IXR2-B-2-20210901 ng/L
Acids	PFBA	375-22-4	11600	<LOD (191) U	<LOD (191) U	11800	<LOD (191) U
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	1120	1080	1070	1210
	HQ-115	90076-65-6	<LOD (10000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	12900 J	<LOD (700) U	<LOD (700) U	10500	4530
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	33700	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Initial prep batch ID: 12252

Samples 007 and 008 showed decreased recovery for ES compounds and were re-direct injected in Batch 12291.

Reinject batch 12294: PFBS, PFHpS, and PFOS fell above method recovery criteria but samples 007 and 008 were non-detect for these compounds.

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Enthalpy Analytical

Job No.: 0921-719-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA complete: 11/9/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-UF-INF-20210902 ng/L	3MCG-Test 01_B-UF-PERM-20210902 ng/L	3MCG-Test 01_B-INF-A (RO-REJ)-20210902 ng/L	3MCG-Test 01_B-GAC1-A-20210902 ng/L	3MCG-Test 01_B-GAC2-A-20210902 ng/L
Acids	PFBA	375-22-4	<LOD (1910) U	1640	7890	9120	9160
	PFPeA	2706-90-3	<LOD (2120) U	<LOD (212) U	<LOD (2120) U	<LOD (2120) U	<LOD (2120) U
	PFHxA	307-24-4	<LOD (2410) U	<LOD (241) U	<LOD (2410) U	<LOD (2410) U	<LOD (2410) U
	PFHpA	375-85-9	<LOD (1520) U	<LOD (152) U	<LOD (1520) U	<LOD (1520) U	<LOD (1520) U
	PFOA	335-67-1	<LOD (2210) U	<LOD (221) U	<LOD (2210) U	<LOD (2210) U	<LOD (2210) U
Sulfonates	PFBS	375-73-5	<LOD (4440) U	<LOD (444) U	9200	<LOD (4440) U	<LOD (4440) U
	PFPeS	2706-91-4	<LOD (2580) U	<LOD (258) U	<LOD (2580) U	<LOD (2580) U	<LOD (2580) U
	PFHxS	355-46-4	<LOD (2390) U	<LOD (239) U	<LOD (2390) U	<LOD (2390) U	<LOD (2390) U
	PFHpS	375-92-8	<LOD (1690) U	<LOD (169) U	<LOD (1690) U	<LOD (1690) U	<LOD (1690) U
	PFOS	1763-23-1	<LOD (2000) U	<LOD (200) U	<LOD (2000) U	<LOD (2000) U	<LOD (2000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (10000) U	<LOD (1000) U	<LOD (10000) U	<LOD (10000) U	<LOD (10000) U
	2,3,3,3 TFPA	359-49-9	<LOD (7520) U	<LOD (752) U	<LOD (7520) U	<LOD (7520) U	<LOD (7520) U
	HQ-115	90076-65-6	<LOD (10000) U	<LOD (1000) U	56700	<LOD (10000) U	<LOD (10000) U
	PFPA	422-64-0	<LOD (7000) U	2290	12500 J	8100 J	10900 J
	TFA	76-05-1	<LOD (7000) U	<LOD (700) U	<LOD (7000) U	<LOD (7000) U	<LOD (7000) U
	TFMS	1493-13-6	<LOD (10000) U	6540	29300	28000	27000

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Enthalpy Analytical

Job No.: 0921-719-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M CG

QA complete: 11/9/2021 LKB

Summary

	Compound	CAS	3MCG-Test 01_B-IX1-A-20210902 ng/L	3MCG-Test 01_B-IX2-A-20210902 ng/L	3MCG-Test 01_B-IXR1-B-20210902 ng/L	3MCG-Test 01_B-IXR2-B-20210902 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	12800	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	1280	1220	1280	1220
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	964 J	<LOD (700) U	9730	6630
	TFA	76-05-1	<LOD (700) U	<LOD (700) U	<LOD (700) U	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U

QA Notes:

Due to acquisition requirements for analytes requested, the sample was analyzed in more than one sequence.

CG additional compounds were run using a single point calibration.

Enthalpy Analytical

Job No.: 0921-777-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA Review: 12/1/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-UF-INF-20210914 ng/L	3MCG-Test 02-UF-PERM-20210914 ng/L	3MCG-Test 02-D.0-INF (RO-REJ)-20210914 ng/L	3MCG-Test 02-D.1-GAC1-20210914 ng/L	3MCG-Test 02-D.2-GAC2-20210914 ng/L	3MCG-Test 02-D.3-IX1-20210914 ng/L	3MCG-Test 02-D.4-IX2-20210914 ng/L	3MCG-Test 02-E.3-IXR1-20210914 ng/L	3MCG-Test 02-E.4-IXR2-20210914 ng/L	3MCG-Test 02-D.0-INF (RO REJ)-20210915-1300 ng/L	3MCG-Test 02-D.1-GAC1-20210915-1245 ng/L
Acids	PFBA	375-22-4	2340	2080	14500	ND (322) U	ND (336) U	ND (65.1) U	ND (68.3) U	ND (75.3) U	ND (74.6) U	16100	1040 J
	PFPeA	2706-90-3	ND (1062) U	ND (212) U	40.2 L	ND (1062) U	ND (1062) U	ND (212) U	ND (212) U	ND (212) U	ND (212) U	ND (1062) U	313 L
	PFHxA	307-24-4	ND (1206) U	ND (241) U	ND (1206) U	ND (1206) U	ND (1206) U	ND (241) U	ND (241) U	ND (241) U	ND (241) U	ND (1206) U	ND (1206) U
	PFHpA	375-85-9	ND (762) U	ND (152) U	ND (762) U	ND (762) U	ND (762) U	ND (152) U	ND (152) U	ND (152) U	ND (152) U	ND (762) U	186 L
	PFOA	335-67-1	ND (1106) U	ND (221) U	320 L	ND (1106) U	ND (1106) U	ND (221) U	ND (221) U	ND (221) U	ND (221) U	614 L	755 L
Sulfonates	PFBS	375-73-5	16200	15200	136000	ND (2219) U	ND (2219) U	ND (444) U	ND (444) U	ND (444) U	ND (444) U	143000	ND (2219) U
	PFPeS	2706-91-4	ND (1288) U	ND (258) U	ND (1288) U	ND (1288) U	ND (1288) U	ND (258) U	ND (258) U	ND (258) U	ND (258) U	ND (1288) U	494 L
	PFHxS	355-46-4	ND (1194) U	ND (239) U	91.3 L	ND (1194) U	ND (1194) U	ND (239) U	ND (239) U	ND (239) U	ND (239) U	295 L	34.7 L
	PFHpS	375-92-8	ND (844) U	ND (169) U	ND (844) U	ND (844) U	ND (844) U	ND (169) U	ND (169) U	ND (169) U	ND (169) U	ND (844) U	ND (844) U
	PFOS	1763-23-1	204 L	ND (200) U	ND (1000) U	ND (1000) U	ND (1000) U	ND (200) U	ND (200) U	ND (200) U	ND (200) U	ND (1000) U	ND (1000) U
other	2,2,3,3-TFPA	756-09-2	ND (12161) U	ND (2281) U	ND (15037) U	ND (12960) U	ND (15648) U	ND (2747) U	ND (2462) U	ND (2592) U	ND (2474) U	ND (16105) U	ND (13778) U
	2,3,3,3 TFPA	359-49-9	ND (8517) U	1610	7300	7640	7920	ND (4507) U	ND (4337) U	ND (3906) U	ND (4422) U	6880	8910
	HQ-115	90076-65-6	17000	15000	133000	ND (41) U	0.762 LB	0.0340 LB	0.687 LB	1.74 LB	0.115 LB	146000	69.0 LB
	PFPA	422-64-0	ND (39382) U	ND (5772) U	ND (16207) U	ND (45731) U	ND (23723) U	17800	ND (4864) U	ND (7593) U	ND (24948) U	14200	ND (45881) U
	TFA	76-05-1	ND (50322) U	ND (4886) U	ND (74293) U	ND (20) U	ND (56686) U	ND (24553) U	ND (7893) U	ND (16108) U	ND (25017) U	ND (24.2) U	ND (99379) U
	TFMS	1493-13-6	166000	101000	843000	59900	ND (610) U	ND (106) U	ND (138) U	ND (154) U	ND (135) U	933000	740000

QA Notes:
The samples were extracted within the 28-day from collection holding time.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

Samples analyzed by direct inject methodology utilizing 10 - 120uL of sample fortified by ES for legacy compounds.
CG additional compounds were analyzed using a single point calibration.

Batch prep ID 12326: samples 001 - 020
PFPA, TFA, 2333-TFA: samples 006-009, 013-016, and 020 were reinjected at a x20 dilution to report these analytes.
PFOS and PFHpS: Low ES area count in samples 007 and 008 necessitated a re-extraction for these analytes. They are reported in from the analysis of batch prep ID: 12383.

Batch prep ID 12327: samples 021 - 040
Samples 021-023. 028-030, and 035-038 required a x10 dilution to report PFPA, TFA, 2333-TFA. Samples 024-025, 027 and 031-034 required a x5 dilution to report these analytes.
Sample 026 was re-extracted in prep batch 12354 to report PFOS and PFHpS due to low ES M8PFOS area. All polar analytes were reported from this extraction batch analysis: PFPA, TFA, 2333-TFA

Batch prep ID 12358: samples 041 - 042
PFPeS fell above the method recovery criteria in the OPR. All samples were non-detects for this analyte and the data was accepted.

Analyte(s) were detected in the method blank (MB) at or below 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Enthalpy Analytical

Job No.: 0921-777-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA Review: 12/1/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.2-GAC2-20210915-1230 ng/L	3MCG-Test 02-D.3-IX1-20210915-1155 ng/L	3MCG-Test 02-D.4-IX2-20210915-1055 ng/L	3MCG-Test 02-E.3-IXR1-20210915-1155 ng/L	3MCG-Test 02-E.4-IXR2-20210915-1056 ng/L	3MCG-Test 02-D.0-INF (RO REJ)-20210915-1645 ng/L	3MCG-Test 02-D.1-GAC1-20210915-1635 ng/L	3MCG-Test 02-D.2-GAC2-20210915-1625 ng/L	3MCG-Test 02-D.3-IX1-20210915-1610 ng/L	3MCG-Test 02-D.4-IX2-20210915-1600 ng/L	3MCG-Test 02-E.3-IXR1-20210915-1610 ng/L
Acids	PFBA	375-22-4	ND (344) U	ND (71.7) U	ND (68.6) U	ND (67) U	ND (60.9) U	14500	ND (324) U	ND (309) U	ND (71) U	ND (68.7) U	ND (62.3) U
	PFPeA	2706-90-3	ND (1062) U	ND (212) U	ND (212) U	ND (212) U	ND (212) U	92.3 L	ND (1062) U	ND (1062) U	ND (212) U	ND (212) U	ND (212) U
	PFHxA	307-24-4	ND (1206) U	ND (241) U	ND (241) U	ND (241) U	ND (241) U	ND (1206) U	ND (1206) U	ND (1206) U	ND (241) U	ND (241) U	ND (241) U
	PFHpA	375-85-9	ND (762) U	ND (152) U	ND (152) U	ND (152) U	ND (152) U	ND (762) U	ND (762) U	ND (762) U	ND (152) U	ND (152) U	ND (152) U
	PFOA	335-67-1	ND (1106) U	ND (221) U	ND (221) U	ND (221) U	ND (221) U	ND (1106) U	ND (1106) U	ND (1106) U	ND (221) U	ND (221) U	ND (221) U
Sulfonates	PFBS	375-73-5	ND (2219) U	ND (444) U	ND (444) U	ND (444) U	ND (444) U	94000	ND (2219) U	ND (2219) U	ND (444) U	ND (444) U	ND (444) U
	PFPeS	2706-91-4	ND (1288) U	ND (258) U	ND (258) U	ND (258) U	ND (258) U	ND (1288) U	ND (1288) U	ND (1288) U	ND (258) U	ND (258) U	ND (258) U
	PFHxS	355-46-4	ND (1194) U	ND (239) U	ND (239) U	ND (239) U	ND (239) U	ND (1194) U	ND (1194) U	ND (1194) U	ND (239) U	ND (239) U	ND (239) U
	PFHpS	375-92-8	ND (844) U	ND (169) U	ND (169) U	ND (169) U	ND (169) U	ND (844) U	ND (844) U	ND (844) U	ND (169) U	ND (169) U	ND (169) U
	PFOS	1763-23-1	ND (1000) U	ND (200) U	ND (200) U	ND (200) U	ND (200) U	ND (1000) U	ND (1000) U	ND (1000) U	ND (200) U	ND (200) U	ND (200) U
other	2,2,3,3-TFPA	756-09-2	ND (17411) U	ND (2327) U	ND (2785) U	ND (2126) U	ND (2850) U	ND (18334) U	ND (14923) U	ND (17957) U	ND (3428) U	ND (2537) U	ND (2516) U
	2,3,3,3 TFPA	359-49-9	6510	ND (4626) U	ND (4312) U	ND (3464) U	ND (5051) U	ND (15723) U	ND (16581) U	ND (24748) U	ND (4046) U	ND (4363) U	ND (4142) U
	HQ-115	90076-65-6	7.94 LB	ND (6.81) U	0.224 LB	0.0808 LB	4.23 LB	128000	4.18 LB	0.640 LB	1.80 LB	ND (18.6) U	ND (5.97) U
	PFPA	422-64-0	ND (18902) U	ND (7094) U	11000	7380	12400	ND (28416) U	ND (11724) U	ND (15864) U	ND (6012) U	7000	ND (6305) U
	TFA	76-05-1	ND (54923) U	ND (13551) U	ND (24871) U	ND (14260) U	ND (19918) U	ND (109136) U	ND (18994) U	ND (6328) U	ND (24487) U	ND (9712) U	ND (13578) U
	TFMS	1493-13-6	487000	ND (116) U	ND (135) U	ND (99) U	ND (143) U	827000	794000	577000	ND (132) U	ND (132) U	ND (110) U

QA Notes:
The samples were extracted within the 28-day from collection holding time.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

Samples analyzed by direct inject methodology utilizing 10 - 120uL of sample fortified by ES for legacy compounds.
CG additional compounds were analyzed using a single point calibration.

Batch prep ID 12326: samples 001 - 020
PFPA, TFA, 2333-TFA: samples 006-009, 013-016, and 020 were reinjected at a x20 dilution to report these analytes.
PFOS and PFHpS: Low ES area count in samples 007 and 008 necessitated a re-extraction for these analytes. They are reported in from the analysis of batch prep ID: 12383.

Batch prep ID 12327: samples 021 - 040
Samples 021-023. 028-030, and 035-038 required a x10 dilution to report PFPA, TFA, 2333-TFA. Samples 024-025, 027 and 031-034 required a x5 dilution to report these analytes. Sample 026 was re-extracted in prep batch 12354 to report PFOS and PFHpS due to low ES M8PFOS area. All polar analytes were reported from this extraction batch analysis: PFPA, TFA, 2333-TFA

Batch prep ID 12358: samples 041 - 042
PFPeS fell above the method recovery criteria in the OPR. All samples were non-detects for this analyte and the data was accepted.

Analyte(s) were detected in the method blank (MB) at or below 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Enthalpy Analytical

Job No.: 0921-777-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA Review: 12/1/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-E.4-IXR2-20210915-1600 ng/L	3MCG-Test 02-UF-PERM-20210916 ng/L	3MCG-Test 02-D.0-INF (RO-REJ)-20210916-0936 ng/L	3MCG-Test 02-D.1-GAC1-20210916-0918 ng/L	3MCG-Test 02-D.2-GAC2-20210916-0849 ng/L	3MCG-Test 02-D.3-IX1-20210916-0800 ng/L	3MCG-Test 02-D.4-IX2-20210916-0731 ng/L	3MCG-Test 02-E.3-IXR1-20210916-0800 ng/L	3MCG-Test 02-E.4-IXR2-20210916-0731 ng/L	3MCG-Test 02-D.0-INF (RO-REJ)-20210916-1628 ng/L
Acids	PFBA	375-22-4	ND (63.2) U	2450	20600	ND (246) U	ND (410) U	ND (84.8) U	ND (70.6) U	ND (59) U	ND (71.5) U	18700
	PFPeA	2706-90-3	ND (212) U	24.2 L	218 L	ND (1062) U	ND (1062) U	ND (212) U	ND (212) U	ND (212) U	ND (212) U	267 L
	PFHxA	307-24-4	ND (241) U	ND (241) U	ND (1206) U	ND (1206) U	ND (1206) U	ND (241) U	ND (241) U	ND (241) U	ND (241) U	ND (1206) U
	PFHpA	375-85-9	ND (152) U	ND (152) U	ND (762) U	ND (762) U	ND (762) U	ND (152) U	ND (152) U	ND (152) U	ND (152) U	ND (762) U
	PFOA	335-67-1	ND (221) U	ND (221) U	1150 J	ND (1106) U	ND (1106) U	ND (221) U	ND (221) U	ND (221) U	ND (221) U	ND (1106) U
Sulfonates	PFBS	375-73-5	ND (444) U	3570	133000	ND (2219) U	ND (2219) U	ND (444) U	ND (444) U	ND (444) U	ND (444) U	96100
	PFPeS	2706-91-4	ND (258) U	ND (258) U	ND (1288) U	ND (1288) U	ND (1288) U	ND (258) U	ND (258) U	ND (258) U	ND (258) U	ND (1288) U
	PFHxS	355-46-4	ND (239) U	ND (239) U	1210 J	ND (1194) U	ND (1194) U	ND (239) U	ND (239) U	ND (239) U	ND (239) U	524 L
	PFHpS	375-92-8	ND (169) U	ND (169) U	ND (844) U	ND (3375) U	ND (844) U	ND (169) U	ND (169) U	ND (169) U	ND (169) U	ND (844) U
	PFOS	1763-23-1	ND (200) U	ND (200) U	ND (1000) U	ND (4000) U	ND (1000) U	ND (200) U	ND (200) U	ND (200) U	ND (200) U	ND (1000) U
other	2,2,3,3-TFPA	756-09-2	ND (2647) U	ND (2910) U	ND (12988) U	ND (7828) U	ND (16359) U	ND (1955) U	ND (2642) U	ND (2549) U	ND (2269) U	ND (13926) U
	2,3,3,3 TFPA	359-49-9	ND (4932) U	ND (4422) U	ND (18111) U	ND (3163) U	ND (23011) U	ND (4131) U	ND (4184) U	ND (4789) U	ND (3353) U	ND (15284) U
	HQ-115	90076-65-6	ND (9.18) U	19800	257000	ND (21.3) U	ND (29.3) U	ND (8.47) U	ND (10.9) U	ND (6.43) U	ND (6.76) U	191000
	PFPA	422-64-0	5420	10100	44000	ND (14000) U	39100	ND (6201) U	ND (6204) U	ND (4287) U	ND (5043) U	39700
	TFA	76-05-1	ND (13241) U	ND (22060) U	ND (106061) U	ND (14000) U	ND (72521) U	ND (11396) U	ND (4.28) U	ND (19068) U	ND (12453) U	ND (55825) U
	TFMS	1493-13-6	ND (105) U	145000	1850000	1630000	1120000	ND (162) U	ND (86.7) U	ND (116) U	ND (102) U	1340000

QA Notes:
The samples were extracted within the 28-day from collection holding time.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

Samples analyzed by direct inject methodology utilizing 10 - 120uL of sample fortified by ES for legacy compounds.
CG additional compounds were analyzed using a single point calibration.

Batch prep ID 12326: samples 001 - 020
PFPA, TFA, 2333-TFA: samples 006-009, 013-016, and 020 were reinjected at a x20 dilution to report these analytes.
PFOS and PFHpS: Low ES area count in samples 007 and 008 necessitated a re-extraction for these analytes. They are reported in from the analysis of batch prep ID: 12383.

Batch prep ID 12327: samples 021 - 040
Samples 021-023. 028-030, and 035-038 required a x10 dilution to report PFPA, TFA, 2333-TFA. Samples 024-025, 027 and 031-034 required a x5 dilution to report these analytes. Sample 026 was re-extracted in prep batch 12354 to report PFOS and PFHpS due to low ES M8PFOS area. All polar analytes were reported from this extraction batch analysis: PFPA, TFA, 2333-TFA

Batch prep ID 12358: samples 041 - 042
PFPeS fell above the method recovery criteria in the OPR. All samples were non-detects for this analyte and the data was accepted.

Analyte(s) were detected in the method blank (MB) at or below 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Enthalpy Analytical

Job No.: 0921-777-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA Review: 12/1/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.1-GAC1-20210916-1615 ng/L	3MCG-Test 02-D.2-GAC2-20210916-1600 ng/L	3MCG-Test 02-D.3-IX1-20210916-1555 ng/L	3MCG-Test 02-D.4-IX2-20210916-1545 ng/L	3MCG-Test 02-E.3-IXR1-20210916-1555 ng/L	3MCG-Test 02-E.4-IXR2-20210916-1545 ng/L	3MCG-Test 02-F.0-INF-(RO PERM)-20210914 ng/L	3MCG-Test 02-F.1-IX1-20210914 ng/L	3MCG-Test 02-F.2-IX2-20210914 ng/L	3MCG-Test 02-UF-INF-20210916 ng/L
Acids	PFBA	375-22-4	ND (301) U	ND (314) U	ND (62.8) U	ND (60.9) U	ND (80.5) U	ND (55.8) U	ND (325) U	ND (298) U	ND (422) U	3160 B
	PFPeA	2706-90-3	ND (1062) U	ND (1062) U	ND (212) U	ND (212) U	ND (212) U	ND (212) U	ND (1062) U	ND (1062) U	ND (1062) U	ND (1062) U
	PFHxA	307-24-4	ND (1206) U	ND (1206) U	ND (241) U	ND (241) U	ND (241) U	ND (241) U	ND (1206) U	ND (1206) U	ND (1206) U	ND (1206) U
	PFHpA	375-85-9	ND (762) U	ND (762) U	ND (152) U	ND (152) U	ND (152) U	ND (152) U	ND (762) U	ND (762) U	ND (762) U	ND (762) U
	PFOA	335-67-1	ND (1106) U	ND (1106) U	ND (221) U	ND (221) U	ND (221) U	ND (221) U	ND (1106) U	ND (1106) U	ND (1106) U	ND (1106) U
Sulfonates	PFBS	375-73-5	ND (2219) U	ND (2219) U	ND (444) U	ND (444) U	ND (444) U	ND (444) U	ND (2219) U	ND (2219) U	ND (2219) U	2870
	PFPeS	2706-91-4	ND (1288) U	ND (1288) U	ND (258) U	ND (258) U	ND (258) U	ND (258) U	ND (1288) U	ND (1288) U	ND (1288) U	ND (1288) U
	PFHxS	355-46-4	ND (1194) U	ND (1194) U	ND (239) U	ND (239) U	ND (239) U	ND (239) U	ND (1194) U	ND (1194) U	ND (1194) U	ND (1194) U
	PFHpS	375-92-8	ND (844) U	ND (844) U	ND (169) U	ND (169) U	ND (169) U	ND (169) U	ND (844) U	ND (844) U	ND (844) U	ND (844) U
	PFOS	1763-23-1	ND (1000) U	ND (1000) U	ND (200) U	ND (200) U	ND (200) U	ND (200) U	ND (1000) U	ND (1000) U	ND (1000) U	1360 J
other	2,2,3,3-TFPA	756-09-2	ND (13029) U	ND (15192) U	ND (1882) U	ND (2344) U	ND (2878) U	ND (1726) U	ND (16601) U	ND (15439) U	ND (18454) U	ND (18780) U
	2,3,3,3 TFPA	359-49-9	ND (24153) U	ND (17999) U	ND (3390) U	ND (4340) U	ND (4556) U	ND (3617) U	ND (19247) U	ND (19805) U	ND (31656) U	ND (18966) U
	HQ-115	90076-65-6	ND (39) U	ND (33.2) U	ND (6.63) U	ND (16.3) U	ND (6.92) U	ND (9.4) U	91.9 L	ND (31.9) U	ND (36.7) U	18400
	PFPA	422-64-0	39400	105000	10600	ND (1231) U	ND (9073) U	8760	ND (82.1) U	ND (34405) U	ND (63771) U	1510 LB
	TFA	76-05-1	ND (76674) U	ND (132727) U	ND (19404) U	ND (17168) U	ND (28609) U	ND (3.84) U	ND (59415) U	ND (30961) U	ND (233046) U	ND (22854) U
	TFMS	1493-13-6	1120000	1090000	ND (93.8) U	ND (102) U	ND (84.2) U	ND (105) U	3090 L	ND (605) U	ND (728) U	112000

QA Notes:
The samples were extracted within the 28-day from collection holding time.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

Samples analyzed by direct inject methodology utilizing 10 - 120uL of sample fortified by ES for legacy compounds.
CG additional compounds were analyzed using a single point calibration.

Batch prep ID 12326: samples 001 - 020
PFPA, TFA, 2333-TFA: samples 006-009, 013-016, and 020 were reinjected at a x20 dilution to report these analytes.
PFOS and PFHpS: Low ES area count in samples 007 and 008 necessitated a re-extraction for these analytes. They are reported in from the analysis of batch prep ID: 12383.

Batch prep ID 12327: samples 021 - 040
Samples 021-023. 028-030, and 035-038 required a x10 dilution to report PFPA, TFA, 2333-TFA. Samples 024-025, 027 and 031-034 required a x5 dilution to report these analytes. Sample 026 was re-extracted in prep batch 12354 to report PFOS and PFHpS due to low ES M8PFOS area. All polar analytes were reported from this extraction batch analysis: PFPA, TFA, 2333-TFA

Batch prep ID 12358: samples 041 - 042
PFPeS fell above the method recovery criteria in the OPR. All samples were non-detects for this analyte and the data was accepted.

Analyte(s) were detected in the method blank (MB) at or below 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Enthalpy Analytical

Job No.: 0921-783-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete 12/2/2021 LKB

Summary

	Compound	CAS	3MCG-Test-02-D.0-INF (RO REJ)-20210917 ng/L	3MCG-Test-02-D.1-GAC1-20210917 ng/L	3MCG-Test-02-D.2-GAC2-20210917 ng/L	3MCG-Test-02-D.3-IX1-20210917 ng/L	3MCG-Test-02-D.4-IX2-20210917 ng/L	3MCG-Test-02-E.3-IXR1-20210917 ng/L	3MCG-Test-02-E.4-IXR2-20210917 ng/L	3MCG-Test-02-F.0-INF (RO PERM)-20210917 ng/L	3MCG-Test-02-F.1-IX1-20210917 ng/L	3MCG-Test-02-F.2-IX2-20210917 ng/L	3MCG-Test-02-D.0-INF (RO REJ) [2]-20210917 ng/L	3MCG-Test-02-D.1-GAC1 [2]-20210917 ng/L	3MCG-Test-02-D.2-GAC2 [2]-20210917 ng/L	3MCG-Test-02-D.3-IX1 [2]-20210917 ng/L
Acids	PFBA	375-22-4	22400	ND(113) U	ND(201) U	ND(210) U	ND(222) U	ND(333) U	ND(311) U	ND(11.8) U	ND(11.6) U	ND(169) U	16700	ND(199) U	ND(158) U	ND(255) U
	PFPeA	2706-90-3	604 L	ND(102) U	ND(144) U	ND(27.9) U	ND(18.3) U	ND(16.0) U	ND(20.9) U	ND(13.2) U	ND(20.3) U	ND(121) U	295 L	ND(123) U	ND(84.7) U	ND(16.0) U
	PFHxA	307-24-4	ND(59.6) U	ND(102) U	ND(22.0) U	ND(2.09) U	ND(8.40) U	ND(3.61) U	ND(13.5) U	ND(1.51) U	ND(2.24) U	ND(89.9) U	ND(712) U	ND(40.1) U	ND(51.5) U	ND(2.36) U
	PFHpA	375-85-9	ND(329) U	ND(131) U	ND(101) U	ND(20.2) U	ND(5.25) U	ND(4.82) U	ND(7.39) U	ND(10.3) U	ND(17.5) U	ND(235) U	ND(86.5) U	ND(95.1) U	ND(162) U	ND(3.41) U
	PFOA	335-67-1	2450 J	ND(285) U	ND(645) U	ND(9.96) U	ND(8.27) U	ND(7.69) U	ND(21.8) U	ND(45.7) U	ND(12.0) U	ND(669) U	1430 L	ND(273) U	ND(395) U	ND(20.4) U
Sulfonates	PFBS	375-73-5	104000	ND(76.5) U	ND(67.4) U	ND(5.27) U	ND(6.25) U	ND(6.01) U	ND(5.88) U	ND(6.25) U	ND(5.42) U	ND(99.1) U	75800	ND(124) U	ND(57.3) U	ND(6.17) U
	PFPeS	2706-91-4	ND(245) U	ND(27.7) U	ND(26.9) U	ND(3.99) U	ND(3.82) U	ND(4.77) U	ND(3.69) U	ND(4.02) U	ND(4.94) U	ND(7.99) U	ND(42.2) U	ND(11.7) U	ND(37.0) U	ND(2.75) U
	PFHxS	355-46-4	2600 J	ND(83.9) U	ND(22.6) U	ND(3.04) U	ND(5.00) U	ND(19.1) U	ND(4.46) U	ND(3.49) U	ND(6.89) U	ND(43.8) U	956 L	ND(54.3) U	ND(28.8) U	ND(3.51) U
	PFHpS	375-92-8	ND(1392) U	ND(43.2) U	ND(67.0) U	ND(5.64) U	ND(5.89) U	ND(6.69) U	ND(7.78) U	ND(4.87) U	ND(3.60) U	ND(41.9) U	ND(553) U	ND(459) U	ND(51.9) U	ND(6.92) U
	PFOS	1763-23-1	452 L	ND(51.9) U	ND(21.6) U	ND(7.97) U	ND(7.20) U	ND(3.31) U	ND(3.71) U	ND(4.71) U	ND(2.74) U	ND(64.1) U	ND(869) U	ND(265) U	ND(21.2) U	ND(8.93) U
other	2,2,3,3-TFPA	756-09-2	ND(8334) U	ND(6513) U	ND(7023) U	ND(9951) U	ND(8255) U	ND(9670) U	ND(9735) U	ND(556) U	ND(485) U	ND(5338) U	ND(5692) U	ND(6901) U	ND(7854) U	ND(6774) U
	2,3,3,3 TFPA	359-49-9	ND(2396) U	ND(2131) U	ND(2414) U	ND(3462) U	ND(2255) U	ND(2768) U	ND(2937) U	ND(131) U	ND(170) U	ND(1212) U	ND(2299) U	ND(2037) U	ND(2177) U	ND(3011) U
	HQ-115	90076-65-6	208000	ND(18.2) U	ND(11.7) U	10.0 LB	ND(20.9) U	ND(22.3) U	7.59 LB	124 L	ND(0.734) U	ND(7.21) U	151000	ND(16.2) U	ND(9.97) U	ND(18.6) U
	PFPA	422-64-0	18000	9740 J	4260 L	ND(700) U	ND(700) U	13100	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	13900 J	13200 J	11000 J	93200
	TFA	76-05-1	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U
	TFMS	1493-13-6	1660000	1220000	1190000	ND(489) U	ND(390) U	ND(427) U	ND(454) U	2150	42.8 L	ND(188) U	1410000	1420000	1190000	ND(361) U

QA Notes:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by direct inject method utilizing 10 - 120uL of sample fortified by ES for the legacy analytes.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

CG additional compounds were analyzed using a single point calibration.

Batch prep ID: 12337: samples 001 -020

Samples 001-007, 014-017 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12338: samples 021 -040

Samples 021-024, 028-031, 036-038 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA

Sample 035 was reprepped and analyzed in batch 12369 due to initial loss of ES labels.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12339: samples 041 -060

Samples 042-045, and 051-054 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12340: samples 061-064

Samples were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12369: sample 035

Sample were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Enthalpy Analytical

Job No.: 0921-783-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete 12/2/2021 LKB

Summary

	Compound	CAS	3MCG-Test-02-D.4-IX2 [2]-20210917 ng/L	3MCG-Test-02-E.3-IXR1 [2]-20210917 ng/L	3MCG-Test-02-E.4-IXR2 [2]-20210917 ng/L	3MCG-Test-02-D.0-INF (RO REJ)-20210918 ng/L	3MCG-Test-02-D.1-GAC1-20210918 ng/L	3MCG-Test-02-D.2-GAC2-20210918 ng/L	3MCG-Test-02-D.3-IX1-20210918 ng/L	3MCG-Test-02-D.4-IX2-20210918 ng/L	3MCG-Test-02-E.3-IXR1-20210918 ng/L	3MCG-Test-02-E.4-IXR2-20210918 ng/L	3MCG-Test-02-D.0-INF (RO REJ) [2]-20210918 ng/L	3MCG-Test-02-D.1-GAC1 [2]-20210918 ng/L	3MCG-Test-02-D.2-GAC2 [2]-20210918 ng/L	3MCG-Test-02-D.3-IX1 [2]-20210918 ng/L
Acids	PFBA	375-22-4	ND(388) U	ND(280) U	ND(290) U	15300	65.9 L	ND(272) U	ND(432) U	ND(408) U	ND(508) U	ND(649) U	18700	385 L	ND(230) U	ND(459) U
	PFPeA	2706-90-3	ND(24.8) U	ND(23.1) U	ND(17.6) U	399 L	ND(272) U	ND(88.6) U	ND(16.0) U	ND(23.2) U	ND(30.8) U	ND(20.4) U	424 L	ND(218) U	ND(176) U	ND(15.3) U
	PFHxA	307-24-4	ND(22.2) U	ND(7.85) U	ND(0.997) U	ND(12.4) U	ND(60.4) U	ND(14.6) U	ND(8.08) U	ND(23.7) U	ND(15.5) U	ND(3.75) U	ND(41.0) U	ND(73.8) U	ND(181) U	ND(3.10) U
	PFHpA	375-85-9	ND(17.4) U	ND(36.7) U	ND(1.96) U	ND(127) U	ND(171) U	ND(90.8) U	ND(9.66) U	ND(5.22) U	ND(3.20) U	ND(11.1) U	ND(73.4) U	ND(82.7) U	ND(306) U	ND(8.09) U
	PFOA	335-67-1	ND(13.1) U	ND(38.3) U	ND(29.1) U	681 L	ND(373) U	ND(191) U	ND(39.8) U	ND(29.1) U	ND(18.0) U	ND(12.0) U	1390 L	ND(216) U	ND(335) U	ND(13.3) U
Sulfonates	PFBS	375-73-5	ND(7.51) U	ND(4.84) U	ND(6.34) U	63400	ND(68.2) U	ND(51.7) U	ND(8.53) U	ND(5.70) U	ND(5.77) U	ND(5.75) U	78700	ND(61.7) U	ND(72.0) U	ND(5.70) U
	PFPeS	2706-91-4	ND(2.57) U	ND(2.85) U	ND(2.49) U	ND(37.0) U	ND(20.8) U	ND(36.9) U	ND(8.41) U	ND(1.75) U	ND(2.68) U	ND(2.67) U	ND(61.2) U	ND(13.1) U	ND(30.7) U	ND(2.08) U
	PFHxS	355-46-4	ND(3.22) U	ND(2.67) U	ND(4.13) U	110 L	ND(28.4) U	ND(25.5) U	ND(54.3) U	ND(7.19) U	ND(11.9) U	ND(18.1) U	1660 L-	ND(47.6) U	ND(267) U	ND(3.76) U
	PFHpS	375-92-8	ND(8.76) U	ND(5.85) U	ND(8.99) U	ND(41.8) U	ND(30.1) U	ND(28.0) U	ND(10.4) U	ND(6.46) U	ND(6.32) U	ND(8.62) U	ND(458) U	ND(71.9) U	ND(37.2) U	ND(4.64) U
	PFOS	1763-23-1	ND(5.88) U	ND(6.93) U	ND(3.02) U	ND(172) U	ND(50.9) U	ND(36.5) U	ND(3.94) U	ND(3.64) U	ND(3.19) U	ND(11.5) U	ND(431) U	ND(30.3) U	ND(53.5) U	ND(3.45) U
other	2,2,3,3-TFPA	756-09-2	ND(8593) U	ND(10446) U	ND(11231) U	ND(7318) U	ND(6046) U	ND(7172) U	ND(13696) U	ND(14290) U	ND(15814) U	ND(13154) U	ND(7834) U	ND(8451) U	ND(7816) U	ND(13103) U
	2,3,3,3 TFPA	359-49-9	ND(2944) U	ND(3699) U	ND(4144) U	ND(2055) U	ND(2050) U	ND(1914) U	ND(3209) U	ND(2902) U	ND(3007) U	ND(4244) U	ND(2429) U	ND(2604) U	ND(2501) U	ND(3141) U
	HQ-115	90076-65-6	ND(16.5) U	ND(24.4) U	ND(19.7) U	130000	ND(13.2) U	ND(16.0) U	ND(28.7) U	ND(32.2) U	7.00 LB	11.5 LB	151000	ND(36.0) U	ND(13.9) U	ND(26.6) U
	PFPA	422-64-0	ND(700) U	ND(700) U	ND(700) U	2780 L	14100 J	34400	ND(700) U	ND(700) U	ND(700) U	ND(700) U	9210 J	10300 J	13600 J	ND(700) U
	TFA	76-05-1	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U
	TFMS	1493-13-6	ND(409) U	ND(588) U	ND(480) U	1330000	1420000	1280000	ND(709) U	ND(625) U	ND(603) U	ND(907) U	1270000	1220000	1220000	ND(789) U

QA Notes:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by direct inject method utilizing 10 - 120uL of sample fortified by ES for the legacy analytes.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

CG additional compounds were analyzed using a single point calibration.

Batch prep ID: 12337: samples 001 -020

Samples 001-007, 014-017 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12338: samples 021 -040

Samples 021-024, 028-031, 036-038 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA

Sample 035 was reprepped and analyzed in batch 12369 due to initial loss of ES labels.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12339: samples 041 -060

Samples 042-045, and 051-054 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12340: samples 061-064

Samples were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12369: sample 035

Sample were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Enthalpy Analytical

Job No.: 0921-783-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete 12/2/2021 LKB

Summary

	Compound	CAS	3MCG-Test-02-D.4-IX2 [2]-20210918 ng/L	3MCG-Test-02-E.3-IXR1 [2]-20210918 ng/L	3MCG-Test-02-E.4-IXR2 [2]-20210918 ng/L	3MCG-Test-02-D.0-INF (RO REJ)-20210919 ng/L	3MCG-Test-02-D.1-GAC1-20210919 ng/L	3MCG-Test-02-D.2-GAC2-20210919 ng/L	3MCG-Test-02-D.3-IX1-20210919 ng/L	3MCG-Test-02-D.4-IX2-20210919 ng/L	3MCG-Test-02-E.3-IXR1-20210919 ng/L	3MCG-Test-02-E.4-IXR2-20210919 ng/L	3MCG-Test-02-D.0-INF (RO REJ) [2]-20210919 ng/L	3MCG-Test-02-D.1-GAC1 [2]-20210919 ng/L	3MCG-Test-02-D.2-GAC2 [2]-20210919 ng/L	3MCG-Test-02-D.3-IX1 [2]-20210919 ng/L
Acids	PFBA	375-22-4	ND(478) U	ND(601) U	ND(445) U	17900	733 L	ND(240) U	ND(44.6) U	ND(359) U	ND(1053) U	ND(588) U	20800	1850 L	ND(172) U	ND(294) U
	PFPeA	2706-90-3	ND(25.0) U	ND(18.6) U	ND(12.8) U	253 L	ND(131) U	ND(132) U	ND(24.1) U	ND(19.2) U	ND(23.0) U	ND(20.1) U	543 L	ND(191) U	ND(84.7) U	ND(15.1) U
	PFHxA	307-24-4	ND(2.08) U	ND(1.81) U	ND(6.13) U	ND(685) U	ND(19.3) U	ND(128) U	ND(21.4) U	ND(0.718) U	ND(1.02) U	ND(25.0) U	ND(34.0) U	ND(36.8) U	ND(128) U	ND(1.73) U
	PFHpA	375-85-9	ND(13.5) U	ND(9.47) U	ND(9.38) U	ND(159) U	ND(111) U	ND(49.4) U	ND(5.80) U	ND(7.09) U	ND(7.63) U	ND(5.56) U	ND(152) U	ND(101) U	ND(143) U	ND(1.49) U
	PFOA	335-67-1	ND(23.1) U	ND(6.93) U	ND(5.46) U	1790 L	ND(8.86) U	ND(358) U	ND(47.9) U	ND(7.11) U	ND(19.6) U	ND(7.49) U	5080	ND(196) U	ND(362) U	ND(3.67) U
Sulfonates	PFBS	375-73-5	ND(7.56) U	ND(5.48) U	ND(4.97) U	69500	ND(63.2) U	ND(58.4) U	ND(8.02) U	ND(6.41) U	ND(5.47) U	ND(5.40) U	72900	ND(57.9) U	ND(55.7) U	ND(5.53) U
	PFPeS	2706-91-4	ND(3.15) U	ND(4.10) U	ND(2.38) U	ND(480) U	ND(28.1) U	ND(29.9) U	ND(2.11) U	ND(2.08) U	ND(3.74) U	ND(3.30) U	ND(24.7) U	ND(54.4) U	ND(67.4) U	ND(4.38) U
	PFHxS	355-46-4	ND(5.11) U	ND(3.94) U	ND(7.09) U	1760 L	ND(79.4) U	ND(58.0) U	ND(6.67) U	ND(2.54) U	ND(10.8) U	ND(4.78) U	5540	ND(66.2) U	ND(33.3) U	ND(5.92) U
	PFHpS	375-92-8	ND(3.80) U	ND(8.70) U	ND(5.84) U	ND(1454) U	ND(54.5) U	ND(41.6) U	ND(5.74) U	ND(5.96) U	ND(6.09) U	ND(7.17) U	53.4 L	ND(86.9) U	ND(84.2) U	ND(3.20) U
	PFOS	1763-23-1	ND(4.00) U	ND(4.53) U	ND(1.60) U	42.3 L	ND(50.5) U	ND(75.4) U	ND(4.16) U	ND(4.65) U	ND(5.19) U	ND(3.55) U	1270 L	ND(22.8) U	ND(234) U	ND(4.15) U
other	2,2,3,3-TFPA	756-09-2	ND(9067) U	ND(14533) U	ND(13087) U	ND(7256) U	ND(6583) U	ND(6691) U	ND(702) U	ND(9549) U	ND(11693) U	ND(19129) U	ND(6883) U	ND(6651) U	ND(7011) U	ND(8459) U
	2,3,3,3 TFPA	359-49-9	ND(2696) U	ND(2540) U	ND(3347) U	ND(2528) U	ND(2102) U	ND(2122) U	ND(2586) U	ND(2528) U	ND(2689) U	ND(3223) U	ND(2446) U	ND(2281) U	ND(1749) U	ND(3311) U
	HQ-115	90076-65-6	10.3 LB	10.9 LB	ND(102) U	129000	ND(12.2) U	ND(16.3) U	ND(2.50) U	11.8 LB	10.1 LB	20.9 LB	186000	ND(14.7) U	ND(11.8) U	ND(21.0) U
	PFPA	422-64-0	ND(700) U	ND(700) U	ND(700) U	8510 J	8070 J	13800 J	ND(700) U	ND(700) U	13400	ND(700) U	10100 J	13300 J	7820 J	ND(700) U
	TFA	76-05-1	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U
	TFMS	1493-13-6	ND(568) U	ND(657) U	ND(733) U	1150000	1020000	1080000	ND(46.8) U	ND(460) U	ND(506) U	ND(665) U	1350000	1430000	1200000	ND(510) U

QA Notes:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by direct inject method utilizing 10 - 120uL of sample fortified by ES for the legacy analytes.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

CG additional compounds were analyzed using a single point calibration.

Batch prep ID: 12337: samples 001 -020

Samples 001-007, 014-017 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12338: samples 021 -040

Samples 021-024, 028-031, 036-038 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA

Sample 035 was reprepped and analyzed in batch 12369 due to initial loss of ES labels.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12339: samples 041 -060

Samples 042-045, and 051-054 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12340: samples 061-064

Samples were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12369: sample 035

Sample were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Enthalpy Analytical

Job No.: 0921-783-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete 12/2/2021 LKB

Summary

	Compound	CAS	3MCG-Test-02-D.4-IX2 [2]-20210919 ng/L	3MCG-Test-02-E.3-IXR1 [2]-20210919 ng/L	3MCG-Test-02-E.4-IXR2 [2]-20210919 ng/L	3MCG-Test-02-UF-INF-20210920 ng/L	3MCG-Test-02-UF-PERM-20210920 ng/L	3MCG-Test-02-D.0-INF (RO REJ)-20210920 ng/L	3MCG-Test-02-D.1-GAC1-20210920 ng/L	3MCG-Test-02-D.2-GAC2-20210920 ng/L	3MCG-Test-02-D.3-IX1-20210920 ng/L	3MCG-Test-02-D.4-IX2-20210920 ng/L	3MCG-Test-02-E.3-IXR1-20210920 ng/L	3MCG-Test-02-E.4-IXR2-20210920 ng/L	3MCG-Test-02-F.0-INF (RO PERM)-20210920 ng/L	3MCG-Test-02-F.1-IX1-20210920 ng/L
Acids	PFBA	375-22-4	ND(275) U	ND(280) U	ND(417) U	1500 L	1740	23000	1740 L	ND(194) U	ND(334) U	ND(326) U	ND(223) U	ND(276) U	ND(191) U	ND(17.5) U
	PFPeA	2706-90-3	ND(12.5) U	ND(15.0) U	ND(15.1) U	ND(175) U	8.64 L	583 L	ND(190) U	ND(115) U	ND(23.0) U	ND(13.1) U	ND(14.2) U	ND(30.5) U	ND(16.2) U	ND(27.5) U
	PFHxA	307-24-4	ND(5.86) U	ND(1.94) U	ND(9.55) U	ND(61.6) U	ND(16.8) U	127 L	ND(13.3) U	ND(63.5) U	ND(23.3) U	ND(13.2) U	ND(1.20) U	ND(7.30) U	ND(1.99) U	ND(1.63) U
	PFHpA	375-85-9	ND(8.52) U	ND(19.8) U	ND(5.36) U	ND(47.7) U	ND(6.90) U	ND(42.6) U	ND(249) U	ND(145) U	ND(0.612) U	ND(14.9) U	ND(2.77) U	ND(14.6) U	ND(26.7) U	ND(13.6) U
	PFOA	335-67-1	ND(15.5) U	ND(22.5) U	ND(10.5) U	ND(318) U	34.0 L	2400 J	ND(247) U	ND(535) U	ND(26.4) U	ND(27.8) U	ND(18.9) U	ND(11.3) U	ND(15.1) U	ND(27.7) U
Sulfonates	PFBS	375-73-5	ND(5.07) U	ND(7.11) U	ND(6.77) U	4240 L	3700	69600	ND(60.4) U	ND(45.0) U	ND(7.59) U	ND(4.43) U	ND(6.87) U	ND(7.62) U	ND(9.46) U	ND(7.16) U
	PFPeS	2706-91-4	ND(1.87) U	ND(2.47) U	ND(2.18) U	ND(37.7) U	ND(3.33) U	ND(208) U	ND(23.9) U	ND(30.8) U	ND(26.3) U	ND(3.07) U	ND(3.84) U	ND(3.98) U	ND(2.19) U	ND(6.69) U
	PFHxS	355-46-4	ND(7.08) U	ND(5.80) U	ND(3.60) U	ND(287) U	ND(2.35) U	2840 J	ND(56.2) U	ND(39.7) U	ND(46.9) U	ND(5.38) U	ND(6.14) U	ND(5.78) U	ND(3.12) U	ND(1.93) U
	PFHpS	375-92-8	ND(4.79) U	ND(6.49) U	ND(7.68) U	ND(72.2) U	ND(8.35) U	ND(738) U	ND(54.6) U	ND(68.6) U	ND(51.8) U	ND(7.47) U	ND(4.42) U	ND(4.70) U	ND(5.48) U	ND(3.98) U
	PFOS	1763-23-1	ND(2.79) U	ND(3.87) U	ND(2.34) U	ND(469) U	ND(9.08) U	603 L	ND(41.0) U	ND(44.8) U	ND(27.2) U	ND(1.41) U	ND(3.65) U	ND(4.28) U	ND(2.30) U	ND(9.62) U
other	2,2,3,3-TFPA	756-09-2	ND(9966) U	ND(8252) U	ND(9332) U	ND(4310) U	ND(820) U	ND(7837) U	ND(5963) U	ND(8134) U	ND(9764) U	ND(7018) U	ND(8342) U	ND(8823) U	ND(509) U	ND(538) U
	2,3,3,3 TFPA	359-49-9	ND(2928) U	ND(2419) U	ND(2673) U	ND(1594) U	ND(242) U	ND(2946) U	ND(1750) U	ND(2075) U	ND(2174) U	ND(2658) U	ND(2132) U	ND(2318) U	ND(122) U	ND(154) U
	HQ-115	90076-65-6	5.52 LB	11.0 LB	7.43 LB	24100	20800	209000	13.9 LB	ND(12.3) U	ND(26.0) U	ND(18.4) U	ND(26.7) U	ND(54.6) U	154 L	ND(1.14) U
	PFPA	422-64-0	ND(700) U	9780	ND(700) U	2420 L	1430 J	18800	6830 L	23300	ND(700) U	ND(700) U	56500	ND(700) U	ND(700) U	ND(700) U
	TFA	76-05-1	ND(700) U	ND(700) U	ND(700) U	ND(7000) U	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U
	TFMS	1493-13-6	ND(385) U	ND(420) U	ND(467) U	137000	106000	1550000	1120000	1170000	ND(432) U	103 LB	ND(421) U	ND(390) U	1970	ND(36.7) U

QA Notes:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by direct inject method utilizing 10 - 120uL of sample fortified by ES for the legacy analytes.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

CG additional compounds were analyzed using a single point calibration.

Batch prep ID: 12337: samples 001 -020

Samples 001-007, 014-017 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12338: samples 021 -040

Samples 021-024, 028-031, 036-038 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA

Sample 035 was reprepped and analyzed in batch 12369 due to initial loss of ES labels.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12339: samples 041 -060

Samples 042-045, and 051-054 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12340: samples 061-064

Samples were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12369: sample 035

Sample were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Enthalpy Analytical

Job No.: 0921-783-1 PFAS by Direct Inject (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete 12/2/2021 LKB

Summary

	Compound	CAS	3MCG-Test-02-F.2-IX2-20210920 ng/L	3MCG-Test-02-D.0-INF (RO REJ) [2]-20210920 ng/L	3MCG-Test-02-D.1-GAC1 [2]-20210920 ng/L	3MCG-Test-02-D.2-GAC2 [2]-20210920 ng/L	3MCG-Test-02-D.3-IX1 [2]-20210920 ng/L	3MCG-Test-02-D.4-IX2 [2]-20210920 ng/L	3MCG-Test-02-E.3-IXR1 [2]-20210920 ng/L	3MCG-Test-02-E.4-IXR2 [2]-20210920 ng/L
Acids	PFBA	375-22-4	ND(13.9) U	19900	2150 J	ND(256) U	ND(419) U	ND(237) U	ND(371) U	ND(368) U
	PFPeA	2706-90-3	ND(19.4) U	419 L	ND(205) U	ND(189) U	ND(17.6) U	ND(34.3) U	ND(21.0) U	ND(16.1) U
	PFHxA	307-24-4	ND(9.43) U	ND(2087) U	ND(366) U	ND(108) U	ND(12.1) U	ND(26.9) U	ND(4.52) U	ND(2.76) U
	PFHpA	375-85-9	ND(14.1) U	ND(276) U	ND(11.2) U	ND(18.8) U	ND(2.78) U	ND(1.05) U	ND(15.9) U	ND(26.6) U
	PFOA	335-67-1	ND(22.9) U	3550 J	ND(353) U	ND(461) U	ND(0.122) U	ND(11.5) U	ND(5.77) U	ND(23.8) U
Sulfonates	PFBS	375-73-5	ND(6.20) U	58000	ND(64.9) U	ND(75.9) U	ND(5.43) U	ND(4.76) U	ND(5.84) U	ND(5.48) U
	PFPeS	2706-91-4	ND(5.47) U	ND(289) U	ND(55.0) U	ND(35.3) U	ND(3.15) U	ND(2.95) U	ND(2.89) U	ND(2.73) U
	PFHxS	355-46-4	ND(4.59) U	3710	ND(35.7) U	ND(120) U	ND(18.0) U	ND(2.03) U	ND(6.33) U	ND(2.31) U
	PFHpS	375-92-8	ND(6.25) U	ND(94.2) U	ND(97.9) U	ND(77.6) U	ND(6.49) U	ND(7.53) U	ND(2.17) U	ND(8.37) U
	PFOS	1763-23-1	ND(20.1) U	894 L	ND(25.9) U	ND(44.0) U	ND(9.28) U	ND(4.50) U	ND(1.73) U	ND(7.72) U
other	2,2,3,3-TFPA	756-09-2	ND(577) U	ND(8517) U	ND(7921) U	ND(7249) U	ND(6909) U	ND(8087) U	ND(10384) U	ND(7254) U
	2,3,3,3 TFPA	359-49-9	ND(168) U	ND(2320) U	ND(2264) U	ND(2225) U	ND(3269) U	ND(2744) U	ND(2183) U	ND(2019) U
	HQ-115	90076-65-6	ND(1.04) U	188000	ND(27.7) U	ND(11.7) U	7.17 LB	ND(15.9) U	ND(33.5) U	ND(25.2) U
	PFPA	422-64-0	ND(700) U	12100 J	9000 J	7480 J	ND(700) U	ND(700) U	13900	ND(700) U
	TFA	76-05-1	ND(700) U	ND(7000) U	ND(7000) U	ND(7000) U	ND(700) U	ND(700) U	ND(700) U	ND(700) U
	TFMS	1493-13-6	ND(19.5) U	1240000	1150000	1060000	ND(492) U	61.7 L	30.1 LB	24.7 LB

QA Notes:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by direct inject method utilizing 10 - 120uL of sample fortified by ES for the legacy analytes.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

CG additional compounds were analyzed using a single point calibration.

Batch prep ID: 12337: samples 001 -020

Samples 001-007, 014-017 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12338: samples 021 -040

Samples 021-024, 028-031, 036-038 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA

Sample 035 was reprepped and analyzed in batch 12369 due to initial loss of ES labels.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12339: samples 041 -060

Samples 042-045, and 051-054 were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12340: samples 061-064

Samples were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

Batch prep ID: 12369: sample 035

Sample were injected a 10x dilution to report the polar compounds: PFPA, TFA, 2333-TFA Analyte(s) were detected in the method blank (MB) at less than 1/2 the LOQ. Any analyte(s) detected in the samples with less than 10 times the amount detected in the MB were notated with a B qualifier.

PFBS fell below method recovery criteria in the OPR, but was within marginal exceedance acceptance. The data was reported with no adverse impact.

Enthalpy Analytical

Job No.: 0921-803-1 PFAS by Isotope Dilution
(non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete: 12/8/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.0-INF (RO-REJ)-20210921 ng/L	3MCG-Test 02-D.1-GAC1-20210921 ng/L	3MCG-Test 02-D.2-GAC2-20210921 ng/L	3MCG-Test 02-D.3-IX1-20210921 ng/L	3MCG-Test 02-D.4-IX2-20210921 ng/L	3MCG-Test 02-E.3-IXR1-20210921 ng/L	3MCG-Test 02-E.4-IXR2-20210921 ng/L	3MCG-Test 02-D.0-INF (RO-REJ)-20210922 ng/L	3MCG-Test 02-D.1-GAC1-20210922 ng/L
Acids	PFBA	375-22-4	17400	2250 J	ND (111) U	ND (91.4) U	ND (135) U	ND (240) U	ND (281) U	15500	3810
	PFPeA	2706-90-3	680 L	ND (299) U	ND (371) U	ND (39.7) U	ND (37.8) U	ND (38.9) U	ND (31.5) U	ND (279) U	ND (137) U
	PFHxA	307-24-4	ND (113) U	ND (444) U	ND (46.3) U	ND (15.5) U	ND (3.2) U	ND (10.5) U	ND (15) U	ND (255) U	ND (29.9) U
	PFHpA	375-85-9	ND (1056) U	ND (110) U	ND (258) U	ND (9.19) U	ND (36) U	ND (18.1) U	ND (17.7) U	ND (136) U	ND (189) U
	PFOA	335-67-1	874 L	ND (150) U	ND (13.3) U	ND (19.9) U	ND (3.68) U	ND (1.88) U	ND (31.1) U	85.8 L	ND (28.7) U
Sulfonates	PFBS	375-73-5	40500	ND (678) U	ND (180) U	ND (35.4) U	ND (36.4) U	ND (32.4) U	ND (15.4) U	38600	ND (146) U
	PFPeS	2706-91-4	848 LB	ND (52.2) U	ND (84.6) U	ND (8.55) U	ND (7.73) U	ND (4.38) U	ND (9.43) U	ND (131) U	ND (64.8) U
	PFHxS	355-46-4	852 L	ND (154) U	ND (73.3) U	ND (8.92) U	ND (10.7) U	ND (20.2) U	ND (11) U	91.0 L	ND (91.1) U
	PFHpS	375-92-8	ND (209) U	ND (295) U	ND (164) U	ND (18.5) U	ND (15.9) U	ND (7.77) U	ND (10.4) U	ND (795) U	ND (140) U
	PFOS	1763-23-1	ND (2598) U	ND (796) U	ND (95.6) U	ND (110) U	ND (18.4) U	ND (82.6) U	ND (24.6) U	ND (1273) U	ND (312) U
other	2,2,3,3-TFPA	756-09-2	ND (7126) U	ND (4944) U	ND (5612) U	ND (3925) U	ND (5124) U	ND (8191) U	ND (9948) U	ND (8197) U	ND (6471) U
	2,3,3,3 TFPA	359-49-9	ND (9089)	ND (6386)	ND (8720)	ND (8246)	ND (6868)	ND (5276)	ND (6566)	ND (9123)	ND (6834)
	HQ-115	90076-65-6	161000	ND (15.2) U	ND (12.1) U	ND (11.7) U	ND (19.4) U	ND (27.3) U	ND (27.2) U	147000	ND (19.5) U
	PFPA	422-64-0	10100	16000	8080	6140	ND (18651)	15700	ND (7799)	11000	13700
	TFA	76-05-1	ND (23490)	ND (36825)	ND (14352)	ND (14630)	ND (25641)	ND (18504)	ND (22978)	ND (8.72)	ND (30495)
	TFMS	1493-13-6	1140000	973000	877000	ND (469) U	ND (347) U	ND (661) U	ND (511) U	989000	1140000

QA NOTES:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by a direct inject method utilizing 10 - 120uL of sample fortified by ES.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

TFMS, HQ-115, 2233-TFPA were analyzed using a single point callibration.

Prep Batch 12372: samples 001 - 020
All QCs passed criteria.
TFPA fell outside retention time window. For adequate injection volume, samples were reprepped and reported via prep batch 12435.
Prep batch 12373: samples 021- 040

All QCs passed criteria, except where noted below.
OPR: 12373, PFBS recovered below method criteria but within QSM marginal exceedance criteria. Data was reported with no adverse impact.
The following samples were reprepped in batch 12402 to report PFPA: OPR, 021, 027 - 029, and 037-040.

Enthalpy Analytical

Job No.: 0921-803-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete: 12/8/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.2-GAC2-20210922 ng/L	3MCG-Test 02-D.3-IX1-20210922 ng/L	3MCG-Test 02-D.4-IX2-20210922 ng/L	3MCG-Test 02-E.3-IXR1-20210922 ng/L	3MCG-Test 02-E.4-IXR2-20210922 ng/L	3MCG-Test 02-D.0-INF (RO-REJ)[2]-20210922 ng/L	3MCG-Test 02-D.1-GAC1[2]-20210922 ng/L	3MCG-Test 02-D.2-GAC2[2]-20210922 ng/L	3MCG-Test 02-D.3-IX1[2]-20210922 ng/L
Acids	PFBA	375-22-4	ND (137) U	111 L	ND (111) U	ND (203) U	ND (153) U	26500	4670	ND (113) U	ND (226) U
	PFPeA	2706-90-3	ND (330) U	119 L	ND (19) U	ND (36.8) U	ND (37.6) U	679 L	ND (362) U	ND (338) U	ND (32.6) U
	PFHxA	307-24-4	ND (96.1) U	ND (4.04) U	ND (70.9) U	ND (10.2) U	ND (21.8) U	ND (240) U	ND (192) U	ND (161) U	ND (35.6) U
	PFHpA	375-85-9	ND (478) U	111 L	ND (11.5) U	ND (7.96) U	ND (5.87) U	ND (430) U	ND (70.4) U	ND (41.8) U	ND (11.7) U
	PFOA	335-67-1	ND (177) U	79.8 L	ND (0.9) U	ND (15.2) U	ND (18.3) U	4920	ND (268) U	ND (33.4) U	ND (2.98) U
Sulfonates	PFBS	375-73-5	ND (872) U	111 LB	ND (19.6) U	ND (29.5) U	ND (57.4) U	65000	ND (489) U	ND (311) U	ND (51.9) U
	PFPeS	2706-91-4	ND (150) U	163 LB	37.4 LB	ND (7.41) U	ND (5.94) U	ND (437) U	ND (85.2) U	ND (80.9) U	ND (13.4) U
	PFHxS	355-46-4	ND (97.6) U	62.6 L	ND (5.89) U	ND (19.1) U	ND (8.65) U	4030	ND (74.8) U	ND (129) U	ND (5.47) U
	PFHpS	375-92-8	ND (190) U	17.9 L	ND (28.5) U	ND (12.9) U	ND (45.8) U	ND (1515) U	ND (115) U	ND (82) U	ND (17.2) U
	PFOS	1763-23-1	ND (261) U	55.5 L	ND (50.5) U	ND (26.7) U	ND (42.1) U	8940	ND (183) U	ND (515) U	ND (67.6) U
other	2,2,3,3-TFPA	756-09-2	ND (5896) U	ND (8230) U	ND (4473) U	ND (7131) U	ND (5267) U	ND (8871) U	ND (6159) U	ND (5724) U	ND (6611) U
	2,3,3,3 TFPA	359-49-9	ND (5844)	ND (4936)	ND (5548)	ND (4870)	ND (4343)	ND (7517)	ND (7116)	ND (7554)	ND (6138)
	HQ-115	90076-65-6	ND (18.5) U	ND (55.3) U	ND (13.9) U	ND (36.2) U	ND (13) U	259000	ND (17.1) U	ND (11.7) U	ND (52.8) U
	PFPA	422-64-0	4720	4630	ND (7469)	10500	ND (6609)	5540	14000	6040	ND (9368)
	TFA	76-05-1	ND (34986)	ND (27667)	ND (23231)	ND (37509)	ND (25816)	ND (8.81)	ND (7087)	ND (52204)	ND (27339)
	TFMS	1493-13-6	1140000	ND (593) U	ND (306) U	ND (545) U	290 L	1590000	1200000	462 L	ND (509) U

QA NOTES:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by a direct inject method utilizing 10 - 120uL of sample fortified by ES.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

TFMS, HQ-115, 2233-TFPA were analyzed using a single point callibration.

Prep Batch 12372: samples 001 - 020
All QCs passed criteria.

TFPA fell outside retention time window. For adequate injection volume, samples were repepped and reported via prep batch 12435.
Prep batch 12373: samples 021- 040

All QCs passed criteria, except where noted below.
OPR: 12373, PFBS recovered below method criteria but within QSM marginal exceedance criteria. Data was reported with no adverse impact.

The following samples were repepped in batch 12402 to report PFPA: OPR, 021, 027 - 029, and 037-040.

Enthalpy Analytical

Job No.: 0921-803-1 PFAS by Isotope Dilution
(non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete: 12/8/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.4-IX2[2]-20210922 ng/L	3MCG-Test 02-E.3-IXR1[2]-20210922 ng/L	3MCG-Test 02-E.4-IXR2[2]-20210922 ng/L	3MCG-Test 02-UF-INF-20210923 ng/L	3MCG-Test 02-UF-PERM-20210923 ng/L	3MCG-Test 02-D.0-INF (RO REJ)-20210923 ng/L	3MCG-Test 02-D.1-GAC1-20210923 ng/L	3MCG-Test 02-D.2-GAC2-20210923 ng/L	3MCG-Test 02-D.3-IX1-20210923 ng/L
Acids	PFBA	375-22-4	ND (227) U	ND (336) U	ND (196) U	2760 J	2960	18900	7450	ND (61.4) U	ND (200) U
	PFPeA	2706-90-3	ND (47.9) U	ND (27.9) U	ND (39.6) U	ND (126) U	111 L	147 L	ND (180) U	ND (165) U	ND (30) U
	PFHxA	307-24-4	ND (6.76) U	ND (19.8) U	ND (32.3) U	ND (31.8) U	ND (33.7) U	ND (336) U	ND (66.3) U	ND (232) U	ND (16.7) U
	PFHpA	375-85-9	ND (14.8) U	ND (22.4) U	ND (15.9) U	ND (171) U	ND (16.8) U	ND (204) U	ND (90.1) U	ND (56.3) U	ND (28.2) U
	PFOA	335-67-1	ND (39) U	ND (62.2) U	ND (8.41) U	ND (434) U	ND (19.4) U	1120 L	ND (53.7) U	ND (92.3) U	ND (6.61) U
Sulfonates	PFBS	375-73-5	ND (46.9) U	ND (54.6) U	ND (29.9) U	11100	9540	49500	ND (601) U	ND (841) U	ND (29.7) U
	PFPeS	2706-91-4	ND (9.63) U	ND (8.71) U	ND (55.6) U	ND (112) U	ND (22.2) U	ND (417) U	ND (81.9) U	ND (97.3) U	ND (9.64) U
	PFHxS	355-46-4	ND (7.77) U	ND (9.15) U	ND (15.2) U	ND (716) U	32.7 L	936 L	ND (102) U	ND (81.2) U	ND (10.8) U
	PFHpS	375-92-8	ND (15.3) U	ND (13.2) U	ND (18.4) U	ND (69.1) U	ND (96.3) U	ND (639) U	ND (137) U	ND (142) U	ND (15.4) U
	PFOS	1763-23-1	ND (27.7) U	ND (32.2) U	ND (32.8) U	808 L	ND (119) U	ND (7311) U	ND (432) U	ND (202) U	ND (26.5) U
other	2,2,3,3-TFPA	756-09-2	ND (9151) U	ND (12152) U	ND (5882) U	ND (4447) U	ND (655) U	ND (7861) U	ND (6986) U	ND (5354) U	ND (6466) U
	2,3,3,3 TFPA	359-49-9	ND (5615)	ND (4476)	ND (1662) U	ND (1194) U	ND (209) U	ND (1786) U	ND (1802) U	ND (1703) U	ND (1378) U
	HQ-115	90076-65-6	ND (56.2) U	ND (32.7) U	ND (71.5) U	17200	13400	163000	ND (13.5) U	ND (10.8) U	ND (17.4) U
	PFPA	422-64-0	ND (7761)	6280	6160	ND (6797) U	1880	20100	16200	3950 L	11100
	TFA	76-05-1	ND (33301)	ND (16799)	ND (700) U	ND (7000) U	ND (700) U	ND (7000) U	ND (7000) U	ND (7000) U	ND (700) U
	TFMS	1493-13-6	ND (525) U	ND (745) U	ND (342) U	65900	46900	1060000	1010000	633000	ND (422) U

QA NOTES:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by a direct inject method utilizing 10 - 120uL of sample fortified by ES.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

TFMS, HQ-115, 2233-TFPA were analyzed using a single point callibration.

Prep Batch 12372: samples 001 - 020
All QCs passed criteria.

TFPA fell outside retention time window. For adequate injection volume, samples were reprepped and reported via prep batch 12435.
Prep batch 12373: samples 021- 040

All QCs passed criteria, except where noted below.
OPR: 12373, PFBS recovered below method criteria but within QSM marginal exceedance criteria. Data was reported with no adverse impact.
The following samples were reprepped in batch 12402 to report PFPA: OPR, 021, 027 - 029, and 037-040.

Enthalpy Analytical

Job No.: 0921-803-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete: 12/8/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.4-IX2-20210923 ng/L	3MCG-Test 02-E.3-IXR1-20210923 ng/L	3MCG-Test 02-E.4-IXR2-20210923 ng/L	3MCG-Test 02-F.0-INF (RO PERM)-20210923 ng/L	3MCG-Test 02-F.1-IX1-20210923 ng/L	3MCG-Test 02-F.1-IX2-20210923 ng/L	3MCG-Test 02-D.0-INF (RO REJ) [2]-20210923 ng/L	3MCG-Test 02-D.1-GAC1[2]-20210923 ng/L	3MCG-Test 02-D.2-GAC2[2]-20210923 ng/L
Acids	PFBA	375-22-4	ND (227) U	ND (213) U	ND (316) U	9.93 L	ND (191) U	ND (8.17) U	16700	7680	ND (75.8) U
	PFPeA	2706-90-3	ND (48.3) U	ND (22.2) U	ND (28.3) U	5.05 L	ND (36) U	ND (20) U	544 L	ND (241) U	ND (287) U
	PFHxA	307-24-4	ND (9.01) U	ND (23.3) U	ND (9.03) U	ND (2.01) U	ND (18.9) U	ND (1.17) U	ND (120) U	ND (84.8) U	ND (19.6) U
	PFHpA	375-85-9	ND (40.9) U	ND (10.7) U	ND (8.66) U	ND (55.8) U	ND (13.2) U	ND (0.948) U	ND (158) U	ND (10.6) U	ND (190) U
	PFOA	335-67-1	ND (19.8) U	ND (16.4) U	ND (39.3) U	ND (2.31) U	ND (27.9) U	ND (35.7) U	855 L	ND (271) U	ND (21.4) U
Sulfonates	PFBS	375-73-5	ND (58.2) U	ND (51.1) U	ND (91.7) U	83.9 L	ND (32.6) U	ND (60.7) U	44300	ND (644) U	ND (558) U
	PFPeS	2706-91-4	ND (8.62) U	ND (5.31) U	ND (5.34) U	80.2 LB	ND (20) U	ND (8.27) U	ND (56.6) U	ND (58.6) U	ND (106) U
	PFHxS	355-46-4	ND (14.6) U	ND (15.5) U	ND (8.14) U	ND (131) U	ND (8.64) U	ND (30.4) U	628 L	ND (92.6) U	ND (290) U
	PFHpS	375-92-8	ND (16.3) U	ND (11.9) U	ND (12.2) U	ND (82.6) U	ND (13) U	ND (8.15) U	ND (764) U	ND (89) U	ND (124) U
	PFOS	1763-23-1	ND (61) U	ND (9.63) U	ND (39.6) U	ND (75) U	ND (29.3) U	ND (9.95) U	ND (1138) U	ND (324) U	ND (247) U
other	2,2,3,3-TFPA	756-09-2	ND (7215) U	ND (7644) U	ND (11009) U	ND (429) U	ND (507) U	ND (373) U	ND (5842) U	ND (6612) U	ND (6573) U
	2,3,3,3 TFPA	359-49-9	ND (1357) U	ND (1444) U	ND (1464) U	ND (136) U	ND (131) U	ND (129) U	ND (2463) U	ND (2119) U	ND (1839) U
	HQ-115	90076-65-6	ND (50.3) U	ND (50.9) U	ND (26) U	157 L	ND (1.01) U	ND (1.45) U	160000	ND (28.8) U	ND (16) U
	PFPA	422-64-0	ND (5467)	5970	6270	33.9 L	92.5 L	ND (350) U	9090 J	13200 J	10300 J
	TFA	76-05-1	ND (700) U	ND (700) U	ND (700) U	ND (700) U	ND (700) U	ND (700) U	ND (7000) U	ND (7000) U	ND (7000) U
	TFMS	1493-13-6	ND (719) U	2340	ND (578) U	1050	ND (18.4) U	157 LB	1040000	1010000	992000

QA NOTES:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by a direct inject method utilizing 10 - 120uL of sample fortified by ES.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

TFMS, HQ-115, 2233-TFPA were analyzed using a single point callibration.

Prep Batch 12372: samples 001 - 020
All QCs passed criteria.

TFPA fell outside retention time window. For adequate injection volume, samples were reprepped and reported via prep batch 12435.
Prep batch 12373: samples 021- 040

All QCs passed criteria, except where noted below.
OPR: 12373, PFBS recovered below method criteria but within QSM marginal exceedance criteria. Data was reported with no adverse impact.
The following samples were reprepped in batch 12402 to report PFPA: OPR, 021, 027 - 029, and 037-040.

Enthalpy Analytical

Job No.: 0921-803-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 Cottage Grove

QA complete: 12/8/2021 LKB

Summary

	Compound	CAS	3MCG-Test 02-D.3-IX1[2]-20210923 ng/L	3MCG-Test 02-D.4-IX2[2]-20210923 ng/L	3MCG-Test 02-E.3-IXR1[2]-20210923 ng/L	3MCG-Test 02-E.4-IXR2[2]-20210923 ng/L
Acids	PFBA	375-22-4	ND (141) U	ND (234) U	ND (329) U	ND (247) U
	PFPeA	2706-90-3	ND (21.3) U	ND (30.8) U	ND (33.3) U	ND (39.6) U
	PFHxA	307-24-4	ND (21.5) U	ND (25.3) U	ND (53.5) U	ND (20.5) U
	PFHpA	375-85-9	ND (35.8) U	ND (3.97) U	ND (22.1) U	ND (13) U
	PFOA	335-67-1	ND (3.21) U	ND (27.6) U	ND (10.6) U	ND (82.1) U
Sulfonates	PFBS	375-73-5	ND (50.8) U	ND (34.7) U	ND (132) U	ND (64.3) U
	PFPeS	2706-91-4	ND (7.25) U	ND (7.58) U	ND (12) U	ND (7.34) U
	PFHxS	355-46-4	ND (6.57) U	ND (7.85) U	ND (24.3) U	ND (10.7) U
	PFHpS	375-92-8	ND (11.2) U	ND (13.2) U	ND (17.7) U	ND (17.2) U
	PFOS	1763-23-1	ND (30.9) U	ND (36.5) U	ND (15.3) U	ND (40) U
other	2,2,3,3-TFPA	756-09-2	ND (5903) U	ND (6661) U	ND (9726) U	ND (9781) U
	2,3,3,3 TFPA	359-49-9	ND (1353) U	ND (1546) U	ND (1452) U	ND (1399) U
	HQ-115	90076-65-6	ND (18.1) U	ND (23.9) U	ND (28.1) U	ND (41.3) U
	PFPA	422-64-0	11600	ND (20.8)	6760	6230
	TFA	76-05-1	ND (700) U	ND (700) U	ND (700) U	ND (700) U
	TFMS	1493-13-6	ND (390) U	ND (389) U	5460	ND (620) U

QA NOTES:

The samples were extracted within the 28-day from collection holding time.

Samples analyzed by a direct inject method utilizing 10 - 120uL of sample fortified by ES.

Due to acquisition requirements for analytes requested, the samples were analyzed in more than one sequence.

TFMS, HQ-115, 2233-TFPA were analyzed using a single point callibration.

Prep Batch 12372: samples 001 - 020
All QCs passed criteria.
TFPA fell outside retention time window. For adequate injection volume, samples were repepped and reported via prep batch 12435.
Prep batch 12373: samples 021- 040

All QCs passed criteria, except where noted below.
OPR: 12373, PFBS recovered below method criteria but within QSM marginal exceedance criteria. Data was reported with no adverse impact.
The following samples were reprepped in batch 12402 to report PFPA: OPR, 021, 027 - 029, and 037-040.

Enthalpy Analytical

Job No.: 1021-837-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove Pilot Test

Summary

	Compound	CAS	3MCG-Test 01_D-G.0-INF (RO REJ)-20211022	3MCG-Test 01_D-G.1-GAC1-20211022 ng/L	3MCG-Test 01_D-G.2-GAC2-20211022 ng/L	3MCG-Test 01_D-G.3-IX1-20211022 ng/L	3MCG-Test 01_D-G.4-IX2-20211022 ng/L	3MCG-Test 01_D-G.0-INF (RO REJ)-20211024
Acids	PFBA	375-22-4	70400	33200	1980	<LOD (191) U	<LOD (191) U	66000
	PFPeA	2706-90-3	9350	<LOD (1060) U	<LOD (1060) U	<LOD (212) U	<LOD (212) U	8770
	PFHxA	307-24-4	2440	<LOD (1210) U	<LOD (1210) U	<LOD (241) U	<LOD (241) U	2640 IR
	PFHpA	375-85-9	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U	<LOD (221) U	2710 IR
Sulfonates	PFBS	375-73-5	3730	<LOD (2220) U	<LOD (2220) U	<LOD (444) U	<LOD (444) U	3600
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U	<LOD (239) U	2140
	PFHpS	375-92-8	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (844) U
	PFOS	1763-23-1	4510	<LOD (1000) U	<LOD (1000) U	<LOD (200) U	<LOD (200) U	1380 J
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	<LOD (752) U	<LOD (752) U	<LOD (3760) U
	HQ-115	90076-65-6	413000	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	323000
	PFPA	422-64-0	33900	24600	27700	3110	<LOD (700) U	29800
	TFA	76-05-1	14900	7110	<LOD (3500) U	6190	16000	<LOD (3500) U
	TFMS	1493-13-6	142000	108000	83700	<LOD (1000) U	<LOD (1000) U	107000

Enthalpy Analytical

Job No.: 1021-837-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove Pilot Test

Summary

	Compound	CAS	3MCG-Test 01_D-G.1-GAC1-20211024 ng/L	3MCG-Test 01_D-G.2-GAC2-20211024 ng/L	3MCG-Test 01_D-G.3-IX1-20211024 ng/L	3MCG-Test 01_D-G.4-IX2-20211024 ng/L	3MCG-Test 01_D-G.0-INF (RO REJ)-20211027	3MCG-Test 01_D-G.2-GAC2-20211027 ng/L
Acids	PFBA	375-22-4	22900	8020	<LOD (191) U	<LOD (956) U	76200	18300
	PFPeA	2706-90-3	<LOD (1060) U	<LOD (212) U	<LOD (212) U	<LOD (1060) U	10100	<LOD (1060) U
	PFHxA	307-24-4	<LOD (1210) U	<LOD (241) U	<LOD (241) U	<LOD (1210) U	2660 IR	<LOD (1210) U
	PFHpA	375-85-9	<LOD (762) U	<LOD (152) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (1110) U	<LOD (221) U	<LOD (221) U	<LOD (1110) U	4590 IR	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (2220) U	<LOD (444) U	<LOD (444) U	<LOD (2220) U	4460	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (1290) U	<LOD (258) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (1190) U	<LOD (239) U	<LOD (239) U	<LOD (1190) U	3700	<LOD (1190) U
	PFHpS	375-92-8	<LOD (844) U	<LOD (169) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (1000) U	<LOD (200) U	<LOD (200) U	<LOD (1000) U	2550	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (3760) U	<LOD (752) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	369000	<LOD (5000) U
	PFPA	422-64-0	19700	21800	<LOD (700) U	15900	35400	24500
	TFA	76-05-1	<LOD (3500) U	<LOD (700) U	17700	6030	6580	4750
	TFMS	1493-13-6	63500	195000	<LOD (1000) U	<LOD (5000) U	122000	77200

Enthalpy Analytical

Job No.: 1021-837-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove Pilot Test

Summary

	Compound	CAS	3MCG-Test 01_D-G.3-IX1-20211027 ng/L	3MCG-Test 01_D-G.4-IX2-20211027 ng/L	3MCG-Test 01_D-G.0-INF (RO REJ)-20211023	3MCG-Test 01_D-G.1-GAC1-20211023 ng/L	3MCG-Test 01_D-G.2-GAC2-20211023 ng/L	3MCG-Test 01_D-G.3-IX1-20211023 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	70900	29600	4010	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	9140	<LOD (1060) U	<LOD (1060) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	2070	<LOD (1210) U	<LOD (1210) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	<LOD (1110) U	<LOD (1110) U	<LOD (1110) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	3650	<LOD (2220) U	<LOD (2220) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	<LOD (1190) U	<LOD (1190) U	<LOD (1190) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	<LOD (1000) U	<LOD (1000) U	<LOD (1000) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	366000	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U
	PFPA	422-64-0	27000	<LOD (700) U	36100	24100	23100	7940
	TFA	76-05-1	11500	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U	15700
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	120000	117000	98400	<LOD (1000) U

Enthalpy Analytical

Job No.: 1021-837-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove Pilot Test

Summary

	Compound	CAS	3MCG-Test 01_D-G.4-IX2-20211023 ng/L	3MCG-Test 01_D-I.0-INF (RO PERM)-20211023	3MCG-Test 01_D-I.1-IX1-20211023 ng/L	3MCG-Test 01_D-I.2-IX2-20211023 ng/L	3MCG-Test 01_D-G.0-INF (RO REJ)-20211026	3MCG-Test 01_D-G.2-GAC2-20211026 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (956) U	<LOD (191) U	<LOD (956) U	67400	17200
	PFPeA	2706-90-3	<LOD (212) U	<LOD (1060) U	<LOD (212) U	<LOD (1060) U	9090	<LOD (1060) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (1210) U	<LOD (241) U	<LOD (1210) U	2650	<LOD (1210) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (762) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (762) U
	PFOA	335-67-1	<LOD (221) U	<LOD (1110) U	<LOD (221) U	<LOD (1110) U	8490	<LOD (1110) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (2220) U	<LOD (444) U	<LOD (2220) U	4080	<LOD (2220) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (1290) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (1290) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (1190) U	<LOD (239) U	<LOD (1190) U	4440	<LOD (1190) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (844) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (844) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (1000) U	<LOD (200) U	<LOD (1000) U	8350	<LOD (1000) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (5000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (3760) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (3760) U
	HQ-115	90076-65-6	<LOD (1000) U	6200	<LOD (1000) U	<LOD (5000) U	452000	<LOD (5000) U
	PFPA	422-64-0	<LOD (700) U	<LOD (3500) U	<LOD (700) U	<LOD (3500) U	33900	23900
	TFA	76-05-1	17900	<LOD (3500) U	<LOD (700) U	<LOD (3500) U	<LOD (3500) U	<LOD (3500) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (5000) U	<LOD (1000) U	<LOD (5000) U	159000	110000

Enthalpy Analytical

Job No.: 1021-837-1 PFAS by Isotope Dilution (non-potable water)

ECT2 PROJ-009092 3M Cottage Grove Pilot Test

Summary

	Compound	CAS	3MCG-Test 01_D-G.3-IX1-20211026 ng/L	3MCG-Test 01_D-G.4-IX2-20211026 ng/L	3MCG-Test 01_D-G.0-INF (RO REJ)-20211025	3MCG-Test 01_D-G.2-GAC2-20211025 ng/L	3MCG-Test 01_D-G.3-IX1-20211025 ng/L	3MCG-Test 01_D-G.4-IX2-20211025 ng/L
Acids	PFBA	375-22-4	<LOD (191) U	<LOD (191) U	68000	12900	<LOD (191) U	<LOD (191) U
	PFPeA	2706-90-3	<LOD (212) U	<LOD (212) U	8980	<LOD (1060) U	<LOD (212) U	<LOD (212) U
	PFHxA	307-24-4	<LOD (241) U	<LOD (241) U	2180	<LOD (1210) U	<LOD (241) U	<LOD (241) U
	PFHpA	375-85-9	<LOD (152) U	<LOD (152) U	<LOD (762) U	<LOD (762) U	<LOD (152) U	<LOD (152) U
	PFOA	335-67-1	<LOD (221) U	<LOD (221) U	11200 IR	<LOD (1110) U	<LOD (221) U	<LOD (221) U
Sulfonates	PFBS	375-73-5	<LOD (444) U	<LOD (444) U	3500	<LOD (2220) U	<LOD (444) U	<LOD (444) U
	PFPeS	2706-91-4	<LOD (258) U	<LOD (258) U	<LOD (1290) U	<LOD (1290) U	<LOD (258) U	<LOD (258) U
	PFHxS	355-46-4	<LOD (239) U	<LOD (239) U	5610	<LOD (1190) U	<LOD (239) U	<LOD (239) U
	PFHpS	375-92-8	<LOD (169) U	<LOD (169) U	<LOD (844) U	<LOD (844) U	<LOD (169) U	<LOD (169) U
	PFOS	1763-23-1	<LOD (200) U	<LOD (200) U	11800	<LOD (1000) U	<LOD (200) U	<LOD (200) U
other	2,2,3,3-TFPA	756-09-2	<LOD (1000) U	<LOD (1000) U	<LOD (5000) U	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U
	2,3,3,3 TFPA	359-49-9	<LOD (752) U	<LOD (752) U	<LOD (3760) U	<LOD (3760) U	<LOD (752) U	<LOD (752) U
	HQ-115	90076-65-6	<LOD (1000) U	<LOD (1000) U	480000	<LOD (5000) U	<LOD (1000) U	<LOD (1000) U
	PFPA	422-64-0	25000	<LOD (700) U	30100	20400	12600	<LOD (700) U
	TFA	76-05-1	13700	7000	<LOD (3500) U	<LOD (3500) U	7060	<LOD (700) U
	TFMS	1493-13-6	<LOD (1000) U	<LOD (1000) U	174000	122000	<LOD (1000) U	<LOD (1000) U

Appendix D

Laboratory Data Report Summary – 3M EHS Laboratory

Global EHS Laboratory

General Project Outline

To: Chris Bryan – 3M EHS&PS

From: Sue Wolf - 3M Global EHS Laboratory

cc: Brian Mader - 3M Global EHS Laboratory, Laboratory Director

Date: August 15, 2021

Subject: 3M Cottage Grove Pilot Column Study

1 General Project Information

Project Requester	Chris Bryan 3M EHS&PS 224-5W-01 651 325-9718 cbryan@mmm.com
Project Lead	**Pilot Study Coordinator** John Berry ECT2 jberry@ect2.com 603 566-0751 **Principal Analytical Investigator** Susan Wolf 3M EHS Laboratory 260-5N-17 Office: 651 733-8862 stwolf@mmm.com
Lab Request Number	**E21-1752**
Six Digit Department Number	832202
Project Schedule/Test Dates	Sampling to be conducted August – September 2021

All verbal and written correspondence will be directed to Chris Bryan.

The 3M Global EHS Laboratory welcomes requestors to observe the tests being performed for them.

2 Background Information and Project Objective(s)

ECT2 will be conducting a multi-phase pilot study in Cottage Grove. The pilot includes a sampling and analysis plan (SAP) for three (3) different systems; Non-Contact Cooling water (NCCW) and stormwater pond, Phase 1 & 2 wastewater (Pre-LGAC) and Phase 3 wastewater (Pre-LGAC). Samples will be collected daily during the two-month study. Three labs will be utilized for the analysis of the collected samples, with the SAP detailing which samples get collected and analyzed by each of the labs. A copy of the initial Column Plan and SAP is included as an attachment, which is subject to change as needed. Samples for background chemistry is being performed by Pace. Samples for a short list of PFAS compounds are being analyzed by Enthalpy. Samples requiring analysis of a more extensive list of PFAS compounds will be run by the 3M Global EHS Laboratory. All sample coordination with Pace and Enthalpy is being managed by ECT2.

The 3M Global EHS Laboratory will analyze specified samples for the list of target compounds identified in **Table 1**. It is expected that the 3M EHS Laboratory may receive approximately 93 samples over the course of the study.

Peer-reviewed preliminary results will be provided, with laboratory manager approval.

The final report will be sent to the requester, Chris Bryan upon completion.

3 Project Schedule

Sample collection bottles will be prepared by 3M Global EHS Laboratory personnel and shipped to 3M Cottage Grove as needed.

4 Sample Collection

Sample containers for the collection of the study samples designated to be analyzed by the 3M Global EHS Lab will be prepared and sent to the Decatur facility prior to sampling. A pre-printed CoC form, sample labels and sampling instructions will be included. A travel blank set will be included when possible, with each weekly set of sample containers.

For each sampling location, the bottle set will include a 250-mL HDPE bottle and a 125-mL HDPE bottle marked with a fill to line at 50-mL. The 125-mL sample bottles will be pre-spiked with known concentrations of internal standards (a mixture of isotopically labeled perfluorocarboxylic acids, perfluorosulfonic acids, perfluorooctanesulfonamides and perfluorooctanesulfonamidoacetic acids) by the 3M Global EHS Laboratory before shipment of sample bottles. A travel blank set, including a travel blank matrix spike will be included when possible, with each weekly set of sample containers.

5 Sample Analysis

Samples will be analyzed for the compounds listed in **Table 1**. While the compound list to be analyzed by the 3M EHS Laboratory in Attachment A, the three surrogate recovery standards listed; M3PFBA, M4PFOA and M4PFOS, will not be added to the sample containers or analyzed for.

Table 1. Target Analytes

Acronym	Compound Name
2233-TFPA	2,2,3,3-Tetrafluoropropionic acid
2333-TFPA	2,3,3,3-Tetrafluoropropionic acid
TFA	Trifluoroacetic acid
PFPA	Perfluoropropionic acid
PFBA	Perfluorobutyric acid
PFPeA	Perfluoropentanoic Acid
PFHxA	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid
TFMS	Perifluoromethanesulfonate
PFES	Perfluoroethanesulfonate
PFBS	Perfluorobutanesulfonate
PFPeS	Perfluoropentanesulfonate
PFHxS	Perfluorohexanesulfonate
PFHpS	Perfluoroheptanesulfonate
PFOS	Perfluorooctanesulfonate
FOSA	Perfluorooctanesulfonamide
FBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-1-butanesulfonamide
MeFBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methylbutane-1-sulfonamide
FBSA	1,1,2,2,3,3,4,4,4-Nonafluorobutane-1-sulfonamide
MeFBSA	1,1,2,2,3,3,4,4,4-Nonafluoro-N-methylbutane-1-sulfonamide
FBSAA	Perfluorobutyl sulfonamido acetic acid
MeFBSAA	Perfluorobutyl-methyl sulfonamido acetic acid
FBSEE Diol	1,1,2,2,3,3,4,4,4-Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide
FBSEE-DA	[(Nonafluorobutane-1-sulfonyl)-carboxymethylamino]acetic acid
PFBSi	Nonafluorobutane-1-sulfinic acid
PECHS	Perfluoro-4-ethylcyclohexanesulfonate
PIBA	Perfluoisobutyl amide
HQ-115	Methanesulfonamide, 1,1,1-trifluoro-N-[(trifluoromethyl)sulfonyl-
PBSA	2-Propenoic acid, reaction products with N-[3-(dimethylamino)propyl]-1,1,2,2,3,3,4,4,4-nonafluoro-1-butanesulfonamide OR N-[3-(Dimethylamino)propyl]-N-(1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonyl)-beta-alanine
PBSA-DC	3-((3-((N-(2-carboxyethyl)-perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate
PHSA-C1 [1]	3-((N-(3-(dimethylamino)propyl)-perfluorohexyl)sulfonamido) propanoic acid
PHSA-C2 [1]	2-carboxyethyl-dimethyl-[3-(1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluorohexylsulfonylamino) propyl] ammonium

[1]The LC/MS/MS analytical method used may not be able to chromatographically separate the PHSA-C1 and PHSA-C2 compounds as they are isomers with the same molecular weight. PHSA-C1 and PHSA-C2 will be reported as the sum of the two isomers as PHSA-C.

LC/MS/MS Analysis

Samples will be analyzed by ETS-8-044 "Method of Analysis for the Determination of Perfluorinated Compounds in Water by LC/MS/MS; Direct Injection Analysis". This method is a direct injection method where samples are analyzed as a solvent diluted sample.

Where applicable, samples will be analyzed against an internal standard calibration curve. Each curve point will contain isotopically labeled perfluorinated compounds at a nominal concentration of 1 ng/mL. The calibration curve will be generated by taking the ratio of the standard peak area counts over the internal standard peak area counts to fit the data for each analyte.

All analytical method requirements in ETS-8-044 regarding the generation of the calibration curve, analysis of continuing calibration verification (CCV) samples, analysis of system suitability samples and determination of the limit of quantitation, will be adhered to when analyzing the samples.

For each sampling location, a single sample replicate will be collected and analyzed. A laboratory matrix spike may be prepared as needed.

Laboratory control samples will be prepared with the samples at three levels in triplicate for the target analytes. Acceptance criteria specified in ETS-8-044 for the LCSs will be reviewed when reporting the sample results. The analytical data uncertainty will be based on control charted LCS results. Travel blank matrix spikes will be used to assess stability and holding time of the target analytes and may be used to adjust the analytical data uncertainty if the recoveries exceed method acceptance criteria.

6 Reporting Requirements

The final report will contain the results for the submitted samples along with the results for the travel blanks. Laboratory control spikes of reagent water prepared at the time of sample preparation will also be reported and used to evaluate the overall method accuracy and precision. Any laboratory matrix spikes prepared will also be reported.

7 Attachment

2021-0716-3M CG Pilot Column Plan and SAP-D3 jcb working.xlsx

Final Report

3M Cottage Grove Pilot Study

3M GLOBAL EHS LABORATORY

Laboratory Request Number: E21-1752

Report Date: Date of Last Signature

Testing Laboratory

3M Global EHS Laboratory
Building 260-5N-17
Maplewood, MN 55144-1000

Requester: Bryan, Christopher W

MAPLEWOOD-3MUS-MN 3M CENTER

0235-02-S-27

Phone: +1 (651) 4582091

Email: cbryan@mmm.com

The laboratory's quality system has been audited and was found to be in conformance with the EPA GLPs (40 CFR 792) as well as ISO/IEC 17025:2017 by an independent assessment. The results included in this report are not covered by the lab's accreditation.

Introduction / Summary

The 3M Global EHS Laboratory prepared and analyzed water samples collected as part of a ECT2 multi-phase pilot study in Cottage Grove. The pilot includes a sampling and analysis plan (SAP) for three (3) different systems; Non-Contact Cooling water (NCCW) and stormwater pond, Phase 1 & 2 wastewater (Pre-LGAC) and Phase 3 wastewater (Pre-LGAC). The samples included in this report were collected on August 2, 11, 23, 26, 29, September 1, 2, 18, 23, 24, and October 16, 2021. Samples were received on ice on August 11, 24, 27, September 1, 21, and October 18, 2021. The results in this report apply to the samples as received from Cottage Grove plant personnel. Analysis of the samples was completed as specified under 3M Global EHS Laboratory General Project Outline (GPO) number E21-1752.

The 3M Global EHS Laboratory prepared sample containers for the collection of water from one-hundred-seven specified sampling conditions. Sample containers for the collection of a single field sample from each sampling location was provided, with select locations including a field matrix spike (FMS) sample container. Sample containers designated for LC/MS/MS analysis were either marked with a “fill to here” line that corresponded to a fill volume of 50- mL or were an unmarked 250-mL bottle. All 50-mL sample bottles were fortified with internal standards prior to being sent to the field for sample collection . Four travel blank samples and four travel blank field matrix spikes (FMS) were included with the bottle order. The sample container for the travel blank FMS was fortified with appropriate spike solutions containing all target analytes prior to being sent to the field for sample collection.

Samples were prepared and analyzed for the list of target analytes noted in Table 1 of the GPO, which were amendable to analysis by LC/MS/MS. Analysis was completed using 3M Global EHS Laboratory method ETS-8-044.5 “Method of Analysis for the Determination of Perfluorinated Compounds by LC /MS/MS; Direct Injection Analysis”. Internal standards were used to aid in the data quality objectives of select target analytes.

Table 1 summarizes the sample results using the analytical method identified above. All results for quality control samples prepared and analyzed with the samples are discussed elsewhere in this report.

Quality Control Narrative
The method acceptance criteria followed 3M Global EHS Laboratory method ETS-8-044.5 unless noted otherwise in the General Project Outline for calibration curve, system suitability, continuing calibration samples, laboratory control spikes, field matrix spikes, and laboratory matrix spikes, when applicable. If a quality control sample did not meet the acceptance criteria, the result is flagged in the respective table in the Quality Control section of this report. See the Method Uncertainty Attachment for adjustments made to the method uncertainty due to non-compliant QC elements. Deviations from the method observed for this project are noted below and a method deviation is included with the raw data.

Continuing Calibration Verification (CCV)
During the course of the analytical sequence, several continuing calibration verification samples (CCVs) were analyzed to confirm that the instrument response and the initial calibration curve were still in control. The method acceptance criteria of 100% ± 25% was met for all analyses.

Manual Integration Narrative
Due to the nature of the samples, the wide range of concentrations found in the samples, and the environmental occurrence of multiple isomers of the laboratory’s analytes of interest , the software used for processing the analytical results is not able to consistently integrate the analytical peaks, manual integration of the analytical peak is necessary. All manual integrations are performed following the procedures outlined in method ETS-12-010.3. The consistency of the laboratory’s integration is ensured through the training of laboratory personnel, the peer review process required for all manual integrations, the spot checking of representative samples by the QAU, and where necessary the review of manual integrations by laboratory management.

Data Retention Narrative
All remaining sample and associated project data (hardcopy and electronic) will be archived according to 3M Global EHS Laboratory standard operating procedures.

Sample Summary

Sample ID	Sample Description	Date/Time Sampled
E21-1752-001	UF INFLUENT	08/02/2021 12:00
E21-1752-002	UF PERMEATE	08/02/2021 13:35
E21-1752-003	RO PERMEATE	08/02/2021 12:55
E21-1752-004	RO REJECT	08/02/2021 13:30
E21-1752-011	IX1-C	08/02/2021 12:50
E21-1752-012	IX2-C	08/02/2021 12:45
E21-1752-020	RO PERMEATE	08/11/2021 13:55
E21-1752-024	Travel Blank Week 1-2	07/26/2021 16:45
E21-1752-024-FMS	Travel Blank 1-2 FMS	07/26/2021 16:45
E21-1752-025	3MCG-Test01_B-UF-PERM-20210823	08/23/2021 14:00
E21-1752-026	3MCG-Test01-B-INF-A (RO-REJ)-20210823	08/23/2021 18:20
E21-1752-045	3MCG-Test 01_B-UF-PERM-20210826	08/26/2021 09:30
E21-1752-046	3MCG-Test 01_B-INF-A (RO-REJ)-20210826	08/26/2021 09:30
E21-1752-055	Travel Blank	08/19/2021 10:45
E21-1752-055-FMS	Travel Blank FMS	08/19/2021 10:45
E21-1752-061	3MCG-Test 01_B-INF-A (RO-REJ)-20210829	08/29/2021 09:25
E21-1752-078	3MCG-Test 01_B-IX2-A-20210901	09/01/2021 10:25
E21-1752-080	3MCG-Test 01_B-IXR2-B-20210901	09/01/2021 10:25
E21-1752-081	3MCG-Test 01_B-UF-PERM-20210902	09/02/2021 10:30
E21-1752-082	3MCG-Test 01_B-INF-A (RO-REJ)-20210902	09/02/2021 11:15
E21-1752-096	Travel Blank	08/24/2021 00:55
E21-1752-096-FMS	Travel Blank FMS	08/24/2021 00:55
E21-1752-097	3MCG-Test 02-D.0-INF (RO-REJ)-20210921	09/23/2021 12:00
E21-1752-108	3MCG-Test 02-D.4-IX2-20210924	09/24/2021 12:00
E21-1752-110	3MCG-Test 02-E.4-IXR2-20210924	09/24/2021 12:00
E21-1752-111	Travel Blank	09/20/2021 14:50
E21-1752-111-FMS	Travel Blank FMS	09/20/2021 14:50
E21-1752-145	3MCG-Test 02-F.0-INF (RO PERM)-20210918	09/18/2021 08:48
E21-1752-146	3MCG-Test 02-F.1-IX1-20210918	09/18/2021 08:38
E21-1752-147	3MCG-Test 02-F.2-IX2-20210918	09/18/2021 08:20
E21-1752-148	3MCG-Test 02-F.0-INF (RO PERM)-20210923	09/23/2021 10:00
E21-1752-149	3MCG-Test 02-F.1-IX1-20210923	09/23/2021 09:45
E21-1752-150	3MCG-Test 02-F.2-IX2-20210923	09/23/2021 09:30

33 samples

Analyte List

Target Analyte	Target Analyte Description	CAS Number	Footnote
2233-TFPA	2,2,3,3-Tetrafluoropropionic acid	71592-16-0	3
2333-TFPA	2,3,3,3-Tetrafluoropropionic acid	359-49-9	3
FBSA	Perfluorobutanesulfonamide	30334-69-1	
FBSAA	Perfluorobutyl sulfonamido acetic acid	1910057-70-3	
FBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-1-butanesulf onamide	34454-99-4	
FBSEE Diol	1,1,2,2,3,3,4,4,4-Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide	34455-00-0	
FBSEE-DA	[(Nonafluorobutane-1-sulfonyl)-carboxymethylamino]acetic acid	1268835-43-3	3
FOSA	Perfluorooctanesulfonamide	754-91-6	
HQ-115	Methanesulfonamide, 1,1,1-trifluoro-N-[(trifluoromethyl)sulfon yl-]	90076-65-6	
MeFBSA	1,1,2,2,3,3,4,4,4-Nonafluoro-N-methylbutane-1-sulfonamide	68298-12-4	
MeFBSAA	Perfluorobutyl-methyl sulfonamido acetic acid	159381-10-9	3
MeFBSE	1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methylbut ane-1-sulfonamide	34454-97-2	
PBSA	N-[3-(dimethylamino) propyl]-1,1,2,2,3,3,4,4-nonafluoro-butan e-1-sulfonamide	68555-77-1	
PBSA-DC	3-((3-((N-(2-carboxyethyl)-perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate	225460-13-7	
PECHS	Perfluoro-4-ethylcyclohexanesulfonate	646-83-3	
PFBA	Perfluorobutanoic acid	375-22-4	3
PFBS	Perfluorobutanesulfonate	375-73-5	
PFBSi	Nonafluorobutane-1-sulfinic acid	34642-43-8	3
PFES	Perfluoroethanesulfonate	354-88-1	
PFHpA	Perfluoroheptanoic acid	375-85-9	3
PFHpS	Perfluoroheptanesulfonate	375-92-8	
PFHS			
PFHxA	Perfluorohexanoic acid	307-24-4	3
PFOA	Perfluorooctanoic acid	335-67-1	3
PFOS	Perfluorooctanesulfonate	1763-23-1	
PFPA	Perfluoropropionic acid	422-64-0	3
PFPeA	Perfluoropentanoic acid	2706-90-3	3
PFPeS	Perfluoropentanesulfonate	2706-91-4	
PHSA-C	3-((N-(3-(dimethylamino)propyl)-perfluorohexyl)sulfonamido) propanoate; 3-(dimethyl(3-((perfluorohexylsulfonamido)propy l)ammonio)propanoate	141607-32-1;81190-41-2	8 9
PIBA	Perfluoisobutyl amide	662-20-4	
TFA	Trifluoroacetic Acid	76-05-1	3
TFMS	Trifluoromethanesulfonate	1493-13-6	

32 Target Analytes

3 - The anion is measured by the analytical method.

8 - The LC/MS/MS analytical method used may not be able to chromatographically separate the PHSA-C1 and PHSA-C2 compounds as they are isomers with the same molecular weight. The reported result will be the sum of these two isomers.

9 - PHSA-C was not listed in the GPO, but was inadvertently analyzed and is included in the final results.

Table 1. Sample Results Summary

Sample ID E21-1752-001 **Sampled Date\Time** 08/02/2021 12:00
Description UF INFLUENT

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 20:34	2.00	External
2333-TFPA	1.21	1.00	ug/L		11/05/2021 20:34	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 08:47	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 08:47	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 08:47	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 08:47	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 08:47	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
HQ-115	0.236	0.0100	ug/L		10/28/2021 08:47	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 08:47	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 08:47	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 08:47	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 08:47	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 08:47	2.00	External
PECHS	0.0145	0.00922	ug/L		10/28/2021 08:47	2.00	External
PFBA	8.00	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFBS	0.142	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 08:47	2.00	External
PFES	0.0732	0.0250	ug/L		11/05/2021 20:34	2.00	External
PFHpA	0.0272	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFHS	0.0546	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFHxA	0.173	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFOA	0.0628	0.0192	ug/L		10/28/2021 08:00	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 08:00	2.00	Internal
PFPA	3.18	0.0500	ug/L		11/05/2021 20:34	2.00	External
PFPeA	0.502	0.0100	ug/L		10/28/2021 08:00	2.00	Internal
PFPeS	0.0450	0.00938	ug/L		10/28/2021 08:00	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 08:47	2.00	External
PIBA	0.123	0.100	ug/L		10/28/2021 08:47	2.00	External
TFA	3.36	0.200	ug/L		11/05/2021 20:34	2.00	External
TFMS	3.16	0.0250	ug/L		11/05/2021 20:34	2.00	External

Sample ID E21-1752-002 **Sampled Date\Time** 08/02/2021 13:35
Description UF PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 20:41	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 20:41	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-002 (Cont.) **Sampled Date\Time** 08/02/2021 13:35
Description UF PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSA	<0.0101	0.0101	ug/L		10/28/2021 03:06	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 03:06	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 03:06	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 03:06	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 03:06	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
HQ-115	0.256	0.0100	ug/L		10/28/2021 03:06	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 03:06	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 03:06	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 03:06	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 03:06	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 03:06	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 03:06	2.00	External
PFBA	8.12	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFBS	0.147	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 03:06	2.00	External
PFES	0.0710	0.0250	ug/L		11/05/2021 20:41	2.00	External
PFHpA	0.0280	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFHS	0.0356	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFHxA	0.182	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFOA	0.0694	0.0192	ug/L		10/28/2021 08:15	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 08:15	2.00	Internal
PFPA	3.30	0.0500	ug/L		11/05/2021 20:41	2.00	External
PFPeA	0.526	0.0100	ug/L		10/28/2021 08:15	2.00	Internal
PFPeS	0.0442	0.00938	ug/L		10/28/2021 08:15	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 03:06	2.00	External
PIBA	0.106	0.100	ug/L		10/28/2021 03:06	2.00	External
TFA	3.16	0.200	ug/L		11/05/2021 20:41	2.00	External
TFMS	3.14	0.0250	ug/L		11/05/2021 20:41	2.00	External

Sample ID E21-1752-003 **Sampled Date\Time** 08/02/2021 12:55
Description RO PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 20:47	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 20:47	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 03:53	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 03:53	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-003 (Cont.) **Sampled Date\Time** 08/02/2021 12:55

Description RO PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSE	<0.0510	0.0510	ug/L		10/28/2021 03:53	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 03:53	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 03:53	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 03:53	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 03:53	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 03:53	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 03:53	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 03:53	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 03:53	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 03:53	2.00	External
PFBA	0.0252	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 03:53	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 20:47	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 08:30	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 08:30	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 20:47	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 08:30	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 08:30	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 03:53	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 03:53	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 20:47	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 20:47	2.00	External

Sample ID E21-1752-004 **Sampled Date\Time** 08/02/2021 13:30

Description RO REJECT

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 20:54	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 20:54	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 08:59	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 08:59	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 08:59	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 08:59	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-004 (Cont.) **Sampled Date\Time** 08/02/2021 13:30

Description RO REJECT

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 08:59	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
HQ-115	1.43	0.0100	ug/L		10/28/2021 08:59	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 08:59	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 08:59	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 08:59	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 08:59	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 08:59	2.00	External
PECHS	0.0312	0.00922	ug/L		10/28/2021 08:59	2.00	External
PFBA	36.8	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFBS	0.546	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 08:59	2.00	External
PFES	0.322	0.0250	ug/L		11/05/2021 20:54	2.00	External
PFHpA	0.0814	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFHS	0.0942	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFHxA	0.670	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFOA	0.242	0.0192	ug/L		10/28/2021 08:45	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 08:45	2.00	Internal
PFPA	16.2	0.0500	ug/L		11/05/2021 20:54	2.00	External
PFPeA	2.14	0.0100	ug/L		10/28/2021 08:45	2.00	Internal
PFPeS	0.133	0.00938	ug/L		10/28/2021 08:45	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 08:59	2.00	External
PIBA	0.334	0.100	ug/L		10/28/2021 08:59	2.00	External
TFA	17.0	0.200	ug/L		11/05/2021 20:54	2.00	External
TFMS	14.6	0.0250	ug/L		11/05/2021 20:54	2.00	External

Sample ID E21-1752-011 **Sampled Date\Time** 08/02/2021 12:50

Description IX1-C

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 21:01	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 21:01	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 05:39	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 05:39	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 05:39	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 05:39	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 05:39	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-011 (Cont.) **Sampled Date\Time** 08/02/2021 12:50
Description IX1-C

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 05:39	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 05:39	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 05:39	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 05:39	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 05:39	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 05:39	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 05:39	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 05:39	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 21:01	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 09:00	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 09:00	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 21:01	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 09:00	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 09:00	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 05:39	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 05:39	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 21:01	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 21:01	2.00	External

Sample ID E21-1752-012 **Sampled Date\Time** 08/02/2021 12:45
Description IX2-C

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 21:08	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 21:08	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 05:51	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 05:51	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 05:51	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 05:51	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 05:51	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 05:51	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 05:51	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-012 (Cont.) **Sampled Date\Time** 08/02/2021 12:45

Description IX2-C

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 05:51	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 05:51	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 05:51	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 05:51	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 05:51	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 05:51	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 21:08	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 09:15	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 09:15	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 21:08	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 09:15	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 09:15	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 05:51	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 05:51	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 21:08	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 21:08	2.00	External

Sample ID E21-1752-020 **Sampled Date\Time** 08/11/2021 13:55

Description RO PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 21:15	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 21:15	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 04:05	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 04:05	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 04:05	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 04:05	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 04:05	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
HQ-115	0.111	0.0100	ug/L		10/28/2021 04:05	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 04:05	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 04:05	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 04:05	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-020 (Cont.) **Sampled Date\Time** 08/11/2021 13:55

Description RO PERMEATE

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PBSA	<0.0100	0.0100	ug/L		10/28/2021 04:05	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 04:05	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 04:05	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFBS	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 04:05	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 21:15	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFHS	<0.0200	0.0200	ug/L		10/28/2021 09:30	2.00	External
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFOA	<0.0192	0.0192	ug/L		10/28/2021 09:30	2.00	External
PFOS	<0.00928	0.00928	ug/L		10/28/2021 09:30	2.00	External
PFPA	<0.0500	0.0500	ug/L		11/05/2021 21:15	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 09:30	2.00	External
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 09:30	2.00	External
PHSA-C	<0.100	0.100	ug/L		10/28/2021 04:05	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 04:05	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 21:15	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 21:15	2.00	External

Sample ID E21-1752-024 **Sampled Date\Time** 07/26/2021 16:45

Description Travel Blank Week 1-2

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 21:22	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 21:22	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 00:33	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 00:33	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 00:33	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 00:33	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 00:33	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 00:33	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 00:33	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 00:33	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 00:33	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 00:33	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 00:33	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-024 (Cont.) **Sampled Date\Time** 07/26/2021 16:45

Description Travel Blank Week 1-2

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PECHS	<0.00922	0.00922	ug/L		10/28/2021 00:33	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 00:33	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 21:22	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 10:16	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 10:16	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 21:22	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 10:16	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 10:16	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 00:33	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 00:33	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 21:22	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 21:22	2.00	External

Sample ID E21-1752-025 **Sampled Date\Time** 08/23/2021 14:00

Description 3MCG-Test01_B-UF-PERM-20210823

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:04	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:04	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 03:18	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 03:18	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 03:18	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 03:18	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 03:18	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
HQ-115	4.44	0.0100	ug/L		10/28/2021 03:18	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 03:18	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 03:18	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 03:18	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 03:18	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 03:18	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 03:18	2.00	External
PFBA	0.528	0.0100	ug/L		10/28/2021 12:01	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-025 (Cont.) **Sampled Date\Time** 08/23/2021 14:00
Description 3MCG-Test01_B-UF-PERM-20210823

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFBS	<0.0100	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 03:18	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 22:04	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFHS	0.0110	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 00:58	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 12:01	2.00	Internal
PFPA	1.80	0.0500	ug/L		11/05/2021 22:04	2.00	External
PFPeA	0.0252	0.0100	ug/L		10/28/2021 12:01	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 12:01	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 03:18	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 03:18	2.00	External
TFA	3.20	0.200	ug/L		11/05/2021 22:04	2.00	External
TFMS	1.28	0.0250	ug/L		11/05/2021 22:04	2.00	External

Sample ID E21-1752-026 **Sampled Date\Time** 08/23/2021 18:20
Description 3MCG-Test01-B-INF-A (RO-REJ)-20210823

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:10	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:10	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 09:11	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 09:11	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 09:11	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 09:11	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 09:11	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
HQ-115	74.0	0.0100	ug/L		10/28/2021 09:11	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 09:11	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 09:11	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 09:11	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 09:11	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 09:11	2.00	External
PECHS	0.0762	0.00922	ug/L		10/28/2021 09:11	2.00	External
PFBA	17.3	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFBS	0.650	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 09:11	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-026 (Cont.) **Sampled Date\Time** 08/23/2021 18:20
Description 3MCG-Test01-B-INF-A (RO-REJ)-20210823

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFES	0.185	0.0250	ug/L		11/05/2021 22:10	2.00	External
PFHpA	0.0822	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFHpS	0.0169	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFHS	0.300	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFHxA	0.740	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFOA	0.324	0.00958	ug/L		11/05/2021 01:13	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 12:16	2.00	Internal
PFPA	9.92	0.0500	ug/L		11/05/2021 22:10	2.00	External
PFPeA	1.71	0.0100	ug/L		10/28/2021 12:16	2.00	Internal
PFPeS	0.256	0.00938	ug/L		10/28/2021 12:16	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 09:11	2.00	External
PIBA	0.139	0.100	ug/L		10/28/2021 09:11	2.00	External
TFA	19.1	0.200	ug/L		11/05/2021 22:10	2.00	External
TFMS	9.50	0.0250	ug/L		11/05/2021 22:10	2.00	External

Sample ID E21-1752-045 **Sampled Date\Time** 08/26/2021 09:30
Description 3MCG-Test 01_B-UF-PERM-20210826

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:17	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:17	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 03:30	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 03:30	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 03:30	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 03:30	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 03:30	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
HQ-115	3.50	0.0100	ug/L		10/28/2021 03:30	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 03:30	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 03:30	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 03:30	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 03:30	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 03:30	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 03:30	2.00	External
PFBA	0.482	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 03:30	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 22:17	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-045 (Cont.) **Sampled Date\Time** 08/26/2021 09:30

Description 3MCG-Test 01_B-UF-PERM-20210826

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 01:28	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 12:31	2.00	Internal
PFPA	2.06	0.0500	ug/L		11/05/2021 22:17	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 12:31	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 12:31	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 03:30	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 03:30	2.00	External
TFA	3.04	0.200	ug/L		11/05/2021 22:17	2.00	External
TFMS	1.44	0.0250	ug/L		11/05/2021 22:17	2.00	External

Sample ID E21-1752-046 **Sampled Date\Time** 08/26/2021 09:30

Description 3MCG-Test 01_B-INF-A (RO-REJ)-20210826

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:24	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:24	2.00	External
FBSA	0.0112	0.00904	ug/L		10/28/2021 09:23	1.79	External
FBSAA	<0.0895	0.0895	ug/L		10/28/2021 09:23	1.79	External
FBSE	<0.0456	0.0456	ug/L		10/28/2021 09:23	1.79	External
FBSEE Diol	<0.0448	0.0448	ug/L		10/28/2021 09:23	1.79	External
FBSEE-DA	<0.00895	0.00895	ug/L		10/28/2021 09:23	1.79	External
FOSA	0.0116	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
HQ-115	58.7	0.00895	ug/L		10/28/2021 09:23	1.79	External
MeFBSA	<0.0394	0.0394	ug/L		10/28/2021 09:23	1.79	External
MeFBSAA	<0.0448	0.0448	ug/L		10/28/2021 09:23	1.79	External
MeFBSE	<0.0179	0.0179	ug/L		10/28/2021 09:23	1.79	External
PBSA	<0.00895	0.00895	ug/L		10/28/2021 09:23	1.79	External
PBSA-DC	<0.0107	0.0107	ug/L		10/28/2021 09:23	1.79	External
PECHS	0.0591	0.00825	ug/L		10/28/2021 09:23	1.79	External
PFBA	14.4	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFBS	0.600	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFBSi	<0.00895	0.00895	ug/L		10/28/2021 09:23	1.79	External
PFES	0.140	0.0250	ug/L		11/05/2021 22:24	2.00	External
PFHpA	0.0748	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFHpS	0.0236	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFHS	0.279	0.00895	ug/L		10/28/2021 12:46	1.79	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-046 (Cont.) **Sampled Date\Time** 08/26/2021 09:30

Description 3MCG-Test 01_B-INF-A (RO-REJ)-20210826

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFHxA	0.426	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFOA	0.260	0.00857	ug/L		11/05/2021 01:43	1.79	Internal
PFOS	<0.00831	0.00831	ug/L		10/28/2021 12:46	1.79	Internal
PFPA	9.84	0.0500	ug/L		11/05/2021 22:24	2.00	External
PFPeA	1.35	0.00895	ug/L		10/28/2021 12:46	1.79	Internal
PFPeS	0.209	0.00840	ug/L		10/28/2021 12:46	1.79	Internal
PHSA-C	<0.0895	0.0895	ug/L		10/28/2021 09:23	1.79	External
PIBA	0.158	0.0895	ug/L		10/28/2021 09:23	1.79	External
TFA	18.6	0.200	ug/L		11/05/2021 22:24	2.00	External
TFMS	8.56	0.0250	ug/L		11/05/2021 22:24	2.00	External

Sample ID E21-1752-055 **Sampled Date\Time** 08/19/2021 10:45

Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:31	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:31	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 00:45	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 00:45	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 00:45	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 00:45	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 00:45	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 00:45	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 00:45	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 00:45	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 00:45	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 00:45	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 00:45	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 00:45	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 00:45	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 22:31	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 01:58	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-055 (Cont.) **Sampled Date\Time** 08/19/2021 10:45

Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFOS	<0.00928	0.00928	ug/L		10/28/2021 13:32	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 22:31	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 13:32	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 13:32	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 00:45	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 00:45	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 22:31	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 22:31	2.00	External

Sample ID E21-1752-061 **Sampled Date\Time** 08/29/2021 09:25

Description 3MCG-Test 01_B-INF-A (RO-REJ)-20210829

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:45	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:45	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 09:35	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 09:35	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 09:35	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 09:35	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 09:35	2.00	External
FOSA	0.0220	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
HQ-115	53.4	0.0100	ug/L		10/28/2021 09:35	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 09:35	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 09:35	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 09:35	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 09:35	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 09:35	2.00	External
PECHS	0.0442	0.00922	ug/L		10/28/2021 09:35	2.00	External
PFBA	10.8	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFBS	4.44	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 09:35	2.00	External
PFES	0.106	0.0250	ug/L		11/05/2021 22:45	2.00	External
PFHpA	0.0552	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFHpS	0.0117	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFHS	0.188	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFHxA	0.324	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFOA	0.226	0.00958	ug/L		11/05/2021 02:29	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 14:02	2.00	Internal
PFPA	10.7	0.0500	ug/L		11/05/2021 22:45	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-061 (Cont.) **Sampled Date\Time** 08/29/2021 09:25
Description 3MCG-Test 01_B-INF-A (RO-REJ)-20210829

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFPeA	0.968	0.0100	ug/L		10/28/2021 14:02	2.00	Internal
PFPeS	0.156	0.00938	ug/L		10/28/2021 14:02	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 09:35	2.00	External
PIBA	0.168	0.100	ug/L		10/28/2021 09:35	2.00	External
TFA	20.2	0.200	ug/L		11/05/2021 22:45	2.00	External
TFMS	8.62	0.0250	ug/L		11/05/2021 22:45	2.00	External

Sample ID E21-1752-078 **Sampled Date\Time** 09/01/2021 10:25
Description 3MCG-Test 01_B-IX2-A-20210901

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:52	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:52	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 06:03	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 06:03	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 06:03	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 06:03	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 06:03	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 06:03	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 06:03	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 06:03	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 06:03	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 06:03	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 06:03	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 06:03	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 06:03	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 22:52	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 02:44	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 14:17	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 22:52	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 14:17	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 14:17	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-078 (Cont.) **Sampled Date\Time** 09/01/2021 10:25

Description 3MCG-Test 01_B-IX2-A-20210901

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PHSA-C	<0.100	0.100	ug/L		10/28/2021 06:03	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 06:03	2.00	External
TFA	19.8	0.200	ug/L		11/05/2021 22:52	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 22:52	2.00	External

Sample ID E21-1752-080 **Sampled Date\Time** 09/01/2021 10:25

Description 3MCG-Test 01_B-IXR2-B-20210901

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 22:59	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 22:59	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 06:14	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 06:14	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 06:14	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 06:14	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 06:14	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 06:14	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 06:14	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 06:14	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 06:14	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 06:14	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 06:14	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 06:14	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 06:14	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 22:59	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 02:59	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 14:32	2.00	Internal
PFPA	4.32	0.0500	ug/L		11/05/2021 22:59	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 14:32	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 14:32	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 06:14	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 06:14	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-080 (Cont.) **Sampled Date\Time** 09/01/2021 10:25

Description 3MCG-Test 01_B-IXR2-B-20210901

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
TFA	19.8	0.200	ug/L		11/05/2021 22:59	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 22:59	2.00	External

Sample ID E21-1752-081 **Sampled Date\Time** 09/02/2021 10:30

Description 3MCG-Test 01_B-UF-PERM-20210902

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 23:34	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 23:34	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 03:41	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 03:41	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 03:41	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 03:41	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 03:41	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
HQ-115	0.564	0.0100	ug/L		10/28/2021 03:41	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 03:41	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 03:41	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 03:41	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 03:41	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 03:41	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 03:41	2.00	External
PFBA	1.73	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFBS	0.101	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 03:41	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 23:34	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 03:59	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 16:17	2.00	Internal
PFPA	2.88	0.0500	ug/L		11/05/2021 23:34	2.00	External
PFPeA	0.0148	0.0100	ug/L		10/28/2021 16:17	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 16:17	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 03:41	2.00	External
PIBA	0.109	0.100	ug/L		10/28/2021 03:41	2.00	External
TFA	3.32	0.200	ug/L		11/05/2021 23:34	2.00	External
TFMS	2.32	0.0250	ug/L		11/05/2021 23:34	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-082 **Sampled Date\Time** 09/02/2021 11:15
Description 3MCG-Test 01_B-INF-A (RO-REJ)-20210902

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 23:41	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 23:41	2.00	External
FBSA	0.0134	0.0101	ug/L		10/28/2021 09:47	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 09:47	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 09:47	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 09:47	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 09:47	2.00	External
FOSA	0.0452	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
HQ-115	42.4	0.0100	ug/L		10/28/2021 09:47	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 09:47	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 09:47	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 09:47	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 09:47	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 09:47	2.00	External
PECHS	0.0386	0.00922	ug/L		10/28/2021 09:47	2.00	External
PFBA	8.70	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFBS	13.8	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 09:47	2.00	External
PFES	0.0748	0.0250	ug/L		11/05/2021 23:41	2.00	External
PFHpA	0.0344	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFHpS	0.0141	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFHS	0.135	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFHxA	0.204	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFOA	0.173	0.00958	ug/L		11/05/2021 04:14	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 16:32	2.00	Internal
PFPA	12.7	0.0500	ug/L		11/05/2021 23:41	2.00	External
PFPeA	0.560	0.0100	ug/L		10/28/2021 16:32	2.00	Internal
PFPeS	0.0968	0.00938	ug/L		10/28/2021 16:32	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 09:47	2.00	External
PIBA	0.232	0.100	ug/L		10/28/2021 09:47	2.00	External
TFA	21.6	0.200	ug/L		11/05/2021 23:41	2.00	External
TFMS	9.58	0.0250	ug/L		11/05/2021 23:41	2.00	External

Sample ID E21-1752-096 **Sampled Date\Time** 08/24/2021 00:55
Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/05/2021 23:47	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/05/2021 23:47	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-096 (Cont.) **Sampled Date\Time** 08/24/2021 00:55

Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSA	<0.0101	0.0101	ug/L		10/28/2021 00:57	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 00:57	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 00:57	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 00:57	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 00:57	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 00:57	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 00:57	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 00:57	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 00:57	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 00:57	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 00:57	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 00:57	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 00:57	2.00	External
PFES	<0.0250	0.0250	ug/L		11/05/2021 23:47	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 04:29	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 17:18	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/05/2021 23:47	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 17:18	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 17:18	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 00:57	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 00:57	2.00	External
TFA	<0.200	0.200	ug/L		11/05/2021 23:47	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/05/2021 23:47	2.00	External

Sample ID E21-1752-097 **Sampled Date\Time** 09/23/2021 12:00

Description 3MCG-Test 02-D.0-INF (RO-REJ)-20210921

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 00:01	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 00:01	2.00	External
FBSA	1.60	0.0101	ug/L		10/28/2021 09:58	2.00	External
FBSAA	0.141	0.100	ug/L		10/28/2021 09:58	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-097 (Cont.) **Sampled Date\Time** 09/23/2021 12:00

Description 3MCG-Test 02-D.0-INF (RO-REJ)-20210921

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSE	0.234	0.0510	ug/L		10/28/2021 09:58	2.00	External
FBSEE Diol	0.107	0.0500	ug/L		10/28/2021 09:58	2.00	External
FBSEE-DA	0.212	0.0100	ug/L		10/28/2021 09:58	2.00	External
FOSA	0.0418	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
HQ-115	91.0	0.0100	ug/L		10/28/2021 09:58	2.00	External
MeFBSA	0.464	0.0440	ug/L		10/28/2021 09:58	2.00	External
MeFBSAA	0.134	0.0500	ug/L		10/28/2021 09:58	2.00	External
MeFBSE	0.0846	0.0200	ug/L		10/28/2021 09:58	2.00	External
PBSA	0.436	0.0100	ug/L		10/28/2021 09:58	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 09:58	2.00	External
PECHS	0.179	0.00922	ug/L		10/28/2021 09:58	2.00	External
PFBA	13.8	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFBS	37.0	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFBSi	2.46	0.0100	ug/L		10/28/2021 09:58	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 00:01	2.00	External
PFHpA	0.0358	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFHpS	0.110	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFHS	0.510	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFHxA	0.252	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFOA	0.488	0.00958	ug/L		11/05/2021 04:59	2.00	Internal
PFOS	0.170	0.00928	ug/L		10/28/2021 17:48	2.00	Internal
PFPA	8.50	0.0500	ug/L		11/06/2021 00:01	2.00	External
PFPeA	0.706	0.0100	ug/L		10/28/2021 17:48	2.00	Internal
PFPeS	0.174	0.00938	ug/L		10/28/2021 17:48	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 09:58	2.00	External
PIBA	0.140	0.100	ug/L		10/28/2021 09:58	2.00	External
TFA	11.3	0.200	ug/L		11/06/2021 00:01	2.00	External
TFMS	414	0.250	ug/L		11/23/2021 00:42	20.0	External

Sample ID E21-1752-108 **Sampled Date\Time** 09/24/2021 12:00

Description 3MCG-Test 02-D.4-IX2-20210924

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 00:08	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 00:08	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 06:26	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 06:26	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 06:26	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 06:26	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-108 (Cont.) **Sampled Date\Time** 09/24/2021 12:00

Description 3MCG-Test 02-D.4-IX2-20210924

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 06:26	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 06:26	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 06:26	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 06:26	2.00	External
MeFBSE	0.0260	0.0200	ug/L		10/28/2021 06:26	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 06:26	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 06:26	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 06:26	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 06:26	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 00:08	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 05:14	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 18:03	2.00	Internal
PFPA	0.370	0.0500	ug/L		11/06/2021 00:08	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 18:03	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 18:03	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 06:26	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 06:26	2.00	External
TFA	10.7	0.200	ug/L		11/06/2021 00:08	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 00:08	2.00	External

Sample ID E21-1752-110 **Sampled Date\Time** 09/24/2021 12:00

Description 3MCG-Test 02-E.4-IXR2-20210924

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 00:15	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 00:15	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 06:38	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 06:38	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 06:38	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 06:38	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 06:38	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-110 (Cont.) **Sampled Date\Time** 09/24/2021 12:00

Description 3MCG-Test 02-E.4-IXR2-20210924

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 06:38	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 06:38	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 06:38	2.00	External
MeFBSE	0.0262	0.0200	ug/L		10/28/2021 06:38	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 06:38	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 06:38	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 06:38	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 06:38	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 00:15	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 05:29	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 18:18	2.00	Internal
PFPA	6.64	0.0500	ug/L		11/06/2021 00:15	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 18:18	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 18:18	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 06:38	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 06:38	2.00	External
TFA	13.2	0.200	ug/L		11/06/2021 00:15	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 00:15	2.00	External

Sample ID E21-1752-111 **Sampled Date\Time** 09/20/2021 14:50

Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 00:22	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 00:22	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 01:09	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 01:09	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 01:09	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 01:09	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 01:09	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 01:09	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 01:09	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-111 (Cont.) **Sampled Date\Time** 09/20/2021 14:50

Description Travel Blank

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 01:09	2.00	External
MeFBSE	0.0274	0.0200	ug/L		10/28/2021 01:09	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 01:09	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 01:09	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 01:09	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 01:09	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 00:22	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFOA	<0.00958	0.00958	ug/L		11/05/2021 05:44	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 19:03	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 00:22	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 19:03	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 19:03	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 01:09	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 01:09	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 00:22	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 00:22	2.00	External

Sample ID E21-1752-145 **Sampled Date\Time** 09/18/2021 08:48

Description 3MCG-Test 02-F.0-INF (RO PERM)-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 00:57	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 00:57	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 04:17	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 04:17	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 04:17	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 04:17	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 04:17	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
HQ-115	0.0962	0.0100	ug/L		10/28/2021 04:17	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 04:17	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 04:17	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 04:17	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-145 (Cont.) **Sampled Date\Time** 09/18/2021 08:48

Description 3MCG-Test 02-F.0-INF (RO PERM)-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PBSA	<0.0100	0.0100	ug/L		10/28/2021 04:17	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 04:17	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 04:17	2.00	External
PFBA	0.0111	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFBS	0.0165	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 04:17	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 00:57	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 20:34	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 20:34	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 00:57	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 20:34	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 20:34	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 04:17	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 04:17	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 00:57	2.00	External
TFMS	0.582	0.0250	ug/L		11/06/2021 00:57	2.00	External

Sample ID E21-1752-146 **Sampled Date\Time** 09/18/2021 08:38

Description 3MCG-Test 02-F.1-IX1-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 01:04	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 01:04	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 06:50	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 06:50	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 06:50	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 06:50	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 06:50	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 06:50	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 06:50	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 06:50	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 06:50	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 06:50	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 06:50	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-146 (Cont.) **Sampled Date\Time** 09/18/2021 08:38
Description 3MCG-Test 02-F.1-IX1-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PECHS	<0.00922	0.00922	ug/L		10/28/2021 06:50	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 06:50	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 01:04	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 20:49	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 20:49	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 01:04	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 20:49	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 20:49	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 06:50	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 06:50	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 01:04	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 01:04	2.00	External

Sample ID E21-1752-147 **Sampled Date\Time** 09/18/2021 08:20
Description 3MCG-Test 02-F.2-IX2-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 01:11	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 01:11	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 07:02	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 07:02	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 07:02	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 07:02	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 07:02	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 07:02	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 07:02	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 07:02	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 07:02	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 07:02	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 07:02	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 07:02	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-147 (Cont.) **Sampled Date\Time** 09/18/2021 08:20

Description 3MCG-Test 02-F.2-IX2-20210918

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFBS	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 07:02	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 01:11	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 21:04	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 21:04	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 01:11	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 21:04	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 21:04	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 07:02	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 07:02	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 01:11	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 01:11	2.00	External

Sample ID E21-1752-148 **Sampled Date\Time** 09/23/2021 10:00

Description 3MCG-Test 02-F.0-INF (RO PERM)-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 01:18	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 01:18	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 05:27	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 05:27	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 05:27	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 05:27	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 05:27	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
HQ-115	0.120	0.0100	ug/L		10/28/2021 05:27	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 05:27	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 05:27	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 05:27	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 05:27	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 05:27	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 05:27	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFBS	0.0410	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 05:27	2.00	External

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-148 (Cont.) **Sampled Date\Time** 09/23/2021 10:00
Description 3MCG-Test 02-F.0-INF (RO PERM)-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFES	<0.0250	0.0250	ug/L		11/06/2021 01:18	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 21:19	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 21:19	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 01:18	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 21:19	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 21:19	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 05:27	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 05:27	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 01:18	2.00	External
TFMS	0.320	0.0250	ug/L		11/06/2021 01:18	2.00	External

Sample ID E21-1752-149 **Sampled Date\Time** 09/23/2021 09:45
Description 3MCG-Test 02-F.1-IX1-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 01:24	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 01:24	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 08:24	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 08:24	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 08:24	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 08:24	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 08:24	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
HQ-115	<0.0100	0.0100	ug/L		10/28/2021 08:24	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 08:24	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 08:24	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 08:24	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 08:24	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 08:24	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 08:24	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 08:24	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 01:24	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-149 (Cont.) **Sampled Date\Time** 09/23/2021 09:45

Description 3MCG-Test 02-F.1-IX1-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 21:34	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 21:34	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 01:24	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 21:34	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 21:34	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 08:24	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 08:24	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 01:24	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 01:24	2.00	External

Sample ID E21-1752-150 **Sampled Date\Time** 09/23/2021 09:30

Description 3MCG-Test 02-F.2-IX2-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
2233-TFPA	<0.500	0.500	ug/L		11/06/2021 01:31	2.00	External
2333-TFPA	<1.00	1.00	ug/L		11/06/2021 01:31	2.00	External
FBSA	<0.0101	0.0101	ug/L		10/28/2021 08:36	2.00	External
FBSAA	<0.100	0.100	ug/L		10/28/2021 08:36	2.00	External
FBSE	<0.0510	0.0510	ug/L		10/28/2021 08:36	2.00	External
FBSEE Diol	<0.0500	0.0500	ug/L		10/28/2021 08:36	2.00	External
FBSEE-DA	<0.0100	0.0100	ug/L		10/28/2021 08:36	2.00	External
FOSA	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
HQ-115	0.0224	0.0100	ug/L		10/28/2021 08:36	2.00	External
MeFBSA	<0.0440	0.0440	ug/L		10/28/2021 08:36	2.00	External
MeFBSAA	<0.0500	0.0500	ug/L		10/28/2021 08:36	2.00	External
MeFBSE	<0.0200	0.0200	ug/L		10/28/2021 08:36	2.00	External
PBSA	<0.0100	0.0100	ug/L		10/28/2021 08:36	2.00	External
PBSA-DC	<0.0120	0.0120	ug/L		10/28/2021 08:36	2.00	External
PECHS	<0.00922	0.00922	ug/L		10/28/2021 08:36	2.00	External
PFBA	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFBS	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFBSi	<0.0100	0.0100	ug/L		10/28/2021 08:36	2.00	External
PFES	<0.0250	0.0250	ug/L		11/06/2021 01:31	2.00	External
PFHpA	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFHpS	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFHS	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal

Table 1. Sample Results Summary (cont.)

Sample ID E21-1752-150 (Cont.) **Sampled Date\Time** 09/23/2021 09:30

Description 3MCG-Test 02-F.2-IX2-20210923

Analyte	Result	LOQ	Units	Qual	Analysis Date/Time	DF	Quant Mth
PFHxA	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFOA	<0.0192	0.0192	ug/L		10/28/2021 21:49	2.00	Internal
PFOS	<0.00928	0.00928	ug/L		10/28/2021 21:49	2.00	Internal
PFPA	<0.0500	0.0500	ug/L		11/06/2021 01:31	2.00	External
PFPeA	<0.0100	0.0100	ug/L		10/28/2021 21:49	2.00	Internal
PFPeS	<0.00938	0.00938	ug/L		10/28/2021 21:49	2.00	Internal
PHSA-C	<0.100	0.100	ug/L		10/28/2021 08:36	2.00	External
PIBA	<0.100	0.100	ug/L		10/28/2021 08:36	2.00	External
TFA	<0.200	0.200	ug/L		11/06/2021 01:31	2.00	External
TFMS	<0.0250	0.0250	ug/L		11/06/2021 01:31	2.00	External

Quality Control Summary

LCS Summary

Batch: **LCMS-7112**

Analyte: FOSA (Perfluorooctanesulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0492	0.0606	ug/L	123 %	L1	10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0492	0.0508	ug/L	103 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0492	0.0508	ug/L	103 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.492	0.566	ug/L	115 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.492	0.522	ug/L	106 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.492	0.538	ug/L	109 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.93	10.9	ug/L	110 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.93	10.7	ug/L	108 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.93	10.6	ug/L	106 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>30.0	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>30.0	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>30.0	ug/L	N/A		10/28/2021 04:59

Analyte: FOSA (Perfluorooctanesulfonamide) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0492	0.0552	ug/L	112 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0492	0.0528	ug/L	107 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0492	0.0440	ug/L	89.5 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.492	0.518	ug/L	105 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.492	0.494	ug/L	100 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.492	0.502	ug/L	102 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.93	11.3	ug/L	114 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.93	11.2	ug/L	113 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.93	10.9	ug/L	110 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	146	ug/L	106 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	151	ug/L	110 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	155	ug/L	112 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.497	0.634	ug/L	127 %	L1	10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.497	0.488	ug/L	98.2 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.497	0.522	ug/L	105 %		10/28/2021 06:29

Analyte: PFBA (Perfluorobutanoic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0400	ug/L	81.0 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0378	ug/L	76.6 %	L1	10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0472	ug/L	95.6 %		10/28/2021 01:28

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFBA (Perfluorobutanoic acid) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788657 LCS Mid	0.493	0.518	ug/L	105 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.516	ug/L	105 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.514	ug/L	104 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.3	ug/L	113 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.3	ug/L	114 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.0	ug/L	111 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	171	ug/L	N/A	L1,L0	10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	146	ug/L	N/A	L0	10/28/2021 04:59

Analyte: PFBA (Perfluorobutanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0424	ug/L	85.9 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0412	ug/L	83.5 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0466	ug/L	94.3 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.540	ug/L	109 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.536	ug/L	109 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.536	ug/L	108 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.3	ug/L	114 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.6	ug/L	116 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.6	ug/L	117 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	147	ug/L	107 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	148	ug/L	107 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	145	ug/L	105 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.498	0.530	ug/L	106 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.498	0.534	ug/L	107 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.498	0.546	ug/L	109 %		10/28/2021 06:29

Analyte: PFBS (Perfluorobutanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0492	0.0546	ug/L	111 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0492	0.0510	ug/L	103 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0492	0.0516	ug/L	105 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.492	0.598	ug/L	122 %	L1	10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.492	0.560	ug/L	114 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.492	0.576	ug/L	117 %		10/28/2021 02:13

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFBS (Perfluorobutanesulfonate) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788660 LCS High	9.94	12.3	ug/L	N/A	L1,L0	10/28/2021 02:28
QC-LCS-788661 LCS High	9.94	12.4	ug/L	N/A	L1,L0	10/28/2021 02:43
QC-LCS-788662 LCS High	9.94	11.9	ug/L	N/A	L1,L0	10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>10.0	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>10.0	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>10.0	ug/L	N/A		10/28/2021 04:59

Analyte: PFBS (Perfluorobutanesulfonate) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0492	0.0552	ug/L	112 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0492	0.0528	ug/L	107 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0492	0.0448	ug/L	91.1 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.492	0.602	ug/L	122 %	L1	10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.492	0.588	ug/L	119 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.492	0.588	ug/L	119 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.94	11.9	ug/L	120 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.94	11.7	ug/L	118 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.94	12.3	ug/L	124 %	L1	10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	153	ug/L	111 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	154	ug/L	112 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	155	ug/L	112 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.497	0.558	ug/L	112 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.497	0.572	ug/L	115 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.497	0.598	ug/L	120 %		10/28/2021 06:29

Analyte: PFHpA (Perfluoroheptanoic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0498	ug/L	101 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0464	ug/L	94.1 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0502	ug/L	102 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.502	ug/L	102 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.474	ug/L	96.0 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.466	ug/L	94.3 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.4	ug/L	115 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.1	ug/L	111 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.2	ug/L	112 %		10/28/2021 02:58

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFHpA (Perfluoroheptanoic acid) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:59

Analyte: PFHpA (Perfluoroheptanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0530	ug/L	107 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0494	ug/L	100 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0522	ug/L	106 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.498	ug/L	101 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.492	ug/L	99.6 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.480	ug/L	97.1 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.0	ug/L	111 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	10.8	ug/L	109 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	10.2	ug/L	102 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	148	ug/L	N/A	L0	10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	152	ug/L	N/A	L0	10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	162	ug/L	N/A	L0	10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.498	0.500	ug/L	100 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.498	0.466	ug/L	93.2 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.498	0.490	ug/L	98.1 %		10/28/2021 06:29

Analyte: PFHpS (Perfluoroheptanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0472	ug/L	95.7 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0482	ug/L	97.7 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0460	ug/L	93.3 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.496	ug/L	100 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.502	ug/L	102 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.492	ug/L	99.8 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.8	ug/L	118 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.5	ug/L	115 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	<0.0100	ug/L	N/A	L1	10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:44

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFHpS (Perfluoroheptanesulfonate) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:59

Analyte: PFHpS (Perfluoroheptanesulfonate) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0490	ug/L	99.3 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0512	ug/L	104 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0468	ug/L	94.8 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.512	ug/L	103 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.514	ug/L	104 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.494	ug/L	99.9 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.3	ug/L	113 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.1	ug/L	111 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	<0.0100	ug/L	N/A	L1	10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>50.0	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>50.0	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>50.0	ug/L	N/A		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.498	0.480	ug/L	96.0 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.498	0.492	ug/L	98.5 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.498	0.530	ug/L	106 %		10/28/2021 06:29

Analyte: PFHS () **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0486	ug/L	98.4 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0528	ug/L	107 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0522	ug/L	106 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.576	ug/L	116 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.550	ug/L	111 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.562	ug/L	114 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.8	ug/L	118 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.9	ug/L	119 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.6	ug/L	117 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	149	ug/L	108 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	150	ug/L	109 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	145	ug/L	105 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.498	0.536	ug/L	107 %		10/28/2021 05:59

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFHS () - Continued **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788672 Laboratory Control Sample (Spike)	0.498	0.554	ug/L	111 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.498	0.558	ug/L	111 %		10/28/2021 06:29

Analyte: PFHxA (Perfluorohexanoic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0514	ug/L	104 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0418	ug/L	84.7 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0464	ug/L	94.1 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.540	ug/L	109 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.498	ug/L	101 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.528	ug/L	107 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.9	ug/L	120 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.2	ug/L	112 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.0	ug/L	111 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	197	ug/L	143 %	L1	10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	160	ug/L	116 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	146	ug/L	106 %		10/28/2021 04:59

Analyte: PFHxA (Perfluorohexanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0550	ug/L	111 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0484	ug/L	98.0 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0488	ug/L	98.9 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.532	ug/L	108 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.478	ug/L	96.6 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.488	ug/L	98.8 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	10.4	ug/L	104 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.0	ug/L	110 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.4	ug/L	114 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	162	ug/L	118 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	162	ug/L	117 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	159	ug/L	116 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.498	0.504	ug/L	101 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.498	0.476	ug/L	95.3 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.498	0.564	ug/L	113 %		10/28/2021 06:29

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFOA (Perfluorooctanoic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0472	0.0450	ug/L	95.2 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0472	0.0394	ug/L	83.6 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0472	0.0362	ug/L	76.9 %	L1	10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.472	0.428	ug/L	90.9 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.472	0.420	ug/L	88.9 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.472	0.436	ug/L	92.5 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.53	10.1	ug/L	106 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.53	9.70	ug/L	102 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.53	9.02	ug/L	94.5 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	132	156	ug/L	118 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	132	143	ug/L	108 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	132	132	ug/L	99.8 %		10/28/2021 04:59

Analyte: PFOA (Perfluorooctanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0472	0.0502	ug/L	106 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0472	0.0388	ug/L	82.0 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0472	0.0374	ug/L	79.2 %	L1	10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.472	0.390	ug/L	82.5 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.472	0.454	ug/L	96.1 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.472	0.468	ug/L	99.0 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.53	10.2	ug/L	107 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.53	10.4	ug/L	109 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.53	10.0	ug/L	105 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	132	146	ug/L	110 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	132	151	ug/L	114 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	132	145	ug/L	110 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.477	0.462	ug/L	96.7 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.477	0.468	ug/L	98.0 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.477	0.458	ug/L	95.6 %		10/28/2021 06:29

Analyte: PFOS (Perfluorooctanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0457	0.0450	ug/L	98.1 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0457	0.0432	ug/L	94.5 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0457	0.0444	ug/L	97.0 %		10/28/2021 01:28

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFOS (Perfluorooctanesulfonate) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788657 LCS Mid	0.457	0.476	ug/L	104 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.457	0.476	ug/L	104 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.457	0.478	ug/L	104 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.22	9.92	ug/L	108 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.22	9.88	ug/L	107 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.22	9.42	ug/L	102 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	128	>46.4	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	128	>46.4	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	128	>46.4	ug/L	N/A		10/28/2021 04:59

Analyte: PFOS (Perfluorooctanesulfonate) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0457	0.0444	ug/L	97.1 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0457	0.0440	ug/L	96.1 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0457	0.0438	ug/L	95.7 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.457	0.468	ug/L	102 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.457	0.442	ug/L	96.6 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.457	0.446	ug/L	97.2 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.22	10.2	ug/L	111 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.22	9.86	ug/L	107 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.22	9.96	ug/L	108 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	128	139	ug/L	108 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	128	143	ug/L	111 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	128	140	ug/L	109 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.461	0.466	ug/L	101 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.461	0.456	ug/L	98.6 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.461	0.476	ug/L	103 %		10/28/2021 06:29

Analyte: PFPeA (Perfluoropentanoic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0498	0.0544	ug/L	109 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0498	0.0450	ug/L	90.5 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0498	0.0530	ug/L	106 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.498	0.534	ug/L	107 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.498	0.498	ug/L	100 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.498	0.556	ug/L	112 %		10/28/2021 02:13

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFPeA (Perfluoropentanoic acid) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788660 LCS High	10.0	11.8	ug/L	118 %		10/28/2021 02:28
QC-LCS-788661 LCS High	10.0	11.1	ug/L	111 %		10/28/2021 02:43
QC-LCS-788662 LCS High	10.0	11.1	ug/L	111 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	173	ug/L	125 %	L1	10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	146	ug/L	106 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	132	ug/L	96.0 %		10/28/2021 04:59

Analyte: PFPeA (Perfluoropentanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0498	0.0546	ug/L	110 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0498	0.0454	ug/L	91.1 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0498	0.0526	ug/L	106 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.498	0.508	ug/L	102 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.498	0.474	ug/L	95.2 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.498	0.532	ug/L	107 %		10/28/2021 02:13
QC-LCS-788660 LCS High	10.0	11.0	ug/L	110 %		10/28/2021 02:28
QC-LCS-788661 LCS High	10.0	11.1	ug/L	111 %		10/28/2021 02:43
QC-LCS-788662 LCS High	10.0	10.9	ug/L	109 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	149	ug/L	108 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	148	ug/L	107 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	146	ug/L	106 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.502	0.496	ug/L	98.5 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.502	0.546	ug/L	108 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.502	0.488	ug/L	96.9 %		10/28/2021 06:29

Analyte: PFPeS (Perfluoropentanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0462	0.0464	ug/L	100 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0462	0.0430	ug/L	93.1 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0462	0.0454	ug/L	98.1 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.462	0.488	ug/L	105 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.462	0.464	ug/L	100 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.462	0.474	ug/L	103 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.33	10.8	ug/L	116 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.33	10.5	ug/L	112 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.33	0.0125	ug/L	0.134 %	L1	10/28/2021 02:58

LCS Summary (cont.)

Batch: **LCMS-7112 - Continued**

Analyte: PFPeS (Perfluoropentanesulfonate) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788668 Laboratory Control Sample (Spike)	130	>93.8	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	130	>93.8	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	130	>93.8	ug/L	N/A		10/28/2021 04:59

Analyte: PFPeS (Perfluoropentanesulfonate) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0462	0.0432	ug/L	93.4 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0462	0.0420	ug/L	90.8 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0462	0.0380	ug/L	82.0 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.462	0.458	ug/L	99.1 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.462	0.454	ug/L	98.4 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.462	0.452	ug/L	97.8 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.33	10.2	ug/L	110 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.33	9.72	ug/L	104 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.33	0.0135	ug/L	0.145 %	L1	10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	130	139	ug/L	107 %		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	130	146	ug/L	113 %		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	130	146	ug/L	112 %		10/28/2021 04:59
QC-LCS-788671 Laboratory Control Sample (Spike)	0.467	0.428	ug/L	91.5 %		10/28/2021 05:59
QC-LCS-788672 Laboratory Control Sample (Spike)	0.467	0.452	ug/L	96.6 %		10/28/2021 06:14
QC-LCS-788673 Laboratory Control Sample (Spike)	0.467	0.464	ug/L	99.1 %		10/28/2021 06:29

Batch: **LCMS-7115**

Analyte: FBSA (Perfluorobutanesulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.203	0.198	ug/L	97.3 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.203	0.200	ug/L	98.4 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.203	0.207	ug/L	102 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.03	2.05	ug/L	101 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.03	2.15	ug/L	106 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.03	2.19	ug/L	108 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	70.6	69.4	ug/L	98.2 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	70.6	73.2	ug/L	104 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	70.6	74.2	ug/L	105 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.03	2.14	ug/L	105 %		10/27/2021 23:58

LCS Summary (cont.)

Batch: **LCMS-7115 - Continued**

Analyte: FBSA (Perfluorobutanesulfonamide) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789202 LCS High	2.03	2.12	ug/L	103 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.03	2.16	ug/L	106 %		10/28/2021 00:22

Analyte: FBSAA (Perfluorobutyl sulfonamido acetic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.184	ug/L	91.4 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.147	ug/L	72.9 %	L1	10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.176	ug/L	87.6 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	2.11	ug/L	105 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.23	ug/L	111 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.07	ug/L	103 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	71.2	ug/L	102 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	71.8	ug/L	103 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	76.4	ug/L	109 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.20	ug/L	109 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.02	ug/L	99.6 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.24	ug/L	111 %		10/28/2021 00:22

Analyte: FBSE (1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-1-butanesulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.205	0.205	ug/L	99.8 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.205	0.211	ug/L	103 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.205	0.209	ug/L	102 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.05	2.13	ug/L	103 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.05	2.15	ug/L	105 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.05	2.21	ug/L	108 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	71.3	70.8	ug/L	99.3 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	71.3	75.6	ug/L	106 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	71.3	75.4	ug/L	105 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.05	2.06	ug/L	99.6 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.05	2.08	ug/L	101 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.05	2.10	ug/L	102 %		10/28/2021 00:22

Analyte: FBSEE Diol (1,1,2,2,3,3,4,4,4-Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.198	ug/L	98.5 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.198	ug/L	98.3 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.203	ug/L	101 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	1.89	ug/L	93.8 %		10/27/2021 21:37

LCS Summary (cont.)

Batch: **LCMS-7115 - Continued**

Analyte: FBSEE Diol (1,1,2,2,3,3,4,4,4-Nonafluoro-N,N-bis(2-hydroxyethyl)butane-1-sulfonamide) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789196 LCS Mid	2.01	1.95	ug/L	97.0 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	1.96	ug/L	97.5 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	71.8	ug/L	103 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	75.8	ug/L	108 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	73.8	ug/L	105 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	1.94	ug/L	96.1 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	1.91	ug/L	94.4 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	1.92	ug/L	94.9 %		10/28/2021 00:22

Analyte: FBSEE-DA ([(Nonafluorobutane-1-sulfonyl)-carboxymethylamino]acetic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.193	ug/L	96.1 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.209	ug/L	104 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.209	ug/L	104 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	2.17	ug/L	108 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.23	ug/L	111 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.23	ug/L	111 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	69.0	ug/L	98.5 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	74.2	ug/L	106 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	75.4	ug/L	108 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.30	ug/L	114 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.30	ug/L	114 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.64	ug/L	130 %	L1	10/28/2021 00:22

Analyte: HQ-115 (Methanesulfonamide, 1,1,1-trifluoro-N-[(trifluoromethyl)sulfonyl-]) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.192	ug/L	95.5 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.199	ug/L	99.2 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.245	ug/L	122 %	L1	10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	2.05	ug/L	102 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.13	ug/L	106 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.17	ug/L	108 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	67.4	ug/L	96.4 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	72.0	ug/L	103 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	73.8	ug/L	106 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.08	ug/L	103 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.14	ug/L	106 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.34	ug/L	116 %		10/28/2021 00:22

Analyte: MeFBSA (1,1,2,2,3,3,4,4,4-Nonafluoro-N-methylbutane-1-sulfonamide) **Quant Method:** External

LCS Summary (cont.)

Batch: **LCMS-7115 - Continued**

Analyte: MeFBSA (1,1,2,2,3,3,4,4,4-Nonafluoro-N-methylbutane-1-sulfonamide) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.177	0.178	ug/L	101 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.177	0.150	ug/L	84.6 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.177	0.189	ug/L	107 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	1.77	1.76	ug/L	99.2 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	1.77	1.72	ug/L	97.3 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	1.77	1.73	ug/L	97.4 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	61.5	62.6	ug/L	102 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	61.5	65.2	ug/L	106 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	61.5	65.6	ug/L	107 %		10/27/2021 22:36
QC-LCS-789200 LCS Mid-High	61.5	65.6	ug/L	107 %		10/27/2021 22:36
QC-LCS-789201 LCS High	1.77	1.59	ug/L	89.9 %		10/27/2021 23:58
QC-LCS-789202 LCS High	1.77	1.67	ug/L	94.1 %		10/28/2021 00:10
QC-LCS-789203 LCS High	1.77	1.63	ug/L	92.1 %		10/28/2021 00:22

Analyte: MeFBSAA (Perfluorobutyl-methyl sulfonamido acetic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.186	ug/L	92.6 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.199	ug/L	98.8 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.203	ug/L	101 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	1.95	ug/L	96.8 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.09	ug/L	104 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.07	ug/L	103 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	70.2	ug/L	100 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	73.8	ug/L	105 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	73.6	ug/L	105 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.00	ug/L	99.2 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.06	ug/L	102 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.16	ug/L	107 %		10/28/2021 00:22

Analyte: MeFBSE (1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methylbutane-1-sulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.201	ug/L	100 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.193	ug/L	96.2 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.199	ug/L	99.2 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	2.01	ug/L	99.9 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.09	ug/L	104 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.07	ug/L	103 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	67.4	ug/L	96.3 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	77.6	ug/L	111 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	69.8	ug/L	99.6 %		10/27/2021 22:36

LCS Summary (cont.)

Batch: **LCMS-7115 - Continued**

Analyte: MeFBSE (1,1,2,2,3,3,4,4,4-Nonafluoro-N-(2-hydroxyethyl)-N-methylbutane-1-sulfonamide) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789201 LCS High	2.01	1.92	ug/L	94.9 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	1.94	ug/L	96.2 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	1.86	ug/L	92.0 %		10/28/2021 00:22

Analyte: PBSA (N-[3-(dimethylamino) propyl]-1,1,2,2,3,3,4,4-nonafluoro-butane-1-sulfonamide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.187	ug/L	93.1 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.207	ug/L	103 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.245	ug/L	122 %	L1	10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	2.05	ug/L	102 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.00	ug/L	99.3 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.23	ug/L	111 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	73.6	ug/L	105 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	75.2	ug/L	107 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	76.6	ug/L	109 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.08	ug/L	103 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.06	ug/L	102 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	1.95	ug/L	96.6 %		10/28/2021 00:22

Analyte: PBSA-DC (3-((3-((N-(2-carboxyethyl)-perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.0483	0.0673	ug/L	139 %	L1	10/27/2021 21:02
QC-LCS-789193 LCS Low	0.0483	0.0571	ug/L	118 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.0483	0.0597	ug/L	123 %	L1	10/27/2021 21:25
QC-LCS-789195 LCS Mid	0.483	0.498	ug/L	103 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	0.483	0.486	ug/L	100 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	0.483	0.543	ug/L	112 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	16.8	17.1	ug/L	102 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	16.8	17.7	ug/L	106 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	16.8	18.3	ug/L	109 %		10/27/2021 22:36
QC-LCS-789201 LCS High	0.483	0.542	ug/L	112 %		10/27/2021 23:58
QC-LCS-789202 LCS High	0.483	0.542	ug/L	112 %		10/28/2021 00:10
QC-LCS-789203 LCS High	0.483	0.566	ug/L	117 %		10/28/2021 00:22

Analyte: PECHS (Perfluoro-4-ethylcyclohexanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.186	0.176	ug/L	94.5 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.186	0.176	ug/L	94.3 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.186	0.184	ug/L	98.7 %		10/27/2021 21:25

LCS Summary (cont.)

Batch: **LCMS-7115 - Continued**

Analyte: PECHS (Perfluoro-4-ethylcyclohexanesulfonate) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789195 LCS Mid	1.86	1.88	ug/L	101 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	1.86	1.87	ug/L	100 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	1.86	1.96	ug/L	105 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	64.5	63.6	ug/L	98.5 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	64.5	68.2	ug/L	106 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	64.5	68.0	ug/L	105 %		10/27/2021 22:36
QC-LCS-789201 LCS High	1.86	1.65	ug/L	88.9 %		10/27/2021 23:58
QC-LCS-789202 LCS High	1.86	1.67	ug/L	89.8 %		10/28/2021 00:10
QC-LCS-789203 LCS High	1.86	1.82	ug/L	97.6 %		10/28/2021 00:22

Analyte: PFBSi (Nonafluorobutane-1-sulfinic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.191	ug/L	95.1 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.195	ug/L	97.1 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.186	ug/L	92.6 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	1.96	ug/L	97.4 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.01	ug/L	100 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.13	ug/L	106 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	70.2	ug/L	100 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	73.4	ug/L	105 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	74.4	ug/L	106 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	2.02	ug/L	99.8 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	2.10	ug/L	104 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.22	ug/L	110 %		10/28/2021 00:22

Analyte: PHSA-C (3-((N-(3-(dimethylamino)propyl)-perfluorohexyl)sulfonamido)propanoate; 3-(dimethyl(3-((perfluorohexylsulfonamido)propyl)ammonio)propanoate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.402	0.398	ug/L	98.8 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.402	0.404	ug/L	100 %		10/27/2021 21:14
QC-LCS-789194 LCS Low	0.402	0.500	ug/L	124 %	L1	10/27/2021 21:25
QC-LCS-789195 LCS Mid	4.02	4.10	ug/L	102 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	4.02	3.78	ug/L	94.0 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	4.02	4.22	ug/L	105 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	140	159	ug/L	N/A	L0	10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	140	158	ug/L	N/A	L0	10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	140	163	ug/L	N/A	L0	10/27/2021 22:36
QC-LCS-789201 LCS High	4.02	3.02	ug/L	75.2 %	L1	10/27/2021 23:58
QC-LCS-789202 LCS High	4.02	2.90	ug/L	72.1 %	L1	10/28/2021 00:10
QC-LCS-789203 LCS High	4.02	2.92	ug/L	72.5 %	L1	10/28/2021 00:22

LCS Summary (cont.)

Batch: LCMS-7115 - Continued

Analyte: PIBA (Perfluoisobutyl amide) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-789192 LCS Low	0.201	0.225	ug/L	112 %		10/27/2021 21:02
QC-LCS-789193 LCS Low	0.201	0.261	ug/L	130 %	L1	10/27/2021 21:14
QC-LCS-789194 LCS Low	0.201	0.217	ug/L	108 %		10/27/2021 21:25
QC-LCS-789195 LCS Mid	2.01	1.92	ug/L	95.5 %		10/27/2021 21:37
QC-LCS-789196 LCS Mid	2.01	2.15	ug/L	107 %		10/27/2021 21:49
QC-LCS-789197 LCS Mid	2.01	2.05	ug/L	102 %		10/27/2021 22:01
QC-LCS-789198 LCS Mid-High	69.9	74.8	ug/L	107 %		10/27/2021 22:12
QC-LCS-789199 LCS Mid-High	69.9	72.0	ug/L	103 %		10/27/2021 22:24
QC-LCS-789200 LCS Mid-High	69.9	74.4	ug/L	106 %		10/27/2021 22:36
QC-LCS-789201 LCS High	2.01	1.78	ug/L	88.2 %		10/27/2021 23:58
QC-LCS-789202 LCS High	2.01	1.86	ug/L	92.3 %		10/28/2021 00:10
QC-LCS-789203 LCS High	2.01	2.10	ug/L	104 %		10/28/2021 00:22

Batch: LCMS-7144

Analyte: PFOA (Perfluorooctanoic acid) **Quant Method:** Internal

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0472	0.0412	ug/L	87.4 %		11/04/2021 18:42
QC-LCS-788655 LCS Low	0.0472	0.0562	ug/L	119 %		11/04/2021 18:57
QC-LCS-788656 LCS Low	0.0472	0.0542	ug/L	115 %		11/04/2021 19:12
QC-LCS-788657 LCS Mid	0.472	0.462	ug/L	97.8 %		11/04/2021 19:27
QC-LCS-788658 LCS Mid	0.472	0.460	ug/L	97.5 %		11/04/2021 19:42
QC-LCS-788659 LCS Mid	0.472	0.474	ug/L	100 %		11/04/2021 19:57
QC-LCS-788660 LCS High	9.53	8.86	ug/L	92.8 %		11/04/2021 20:12
QC-LCS-788661 LCS High	9.53	9.76	ug/L	102 %		11/04/2021 20:27
QC-LCS-788662 LCS High	9.53	10.1	ug/L	105 %		11/04/2021 20:42
QC-LCS-788668 Laboratory Control Sample (Spike)	132	>19.2	ug/L	N/A		11/04/2021 22:43
QC-LCS-788669 Laboratory Control Sample (Spike)	132	>19.2	ug/L	N/A		11/04/2021 22:58
QC-LCS-788670 Laboratory Control Sample (Spike)	132	>19.2	ug/L	N/A		11/04/2021 23:13

Batch: LCMS-7150

Analyte: 2233-TFPA (2,2,3,3-Tetrafluoropropionic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	<0.500	ug/L	N/A		11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	<0.500	ug/L	N/A		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	<0.500	ug/L	N/A		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.9	ug/L	110 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.7	ug/L	108 %		11/05/2021 19:18

LCS Summary (cont.)

Batch: **LCMS-7150 - Continued**

Analyte: 2233-TFPA (2,2,3,3-Tetrafluoropropionic acid) - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793171 LCS Mid	9.90	10.7	ug/L	108 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	38.2	ug/L	109 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	37.2	ug/L	106 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	37.4	ug/L	107 %		11/05/2021 19:45

Analyte: 2333-TFPA (2,3,3,3-Tetrafluoropropionic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	<1.00	ug/L	N/A		11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	<1.00	ug/L	N/A		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	<1.00	ug/L	N/A		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.3	ug/L	104 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.1	ug/L	102 %		11/05/2021 19:18
QC-LCS-793171 LCS Mid	9.90	10.8	ug/L	109 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	36.0	ug/L	103 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	39.2	ug/L	112 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	36.6	ug/L	105 %		11/05/2021 19:45

Analyte: PFES (Perfluoroethanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	0.274	ug/L	110 %		11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	0.264	ug/L	106 %		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	0.254	ug/L	102 %		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.9	ug/L	110 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.7	ug/L	108 %		11/05/2021 19:18
QC-LCS-793171 LCS Mid	9.90	10.7	ug/L	108 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	39.0	ug/L	111 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	38.4	ug/L	110 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	37.6	ug/L	107 %		11/05/2021 19:45

Analyte: PFPA (Perfluoropropionic acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	0.246	ug/L	98.1 %		11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	0.252	ug/L	101 %		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	0.234	ug/L	93.4 %		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.6	ug/L	107 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.7	ug/L	108 %		11/05/2021 19:18
QC-LCS-793171 LCS Mid	9.90	10.9	ug/L	110 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	36.4	ug/L	104 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	36.2	ug/L	104 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	36.8	ug/L	105 %		11/05/2021 19:45

LCS Summary (cont.)

Batch: LCMS-7150 - Continued

Analyte: TFA (Trifluoroacetic Acid) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	<0.200	ug/L	N/A	L1	11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	0.208	ug/L	82.8 %		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	0.218	ug/L	87.6 %		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.3	ug/L	104 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.2	ug/L	103 %		11/05/2021 19:18
QC-LCS-793171 LCS Mid	9.90	10.5	ug/L	106 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	36.0	ug/L	103 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	34.8	ug/L	99.2 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	36.8	ug/L	105 %		11/05/2021 19:45

Analyte: TFMS (Trifluoromethanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-793166 LCS Low	0.249	0.270	ug/L	108 %		11/05/2021 18:50
QC-LCS-793167 LCS Low	0.249	0.270	ug/L	108 %		11/05/2021 18:57
QC-LCS-793168 LCS Low	0.249	0.260	ug/L	104 %		11/05/2021 19:04
QC-LCS-793169 LCS Mid	9.90	10.8	ug/L	109 %		11/05/2021 19:11
QC-LCS-793170 LCS Mid	9.90	10.6	ug/L	107 %		11/05/2021 19:18
QC-LCS-793171 LCS Mid	9.90	10.7	ug/L	109 %		11/05/2021 19:25
QC-LCS-793175 LCS High	34.9	38.6	ug/L	110 %		11/05/2021 19:31
QC-LCS-793176 LCS High	34.9	38.2	ug/L	109 %		11/05/2021 19:38
QC-LCS-793177 LCS High	34.9	38.2	ug/L	109 %		11/05/2021 19:45

Batch: LCMS-7218

Analyte: TFMS (Trifluoromethanesulfonate) **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-800462 LCS Low	2.49	2.68	ug/L	107 %		11/22/2021 22:51
QC-LCS-800463 LCS Low	2.49	2.80	ug/L	112 %		11/22/2021 22:58
QC-LCS-800464 LCS Low	2.49	2.74	ug/L	110 %		11/22/2021 23:05
QC-LCS-800465 LCS Mid	99.0	108	ug/L	109 %		11/22/2021 23:12
QC-LCS-800466 LCS Mid	99.0	107	ug/L	108 %		11/22/2021 23:19
QC-LCS-800467 LCS Mid	99.0	110	ug/L	111 %		11/22/2021 23:25
QC-LCS-800471 LCS High	398	436	ug/L	110 %		11/22/2021 23:32
QC-LCS-800472 LCS High	398	438	ug/L	110 %		11/22/2021 23:39
QC-LCS-800473 LCS High	398	430	ug/L	108 %		11/22/2021 23:46

Batch: LCMS-7220

Analyte: PFHS () **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed

LCS Summary (cont.)

Batch: **LCMS-7220 - Continued**

Analyte: PFHS () - Continued **Quant Method:** External

Sample ID/Description	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed
QC-LCS-788654 LCS Low	0.0493	0.0492	ug/L	99.5 %		10/28/2021 00:58
QC-LCS-788655 LCS Low	0.0493	0.0518	ug/L	105 %		10/28/2021 01:13
QC-LCS-788656 LCS Low	0.0493	0.0534	ug/L	108 %		10/28/2021 01:28
QC-LCS-788657 LCS Mid	0.493	0.526	ug/L	107 %		10/28/2021 01:43
QC-LCS-788658 LCS Mid	0.493	0.508	ug/L	103 %		10/28/2021 01:58
QC-LCS-788659 LCS Mid	0.493	0.532	ug/L	108 %		10/28/2021 02:13
QC-LCS-788660 LCS High	9.95	11.7	ug/L	118 %		10/28/2021 02:28
QC-LCS-788661 LCS High	9.95	11.7	ug/L	118 %		10/28/2021 02:43
QC-LCS-788662 LCS High	9.95	11.6	ug/L	117 %		10/28/2021 02:58
QC-LCS-788668 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:29
QC-LCS-788669 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:44
QC-LCS-788670 Laboratory Control Sample (Spike)	138	>100	ug/L	N/A		10/28/2021 04:59

FMS Summary

Sample ID E21-1752-024-FMS **Description** Travel Blank 1-2 FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
2233-TFPA	5.00	5.30	ug/L	106 %		11/05/2021 21:29	External
2333-TFPA	5.00	5.82	ug/L	116 %		11/05/2021 21:29	External
FBSA	0.404	0.514	ug/L	127 %	L14	10/28/2021 01:20	External
FBSAA	0.200	0.222	ug/L	111 %		10/28/2021 01:20	External
FBSE	0.206	0.220	ug/L	107 %		10/28/2021 01:20	External
FBSEE Diol	0.200	0.216	ug/L	108 %		10/28/2021 01:20	External
FBSEE-DA	0.200	0.196	ug/L	98.0 %	L14	10/28/2021 01:20	External
FOSA	0.207	0.210	ug/L	101 %	L14	10/28/2021 10:31	Internal
HQ-115	0.200	0.228	ug/L	114 %	L14	10/28/2021 01:20	External
MeFBSAA	0.200	0.174	ug/L	87.0 %		10/28/2021 01:20	External
MeFBSA	0.177	0.195	ug/L	110 %		10/28/2021 01:20	External
MeFBSE	0.202	0.204	ug/L	101 %	L14	10/28/2021 01:20	External
PBSA	0.200	0.175	ug/L	87.5 %	L14	10/28/2021 01:20	External
PBSA-DC	0.0476	0.0398	ug/L	83.6 %		10/28/2021 01:20	External
PECHS	0.184	0.199	ug/L	108 %	L14	10/28/2021 01:20	External
PFBSi	0.200	0.184	ug/L	92.0 %	L14	10/28/2021 01:20	External
PFBA	0.216	0.226	ug/L	105 %	L14	10/28/2021 10:31	Internal
PFBS	0.216	0.304	ug/L	141 %	L4,L14	10/28/2021 10:31	Internal
PFES	5.00	5.44	ug/L	109 %	L14	11/05/2021 21:29	External
PFHpA	0.200	0.189	ug/L	94.5 %	L14	10/28/2021 10:31	Internal
PFHpS	0.190	0.212	ug/L	112 %	L14	10/28/2021 10:31	Internal
PFHxA	0.200	0.232	ug/L	116 %	L14	10/28/2021 10:31	Internal
PFPA	5.00	5.16	ug/L	103 %	L14	11/05/2021 21:29	External
PFOA	0.192	0.202	ug/L	105 %		10/28/2021 10:31	Internal
PFOS	0.185	0.198	ug/L	107 %	L14	10/28/2021 10:31	Internal
PHSA-C	0.400	0.374	ug/L	93.5 %		10/28/2021 01:20	External
PFPeA	0.200	0.204	ug/L	102 %	L14	10/28/2021 10:31	Internal
PFPeS	0.188	0.178	ug/L	94.7 %	L14	10/28/2021 10:31	Internal
PIBA	0.200	0.258	ug/L	129 %		10/28/2021 01:20	External
TFA	5.00	5.22	ug/L	104 %	L14	11/05/2021 21:29	External
TFMS	5.00	4.68	ug/L	93.6 %	L14	11/05/2021 21:29	External
PFHS	0.200	0.238	ug/L	119 %	L14	10/28/2021 10:31	Internal

Sample ID E21-1752-055-FMS **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
2233-TFPA	5.00	5.28	ug/L	106 %		11/05/2021 22:38	External
2333-TFPA	5.00	5.38	ug/L	108 %		11/05/2021 22:38	External
FBSA	0.404	0.502	ug/L	124 %	L14	10/28/2021 01:32	External
FBSAA	0.200	0.174	ug/L	87.0 %		10/28/2021 01:32	External
FBSE	0.206	0.214	ug/L	104 %		10/28/2021 01:32	External
FBSEE Diol	0.200	0.197	ug/L	98.5 %		10/28/2021 01:32	External
FBSEE-DA	0.200	0.149	ug/L	74.5 %	L14	10/28/2021 01:32	External
FOSA	0.207	0.185	ug/L	89.4 %	L14	10/28/2021 13:47	Internal

FMS Summary (cont.)

Sample ID E21-1752-055-FMS (Cont.) **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
HQ-115	0.200	0.202	ug/L	101 %	L14	10/28/2021 01:32	External
MeFBSAA	0.200	0.151	ug/L	75.5 %		10/28/2021 01:32	External
MeFBSA	0.177	0.192	ug/L	108 %		10/28/2021 01:32	External
MeFBSE	0.202	0.183	ug/L	90.6 %	L14	10/28/2021 01:32	External
PBSA	0.200	0.222	ug/L	111 %	L14	10/28/2021 01:32	External
PBSA-DC	0.0476	0.0492	ug/L	103 %		10/28/2021 01:32	External
PECHS	0.184	0.183	ug/L	99.5 %	L14	10/28/2021 01:32	External
PFBSi	0.200	0.150	ug/L	75.0 %	L14	10/28/2021 01:32	External
PFBA	0.216	0.190	ug/L	88.0 %	L14	10/28/2021 13:47	Internal
PFBS	0.216	0.274	ug/L	127 %	L14	10/28/2021 13:47	Internal
PFES	5.00	5.62	ug/L	112 %	L14	11/05/2021 22:38	External
PFHpA	0.200	0.156	ug/L	78.0 %	L14	10/28/2021 13:47	Internal
PFHpS	0.200	0.210	ug/L	105 %	L14	10/28/2021 13:47	Internal
PFHxA	0.200	0.190	ug/L	95.0 %	L14	10/28/2021 13:47	Internal
PFOA	0.192	0.158	ug/L	82.3 %	L14	11/05/2021 02:13	Internal
PFPA	5.00	5.20	ug/L	104 %	L14	11/05/2021 22:38	External
PFOS	0.185	0.167	ug/L	90.3 %	L14	10/28/2021 13:47	Internal
PHSA-C	0.396	0.450	ug/L	114 %		10/28/2021 01:32	External
PFPeA	0.200	0.170	ug/L	85.0 %	L14	10/28/2021 13:47	Internal
PFPeS	0.188	0.191	ug/L	102 %	L14	10/28/2021 13:47	Internal
PIBA	0.200	0.198	ug/L	99.0 %		10/28/2021 01:32	External
TFA	5.00	5.08	ug/L	102 %	L14	11/05/2021 22:38	External
TFMS	5.00	4.98	ug/L	99.6 %	L14	11/05/2021 22:38	External
PFHS	0.200	0.183	ug/L	91.5 %	L14	10/28/2021 13:47	Internal

Sample ID E21-1752-096-FMS **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
2233-TFPA	5.00	5.26	ug/L	105 %		11/05/2021 23:54	External
2333-TFPA	5.00	5.34	ug/L	107 %		11/05/2021 23:54	External
FBSA	0.404	0.488	ug/L	121 %	L14	10/28/2021 02:43	External
FBSAA	0.200	0.191	ug/L	95.5 %		10/28/2021 02:43	External
FBSE	0.206	0.218	ug/L	106 %		10/28/2021 02:43	External
FBSEE Diol	0.200	0.220	ug/L	110 %		10/28/2021 02:43	External
FBSEE-DA	0.200	0.178	ug/L	89.0 %	L14	10/28/2021 02:43	External
FOSA	0.207	0.197	ug/L	95.2 %	L14	10/28/2021 17:33	Internal
HQ-115	0.200	0.226	ug/L	113 %	L14	10/28/2021 02:43	External
MeFBSAA	0.200	0.185	ug/L	92.5 %		10/28/2021 02:43	External
MeFBSA	0.177	0.204	ug/L	115 %		10/28/2021 02:43	External
MeFBSE	0.202	0.202	ug/L	100 %	L14	10/28/2021 02:43	External
PBSA	0.200	0.160	ug/L	80.0 %	L14	10/28/2021 02:43	External
PBSA-DC	0.0476	0.0346	ug/L	72.7 %		10/28/2021 02:43	External
PECHS	0.184	0.210	ug/L	114 %	L14	10/28/2021 02:43	External
PFBSi	0.200	0.185	ug/L	92.5 %	L14	10/28/2021 02:43	External

FMS Summary (cont.)

Sample ID E21-1752-096-FMS (Cont.) **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
PFBA	0.216	0.206	ug/L	95.4 %	L14	10/28/2021 17:33	Internal
PFBS	0.216	0.316	ug/L	146 %	L4,L14	10/28/2021 17:33	Internal
PFES	5.00	5.96	ug/L	119 %	L14	11/05/2021 23:54	External
PFHpA	0.200	0.186	ug/L	93.0 %	L14	10/28/2021 17:33	Internal
PFHpS	0.200	0.212	ug/L	106 %	L14	10/28/2021 17:33	Internal
PFHxA	0.200	0.204	ug/L	102 %	L14	10/28/2021 17:33	Internal
PFOA	0.192	0.170	ug/L	88.5 %	L14	11/05/2021 04:44	Internal
PFPA	5.00	5.44	ug/L	109 %	L14	11/05/2021 23:54	External
PFOS	0.185	0.196	ug/L	106 %	L14	10/28/2021 17:33	Internal
PHSA-C	0.396	0.284	ug/L	71.7 %		10/28/2021 02:43	External
PFPeA	0.200	0.202	ug/L	101 %	L14	10/28/2021 17:33	Internal
PFPeS	0.188	0.188	ug/L	100 %	L14	10/28/2021 17:33	Internal
PIBA	0.200	0.232	ug/L	116 %		10/28/2021 02:43	External
TFA	5.00	5.16	ug/L	103 %	L14	11/05/2021 23:54	External
TFMS	5.00	5.24	ug/L	105 %	L14	11/05/2021 23:54	External
PFHS	0.200	0.214	ug/L	107 %	L14	10/28/2021 17:33	Internal

Sample ID E21-1752-111-FMS **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
2233-TFPA	5.00	4.54	ug/L	90.8 %		11/06/2021 00:29	External
2333-TFPA	5.00	4.60	ug/L	92.0 %		11/06/2021 00:29	External
FBSA	0.804	0.838	ug/L	104 %	L14	10/28/2021 02:54	External
FBSAA	0.400	0.304	ug/L	76.0 %		10/28/2021 02:54	External
FBSE	0.408	0.410	ug/L	100 %		10/28/2021 02:54	External
FBSEE Diol	0.400	0.382	ug/L	95.5 %		10/28/2021 02:54	External
FBSEE-DA	0.400	0.398	ug/L	99.5 %	L14	10/28/2021 02:54	External
FOSA	0.400	0.360	ug/L	90.0 %	L14	10/28/2021 19:18	Internal
HQ-115	0.400	0.382	ug/L	95.5 %	L14	10/28/2021 02:54	External
MeFBSAA	0.400	0.360	ug/L	90.0 %		10/28/2021 02:54	External
MeFBSA	0.352	0.316	ug/L	89.8 %		10/28/2021 02:54	External
MeFBSE	0.400	0.390	ug/L	90.7 %	L14	10/28/2021 02:54	External
PBSA	0.400	0.396	ug/L	99.0 %	L14	10/28/2021 02:54	External
PBSA-DC	0.0960	0.0884	ug/L	92.1 %		10/28/2021 02:54	External
PECHS	0.369	0.342	ug/L	92.7 %	L14	10/28/2021 02:54	External
PFBSi	0.400	0.402	ug/L	101 %	L14	10/28/2021 02:54	External
PFBA	0.433	0.382	ug/L	88.2 %	L14	10/28/2021 19:18	Internal
PFBS	0.431	0.462	ug/L	107 %	L14	10/28/2021 19:18	Internal
PFES	5.00	4.76	ug/L	95.2 %	L14	11/06/2021 00:29	External
PFHpA	0.400	0.350	ug/L	87.5 %	L14	10/28/2021 19:18	Internal
PFHpS	0.380	0.394	ug/L	104 %	L14	10/28/2021 19:18	Internal
PFHxA	0.400	0.418	ug/L	105 %	L14	10/28/2021 19:18	Internal
PFOA	0.383	0.328	ug/L	85.6 %	L14	11/05/2021 05:59	Internal
PFPA	5.00	4.84	ug/L	96.8 %	L14	11/06/2021 00:29	External

FMS Summary (cont.)

Sample ID E21-1752-111-FMS (Cont.) **Description** Travel Blank FMS

Analyte	Spike Amt	Result	Units	Recovery	Qualifier	Date/Time Analyzed	Quant Mth
PFOS	0.371	0.362	ug/L	97.6 %	L14	10/28/2021 19:18	Internal
PHSA-C	0.800	0.758	ug/L	94.8 %		10/28/2021 02:54	External
PFPeA	0.400	0.348	ug/L	87.0 %	L14	10/28/2021 19:18	Internal
PFPeS	0.375	0.336	ug/L	89.6 %	L14	10/28/2021 19:18	Internal
PIBA	0.400	0.442	ug/L	111 %		10/28/2021 02:54	External
TFA	5.00	4.68	ug/L	93.6 %	L14	11/06/2021 00:29	External
TFMS	5.00	4.84	ug/L	96.8 %	L14	11/06/2021 00:29	External
PFHS	0.400	0.406	ug/L	102 %	L14	10/28/2021 19:18	Internal

Qualifiers

L0 - Sample Concentration Exceeds ULOQ

L1 - LCS did not meet Recovery criteria (±20%)

L4 - MS did not meet Recovery criteria (±30%)

L14 - MS spike level was greater than 10x the endogenous sample concentration

Attachments

Attachment A: Method Uncertainty / 2 Pages

Signatures

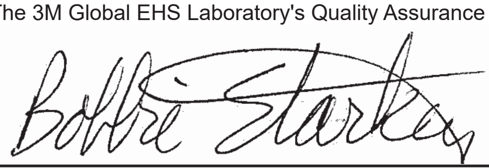
Digitally signed by Scott T. Porcher
DN: c=US, st=MN, l=St. Paul, o=3M, ou=EHS Laboratory, cn=Scott T. Porcher, email=sporcher@mmm.com
Reason: I am the author of this document
Date: 2021.12.10 07:36:36 -06'00'

Report Author | Date

Digitally signed by Susan T. Wolf
DN: c=US, st=MN, l=St. Paul, o=3M, ou=EHS Laboratory, cn=Susan T. Wolf, email=stwolf@mmm.com
Reason: I have reviewed this document
Date: 2021.12.10 08:13:29 -06'00'

Management / Technical Reviewer | Date

The 3M Global EHS Laboratory's Quality Assurance Unit has audited the data and report for this project.



Digitally signed by Bobbie Starkey
DN: c=US, st=MN, l=St. Paul, o=3M, ou=Global EHS Laboratory, cn=Bobbie Starkey, email=bstarkey@mmm.com
Reason: I agree to the terms defined by the placement of my signature on this document
Date: 2021.12.10 08:24:02 -06'00'
Adobe Acrobat version: 2017.011.30204

Quality Assurance Representative | Date

Attachment A: Method Uncertainty / 2 Pages

Analytical Data Uncertainty

Analytical uncertainty is based on historical QC data that is control charted and used to evaluate method accuracy and precision. The method uncertainty is calculated following ETS-12-012.5. The standard deviation is calculated for the set of accuracy results (in %) obtained for the QC samples. For method ETS-8-044.5, where applicable, the most recent fifty QC samples were used. The expanded uncertainty is calculated by multiplying the standard deviation by a factor of 2, which corresponds to a confidence level of 95%.

In addition to the analytical method uncertainty, Travel Blank field matrix spike (FMS) samples were evaluated when determining the analytical data uncertainty assigned to the sample results listed in Table 1 of the report. The recovery of these travel blank FMS samples were reviewed collectively when determining the analytical data uncertainty to be applied to the sample results in Table 1.

Below is a discussion regarding the compounds where one or more quality control elements of the laboratory's direct injection method did not meet method acceptance criteria, resulting in; 1) adjustments made to the analytical data uncertainty assigned to the results in Table 1 of the report or 2) data flagged as not reportable.

- **PFBS:** The method uncertainty calculated using ETS-12-012.5 was ±32%. Laboratory control standards met method acceptance criteria. Two Travel Blank FMS samples did not meet acceptance criteria with a recovery of 141% and 146% while the other two Travel Blank FMS samples did meet method acceptance criteria. The Travel Blank results for PFBS in Table 1 will be footnoted as having an analytical data uncertainty that has been adjusted further to ±46% based on the percent bias of the largest non-compliant FMS recovery.
- **PBSA-DC:** The method uncertainty calculated using ETS-12-012.5 was ±22%. Two of the three low level LCS did not meet method acceptance criteria with recoveries of 139% and 123%. Two Travel Blank FMS samples meet method acceptance criteria. Table 1 will be footnoted as having an analytical data uncertainty that has been adjusted further to ±39% based on the percent bias of the largest non-compliant LCS recovery.
- **PHSA-C:** The method uncertainty calculated using ETS-12-012.5 was ±22%. Three mid-level LCSs were prepared with a 1:1 sample aliquot dilution versus in-situ dilution to match the preparation of samples E21-1752-145 through 150. All three replicates for PHSA-C had recoveries <80%, ranging from 72.1% to 75.2%. These LCSs were prepared to determine potential wall losses without in-situ dilution. Samples prepared by 1:1 dilution will be flagged for PHSA-C in Table 1 as having an adjusted uncertainty of 28% based on the percent bias of the largest non-compliant LCS recovery.

The analytical data uncertainties for the target analytes presented in Table 1 of the report.

Analyte	Calibration Method	Number of Data Points Used	Standard Deviation (%)	Analytical Data Uncertainty
TFA	External	50	10.0	±20%
PFPA	External	50	6.65	±13%
2233-TFPA	External	50	5.27	±11%
2333-TFPA	External	50	7.44	±15%
PFBA	Internal	50	9.51	±19%
PFBA	External	50	10.9	±22%
PFPeA	Internal	50	9.34	±19%
PFPeA	External	50	11.2	±22%
PFHxA	Internal	50	9.21	±18%
PFHxA	External	50	12.1	±24%
PFHpA	Internal	50	8.65	±17%
PFHpA	External	50	15.0	±30%
PFOA	Internal	50	11.7	±23%
PFOA	External	50	11.3	±23%
TFMS	External	50	5.46	±11%
PFES	External	50	5.35	±11%
PFBS	Internal	50	16.0	±32%
PFBS	External	50	10.4	±21%
PFPeS	Internal	50	9.67	±19%
PFPeS	External	50	10.7	±21%
PFHxS	Internal	50	9.98	±20%
PFHxS	External	50	16.3	±33%
PFHpS	Internal	50	8.64	±17%
PFHpS	External	50	8.43	±17%
PFOS	Internal	50	7.00	±14%
PFOS	External	50	7.56	±15%
FBSA	External	50	4.72	±9.4%
PFOSA	Internal	50	8.11	±16%
PFOSA	External	50	9.22	±18%
PFBSi	External	50	6.57	±13%
MeFBSA	External	50.	5.94	±12%
FBSE	External	50	4.87	±9.7%
MeFBSE	External	50	8.16	±16%
FBSEE	External	50	4.49	±9.0%
FBSEE-DA	External	50	8.77	±18%
FBSAA	External	50	8.41	±17%
MeFBSAA	External	50	10.1	±20%
HQ-115	External	50	5.49	±11%
PIBA	External	50	10.3	±21%
PECHS	External	50	4.48	±9.0%
PBSA	External	NA	NA	±39% (1)
PBSA-DC	External	50	11.1	±22%
PHSA-C1-, PHSA-C2 (summed)	External	50	11.2	±22%

NA = Not Applicable

(1) The analytical data uncertainty was expanded due to non-compliant QC element.

Appendix D - 3M Global EHS Laboratory Results Summary Table
PFAS Treatability Study
Cottage Grove MN Facility
December 22, 2021

Sample ID	Description	Sample Date	Units	2233-TFPA	2333-TFPA	FBSA	FBSAA	FBSE	FBSEE Diol	FBSEE-DA	FOSA	HQ-115	MeFBSA	MeFBSAA	MeFBSE	PBSA
NCCW/SW Test Phase																
E21-1752-001	UF INFLUENT	8/2/21 12:00	ng/L	<500	**1,210**	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**236**	<44.0	<50.0	<20.0	<10.0
E21-1752-002	UF PERMEATE	8/2/21 13:35	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**256**	<44.0	<50.0	<20.0	<10.0
E21-1752-003	RO PERMEATE	8/2/21 12:55	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-004	RO REJECT	8/2/21 13:30	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**1,430**	<44.0	<50.0	<20.0	<10.0
E21-1752-011	IX1-C	8/2/21 12:50	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-012	IX2-C	8/2/21 12:45	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-020	RO PERMEATE	8/11/21 13:55	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**111**	<44.0	<50.0	<20.0	<10.0
E21-1752-024	Travel Blank Week 1-2	7/26/21 16:45	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-024-FMS	Travel Blank 1-2 FMS	7/26/21 16:45	ng/L	**5,300**	**5,820**	**514**	**222**	**220**	**216**	**196**	**210**	**228**	**195**	**174**	**204**	**175**
E21-1752-025	3MCG-Test01_B-UF-PERM-20210823	8/23/21 14:00	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**4,440**	<44.0	<50.0	<20.0	<10.0
E21-1752-026	3MCG-Test01-B-INF-A (RO-REJ)-20210823	8/23/21 18:20	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**74,000**	<44.0	<50.0	<20.0	<10.0
E21-1752-045	3MCG-Test 01_B-UF-PERM-20210826	8/26/21 9:30	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**3,500**	<44.0	<50.0	<20.0	<10.0
E21-1752-046	3MCG-Test 01_B-INF-A (RO-REJ)-20210826	8/26/21 9:30	ng/L	<500	<1000	**11.2**	<89.5	<45.6	<44.8	<9.0	**11.6**	**58,700**	<39.4	<44.8	<17.9	<9.0
E21-1752-055	Travel Blank	8/19/21 10:45	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-055-FMS	Travel Blank FMS	8/19/21 10:45	ng/L	**5,280**	**5,380**	**502**	**174**	**214**	**197**	**149**	**185**	**202**	**192**	**151**	**183**	**222**
E21-1752-061	3MCG-Test 01_B-INF-A (RO-REJ)-20210829	8/29/21 9:25	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	**22.0**	**53,400**	<44.0	<50.0	<20.0	<10.0
E21-1752-078	3MCG-Test 01_B-IX2-A-20210901	9/1/21 10:25	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-080	3MCG-Test 01_B-IXR2-B-20210901	9/1/21 10:25	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-081	3MCG-Test 01_B-UF-PERM-20210902	9/2/21 10:30	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**564**	<44.0	<50.0	<20.0	<10.0
E21-1752-082	3MCG-Test 01_B-INF-A (RO-REJ)-20210902	9/2/21 11:15	ng/L	<500	<1000	**13.4**	<100	<51.0	<50.0	<10.0	**45.2**	**42,400**	<44.0	<50.0	<20.0	<10.0
E21-1752-096	Travel Blank	8/24/21 0:55	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-096-FMS	Travel Blank FMS	8/24/21 0:55	ng/L	**5,260**	**5,340**	**488**	**191**	**218**	**220**	**178**	**197**	**226**	**204**	**185**	**202**	**160**
Phase 1/2 WW Test Phase																
E21-1752-097	3MCG-Test 02-D.0-INF (RO-REJ)-20210921	9/23/21 12:00	ng/L	<500	<1000	**1,600**	**141**	**234**	**107**	**212**	**41.8**	**91,000**	**464**	**134**	**84.6**	**436**
E21-1752-108	3MCG-Test 02-D.4-IX2-20210924	9/24/21 12:00	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	**26.0**	<10.0
E21-1752-110	3MCG-Test 02-E.4-IXR2-20210924	9/24/21 12:00	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	**26.2**	<10.0
E21-1752-111	Travel Blank	9/20/21 14:50	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	**27.4**	<10.0
E21-1752-111-FMS	Travel Blank FMS	9/20/21 14:50	ng/L	**4,540**	**4,600**	**838**	**304**	**410**	**382**	**398**	**360**	**382**	**316**	**360**	**390**	**396**
E21-1752-145	3MCG-Test 02-F.0-INF (RO PERM)-20210918	9/18/21 8:48	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**96.2**	<44.0	<50.0	<20.0	<10.0
E21-1752-146	3MCG-Test 02-F.1-IX1-20210918	9/18/21 8:38	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-147	3MCG-Test 02-F.2-IX2-20210918	9/18/21 8:20	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-148	3MCG-Test 02-F.0-INF (RO PERM)-20210923	9/23/21 10:00	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**120**	<44.0	<50.0	<20.0	<10.0
E21-1752-149	3MCG-Test 02-F.1-IX1-20210923	9/23/21 9:45	ng/L	<500	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	<10.0	<44.0	<50.0	<20.0	<10.0
E21-1752-150	3MCG-Test 02-F.2-IX2-20210923	9/23/21 9:30	ng/L	<500.0	<1000	<10.1	<100	<51.0	<50.0	<10.0	<10.0	**22.4**	<44.0	<50.0	<20.0	<10.0

Sample ID	PBSA-DC	PECHS	PFBA	PFBS	PFBSi	PFES	PFHpA	PFHpS	PFHxS	PFHxA	PFOA	PFOS	PFPA	PFPeA	PFPeS	PHSA-C	PIBA	TFA	TFMS
NCCW/SW Test Phase																			
E21-1752-001	<12.0	**14.5**	**8,000**	**142**	<10.0	**73.2**	**27.2**	<10.0	**54.6**	**173**	**62.8**	<9.3	**3,180**	**502**	**45.0**	<100	**123**	**3,360**	**3,160**
E21-1752-002	<12.0	<9.2	**8,120**	**147**	<10.0	**71.0**	**28.0**	<10.0	**35.6**	**182**	**69.4**	<9.3	**3,300**	**526**	**44.2**	<100	**106**	**3,160**	**3,140**
E21-1752-003	<12.0	<9.2	**25.2**	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-004	<12.0	**31.2**	**36,800**	**546**	<10.0	**322**	**81.4**	<10.0	**94.2**	**670**	**242**	<9.3	**16,200**	**2,140**	**133.0**	<100	**334**	**17,000**	**14,600**
E21-1752-011	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-012	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-020	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<20.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-024	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-024-FMS	**39.8**	**199**	**226**	**304**	**184**	**5,440**	**189**	**212**	**238**	**232**	**202**	**198.00**	**5,160**	**204**	**178**	**374**	**258**	**5,220**	**4,680**
E21-1752-025	<12.0	<9.2	**528**	<10.0	<10.0	<25.0	<10.0	<10.0	**11.0**	<10.0	<9.6	<9.3	**1,800**	**25.2**	<9.4	<100	<100	**3,200**	**1,280**
E21-1752-026	<12.0	**76**	**17,300**	**650**	<10.0	**185**	**82.2**	**16.9**	**300**	**740**	**324**	<9.3	**9,920**	**1,710**	**256**	<100	**139**	**19,100**	**9,500**
E21-1752-045	<12.0	<9.2	**482**	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	**2,060**	<10.0	<9.4	<100	<100	**3,040**	**1,440**
E21-1752-046	<10.7	**59.1**	**14,400**	**600**	<9.0	**140**	**74.8**	**23.6**	**279**	**426**	**260**	<8.3	**9,840**	**1,350**	**209**	<89.5	**158**	**18,600**	**8,560**
E21-1752-055	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-055-FMS	**49.2**	**183**	**190**	**274**	**150**	**5,620**	**156**	**210**	**183**	**190**	**158**	**167**	**5,200**	**170**	**191**	**450**	**198**	**5,080**	**4,980**
E21-1752-061	<12.0	**44.2**	**10,800**	**4,440**	<10.0	**106**	**55.2**	**11.7**	**188**	**324**	**226**	<9.3	**10,700**	**968**	**156**	<100	**168**	**20,200**	**8,620**
E21-1752-078	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	<50.0	<10.0	<9.4	<100	<100	**19,800**	<25.0
E21-1752-080	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	**4,320**	<10.0	<9.4	<100	<100	**19,800**	<25.0
E21-1752-081	<12.0	<9.2	**1,730**	**101**	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	**2,880**	**14.8**	<9.4	<100	**109**	**3,320**	**2,320**
E21-1752-082	<12.0	**38.6**	**8,700**	**13,800**	<10.0	**74.8**	**34.4**	**14.1**	**135**	**204**	**173**	<9.3	**12,700**	**560**	**96.8**	<100	**232**	**21,600**	**9,580**
E21-1752-096	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-096-FMS	**34.6**	**210**	**206**	**316**	**185**	**5,960**	**186**	**212**	**214**	**204**	**170**	**196**	**5,440**	**202**	**188**	**284**	**232**	**5,160**	**5,240**
Phase 1/2 WW Test Phase																			
E21-1752-097	<12.0	**179**	**13,800**	**37,000**	**2,460**	<25.0	**35.8**	**110**	**510**	**252**	**488**	**170**	**8,500**	**706**	**174**	<100	**140**	**11,300**	**414,000**
E21-1752-108	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	**370**	<10.0	<9.4	<100	<100	**10,700**	<25.0
E21-1752-110	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	**6,640**	<10.0	<9.4	<100	<100	**13,200**	<25.0
E21-1752-111	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<9.6	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-111-FMS	**88.4**	**342**	**382**	**462**	**402**	**4,760**	**350**	**394**	**406**	**418**	**328**	**362**	**4,840**	**348**	**336**	**758**	**442**	**4,680**	**4,840**
E21-1752-145	<12.0	<9.2	**11.1**	**16.5**	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	**582**
E21-1752-146	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-147	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-148	<12.0	<9.2	<10.0	**41.0**	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	**320**
E21-1752-149	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0
E21-1752-150	<12.0	<9.2	<10.0	<10.0	<10.0	<25.0	<10.0	<10.0	<10.0	<10.0	<19.2	<9.3	<50.0	<10.0	<9.4	<100	<100	<200	<25.0

Cell Shading Key

Grey	Non-detection; value below the LOD.
Yellow	Detected value above the LOD.

Appendix D - 3M Global EHS Laboratory and Enthalpy Analytical Comparison Table
PFAS Treatability Study
Cottage Grove MN Facility
December 22, 2021

Test Phase	NCCW/SW				NCCW/SW				NCCW/SW			
Sample Description	UF INFLUENT				UF PERMEATE				RO PERMEATE			
Sample Date	8/2/2021				8/2/2021				8/2/2021			
Full Name	UF INFLUENT-2021-0802				UF PERMEATE-2021-0802				RO PERMEATE-2021-0802			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 700	3360			< 700	3160			< 700	<200		
2,2,3,3 TFPA	< 1000	<500			< 1000	<500			< 1000	<500		
2,3,3,3 TFPA	< 752	1210			< 752	<1000			< 752	<1000		
PFPA	2750	3180	15%	3M EHS	2740	3300	19%	3M EHS	< 700	<50.0		
PFBA	8060	8000	1%	Enthalpy	8450	8120	4%	Enthalpy	< 191	25.2		
PFPeA	561	502	11%	Enthalpy	562	526	7%	Enthalpy	< 212	<10.0		
PFHxA	< 241	173			< 241	182			< 241	<10.0		
PFHpA	< 152	27.2			< 152	28			< 152	<10.0		
PFOA	< 221	62.8			< 221	69.4			< 221	<19.2		
PFBS	< 444	142			< 444	147			< 444	<10.0		
PFPeS	< 258	45			< 258	44.2			< 258	<9.4		
PFHxS	< 239	54.6			< 239	35.6			< 239	<10.0		
PFHpS	< 169	<10.0			< 169	<10.0			< 169	<10.0		
PFOS	< 200	<9.3			< 200	<9.3			< 200	<9.3		
HQ-115	< 1000	236			< 1000	256			< 1000	<10.0		
TFMS	8530	3160	92%	Enthalpy	7860	3140	86%	Enthalpy	< 1000	<25.0		

Test Phase	NCCW/SW				NCCW/SW				NCCW/SW			
Sample Description	RO REJECT				IX1-C				IX2-C			
Sample Date	8/2/2021				8/2/2021				8/2/2021			
Full Name	RO REJECT-2021-0802				IX1-C-2021-0802				IX2-C-2021-0802			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 7000	17000			< 700	<200			< 700	<200		
2,2,3,3 TFPA	< 10000	<500			< 1000	<500			< 1000	<500		
2,3,3,3 TFPA	< 7520	<1000			< 752	<1000			< 752	<1000		
PFPA	9200	16200	55%	3M EHS	730	<50.0			< 700	<50.0		
PFBA	32200	36800	13%	3M EHS	< 191	<10.0			< 191	<10.0		
PFPeA	< 2120	2140			< 212	<10.0			< 212	<10.0		
PFHxA	< 2410	670			< 241	<10.0			< 241	<10.0		
PFHpA	< 1520	81.4			< 152	<10.0			< 152	<10.0		
PFOA	< 2210	242			< 221	<19.2			< 221	<19.2		
PFBS	< 4440	546			< 444	<10.0			< 444	<10.0		
PFPeS	< 2580	133			< 258	<9.4			< 258	<9.4		
PFHxS	< 2390	94.2			< 239	<10.0			< 239	<10.0		
PFHpS	< 1690	<10.0			< 169	<10.0			< 169	<10.0		
PFOS	< 2000	<9.3			< 200	<9.3			< 200	<9.3		
HQ-115	< 10000	1430			< 1000	<10.0			< 1000	<10.0		
TFMS	36100	14600	85%	Enthalpy	< 1000	<25.0			< 1000	<25.0		

Test Phase	NCCW/SW				NCCW/SW				NCCW/SW			
Sample Description	RO PERMEATE				3MCG-Test01_B-UF-PERM-20210823				3MCG-Test01-B-INF-A (RO-REJ)-20210823			
Sample Date	8/11/2021				8/23/2021				8/23/2021			
Full Name	RO PERMEATE-2021-0811				3MCG-Test01_B-UF-PERM-20210823-2021-0823				3MCG-Test01-B-INF-A (RO-REJ)-20210823-2021-0823			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 700	<200			< 700	3200			< 3500	19100		
2,2,3,3 TFPA	< 1000	<500			< 1000	<500			< 5000	<500		
2,3,3,3 TFPA	< 752	<1000			< 752	<1000			< 3760	<1000		
PFPA	< 700	<50.0			1420	1800	24%	3M EHS	7670	9920	26%	3M EHS
PFBA	< 191	<10.0			398	528	28%	3M EHS	16500	17300	5%	3M EHS
PFPeA	< 212	<10.0			< 212	25.2			1310	1710	26%	3M EHS
PFHxA	< 241	<10.0			< 241	<10.0			< 1210	740		
PFHpA	< 152	<10.0			< 152	<10.0			< 762	82.2		
PFOA	< 221	<19.2			< 221	<9.6			< 1110	324		
PFBS	< 444	<10.0			< 444	<10.0			< 2220	650		
PFPeS	< 258	<9.4			< 258	<9.4			< 1290	256		
PFHxS	< 239	<20.0			< 239	11			< 1190	300		
PFHpS	< 169	<10.0			< 169	<10.0			< 844	16.9		
PFOS	< 200	<9.3			< 200	<9.3			< 1000	<9.3		
HQ-115	< 1000	111			4370	4440	2%	3M EHS	71000	74000	4%	3M EHS
TFMS	< 1000	<25.0			1600	1280	22%	Enthalpy	14900	9500	44%	Enthalpy

Test Phase	NCCW/SW				NCCW/SW				NCCW/SW			
Sample Description	3MCG-Test 01_B-UF-PERM-20210826				3MCG-Test 01_B-INF-A (RO-REJ)-20210826				3MCG-Test 01_B-INF-A (RO-REJ)-20210829			
Sample Date	8/26/2021				8/26/2021				8/29/2021			
Full Name	3MCG-Test 01_B-UF-PERM-20210826-2021-0826				3MCG-Test 01_B-INF-A (RO-REJ)-20210826-2021-0826				3MCG-Test 01_B-INF-A (RO-REJ)-20210829-2021-0829			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 700	3040			< 3500	18600			< 7000	20200		
2,2,3,3 TFPA	< 1000	<500			< 5000	<500			< 10000	<500		
2,3,3,3 TFPA	< 752	<1000			< 3760	<1000			< 7520	<1000		
PFPA	2370	2060	14%	Enthalpy	10800	9840	9%	Enthalpy	9480	10700	12%	3M EHS
PFBA	565	482	16%	Enthalpy	15800	14400	9%	Enthalpy	15600	10800	36%	Enthalpy
PFPeA	< 212	<10.0			1320	1350	2%	3M EHS	< 2120	968		
PFHxA	< 241	<10.0			< 1210	426			< 2410	324		
PFHpA	< 152	<10.0			< 762	74.8			< 1520	55.2		
PFOA	< 221	<9.6			< 1110	260			< 2210	226		
PFBS	< 444	<10.0			< 2220	600			5010	4440	12%	Enthalpy
PFPeS	< 258	<9.4			< 1290	209			< 2580	156		
PFHxS	< 239	<10.0			< 1190	279			< 2390	188		
PFHpS	< 169	<10.0			< 844	23.6			< 1690	11.7		
PFOS	< 200	<9.3			< 1000	<8.3			< 2000	<9.3		
HQ-115	5700	3500	48%	Enthalpy	104000	58700	56%	Enthalpy	102000	53400	63%	Enthalpy
TFMS	5570	1440	118%	Enthalpy	38400	8560	127%	Enthalpy	41900	8620	132%	Enthalpy

Test Phase	NCCW/SW				NCCW/SW				NCCW/SW			
Sample Description	3MCG-Test 01_B-IX2-A-20210901				3MCG-Test 01_B-IXR2-B-20210901				3MCG-Test 01_B-UF-PERM-20210902			
Sample Date	9/1/2021				9/1/2021				9/2/2021			
Full Name	3MCG-Test 01_B-IX2-A-20210901-2021-0901				3MCG-Test 01_B-IXR2-B-20210901-2021-0901				3MCG-Test 01_B-UF-PERM-20210902-2021-0902			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 700	19800			< 700	19800			< 700	3320		
2,2,3,3 TFPA	< 1000	<500			< 1000	<500			< 1000	<500		
2,3,3,3 TFPA	1270	<1000			1080	<1000			< 752	<1000		
PFPA	< 700	<50.0			3190	4320	30%	3M EHS	2290	2880	23%	3M EHS
PFBA	< 191	<10.0			< 191	<10.0			1640	1730	5%	3M EHS
PFPeA	< 212	<10.0			< 212	<10.0			< 212	14.8		
PFHxA	< 241	<10.0			< 241	<10.0			< 241	<10.0		
PFHpA	< 152	<10.0			< 152	<10.0			< 152	<10.0		
PFOA	< 221	<9.6			< 221	<9.6			< 221	<9.6		
PFBS	< 444	<10.0			< 444	<10.0			< 444	101		
PFPeS	< 258	<9.4			< 258	<9.4			< 258	<9.4		
PFHxS	< 239	<10.0			< 239	<10.0			< 239	<10.0		
PFHpS	< 169	<10.0			< 169	<10.0			< 169	<10.0		
PFOS	< 200	<9.3			< 200	<9.3			< 200	<9.3		
HQ-115	< 1000	<10.0			< 1000	<10.0			< 1000	564		
TFMS	< 1000	<25.0			< 1000	<25.0			6540	2320	95%	Enthalpy

Test Phase	NCCW/SW				Phase 1/2 WW				Phase 1/2 WW			
Sample Description	3MCG-Test 01_B-INF-A (RO-REJ)-20210902				3MCG-Test 02-D.0-INF (RO-REJ)-20210921				3MCG-Test 02-D.4-IX2-20210924			
Sample Date	9/2/2021				9/23/2021				9/24/2021			
Full Name	3MCG-Test 01_B-INF-A (RO-REJ)-20210902-2021-0902				3MCG-Test 02-D.0-INF (RO-REJ)-20210921-2021-0923				3MCG-Test 02-D.4-IX2-20210924-2021-0924			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 7000	21600			< 7000	11300			< 9604	10700		
2,2,3,3 TFPA	< 10000	<500			< 7861	<500			< 1928	<500		
2,3,3,3 TFPA	< 7520	<1000			< 1786	<1000			< 2278	<1000		
PFPA	17000	12700	29%	Enthalpy	20100	8500	81%	Enthalpy	1460	370	119%	Enthalpy
PFBA	10900	8700	22%	Enthalpy	18900	13800	31%	Enthalpy	< 191	<10.0		
PFPeA	< 2120	560			147	706	131%	3M EHS	< 212	<10.0		
PFHxA	< 2410	204			< 336	252			< 241	<10.0		
PFHpA	< 1520	34.4			< 204	35.8			< 152	<10.0		
PFOA	< 2210	173			1120	488	79%	Enthalpy	< 221	<9.6		
PFBS	16900	13800	20%	Enthalpy	49500	37000	29%	Enthalpy	< 444	<10.0		
PFPeS	< 2580	96.8			< 417	174			< 31.1	<9.4		
PFHxS	< 2390	135			936	510	59%	Enthalpy	< 239	<10.0		
PFHpS	< 1690	14.1			< 639	110			< 169	<10.0		
PFOS	< 2000	<9.3			< 7311	170			< 200	<9.3		
HQ-115	76500	42400	57%	Enthalpy	163000	91000	57%	Enthalpy	< 6.48	<10.0		
TFMS	43400	9580	128%	Enthalpy	1060000	414000	88%	Enthalpy	< 590	<25.0		

Test Phase	Phase 1/2 WW				Phase 1/2 WW				Phase 1/2 WW				Phase 1/2 WW			
Sample Description	3MCG-Test 02-E.4-IXR2-20210924				3MCG-Test 02-F.0-INF (RO PERM)-20210918[1]				3MCG-Test 02-F.1-IX1-20210918[1]				3MCG-Test 02-F.2-IX2-20210918[1]			
Sample Date	9/24/2021				9/18/2021				9/18/2021				9/18/2021			
Full Name	3MCG-Test 02-E.4-IXR2-20210924-2021-0924				3MCG-Test 02-F.0-INF (RO PERM)-20210918-2021-0918				3MCG-Test 02-F.1-IX1-20210918-2021-0918				3MCG-Test 02-F.2-IX2-20210918-2021-0918			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 6914	13200			< 700	<200			< 700	<200			< 7000	<200		
2,2,3,3 TFPA	< 1953	<500			< 556	<500			< 485	<500			< 5338	<500		
2,3,3,3 TFPA	< 2241	<1000			< 131	<1000			< 170	<1000			< 1212	<1000		
PFPA	8840	6640	28%	Enthalpy	< 700	<50.0			< 700	<50.0			< 7000	<50.0		
PFBA	< 191	<10.0			< 11.8	11.1			< 11.6	<10.0			< 169	<10.0		
PFPeA	< 212	<10.0			< 13.2	<10.0			< 20.3	<10.0			< 121	<10.0		
PFHxA	< 241	<10.0			< 1.51	<10.0			< 2.24	<10.0			< 89.9	<10.0		
PFHpA	< 152	<10.0			< 10.3	<10.0			< 17.5	<10.0			< 235	<10.0		
PFOA	< 221	<9.6			< 45.7	<19.2			< 12.0	<19.2			< 669	<19.2		
PFBS	< 444	<10.0			< 6.25	16.5			< 5.42	<10.0			< 99.1	<10.0		
PFPeS	< 32	<9.4			< 4.02	<9.4			< 4.94	<9.4			< 7.99	<9.4		
PFHxS	< 239	<10.0			< 3.49	<10.0			< 6.89	<10.0			< 43.8	<10.0		
PFHpS	< 169	<10.0			< 4.87	<10.0			< 3.60	<10.0			< 41.9	<10.0		
PFOS	< 200	<9.3			< 4.71	<9.3			< 2.74	<9.3			< 64.1	<9.3		
HQ-115	< 3.78	<10.0			124	96.2	25%	Enthalpy	< 0.734	<10.0			< 7.21	<10.0		
TFMS	< 890	<25.0			2150	582	115%	Enthalpy	42.8	<25.0			< 188	<25.0		

Test Phase	Phase 1/2 WW				Phase 1/2 WW				Phase 1/2 WW			
Sample Description	3MCG-Test 02-F.0-INF (RO PERM)-20210923				3MCG-Test 02-F.1-IX1-20210923				3MCG-Test 02-F.2-IX2-20210923			
Sample Date	9/23/2021				9/23/2021				9/23/2021			
Full Name	3MCG-Test 02-F.0-INF (RO PERM)-20210923-2021-0923				3MCG-Test 02-F.1-IX1-20210923-2021-0923				3MCG-Test 02-F.2-IX2-20210923-2021-0923			
Shared PFAS Analytes	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab	Enthalpy	3M EHS	RPD	Higher Lab
TFA	< 700	<200			< 700	<200			< 700	<200		
2,2,3,3 TFPA	< 429	<500			< 507	<500			< 373	<500.0		
2,3,3,3 TFPA	< 136	<1000			< 131	<1000			< 129	<1000		
PFPA	33.9	<50.0			92.5	<50.0			< 350	<50.0		
PFBA	9.93	<10.0			< 191	<10.0			< 8.17	<10.0		
PFPeA	5.05	<10.0			< 36	<10.0			< 20	<10.0		
PFHxA	< 2.01	<10.0			< 18.9	<10.0			< 1.17	<10.0		
PFHpA	< 55.8	<10.0			< 13.2	<10.0			< 0.948	<10.0		
PFOA	< 2.31	<19.2			< 27.9	<19.2			< 35.7	<19.2		
PFBS	83.9	41	69%	Enthalpy	< 32.6	<10.0			< 60.7	<10.0		
PFPeS	80.2	<9.4			< 20	<9.4			< 8.27	<9.4		
PFHxS	< 131	<10.0			< 8.64	<10.0			< 30.4	<10.0		
PFHpS	< 82.6	<10.0			< 13	<10.0			< 8.15	<10.0		
PFOS	< 75	<9.3			< 29.3	<9.3			< 9.95	<9.3		
HQ-115	157	120	27%	Enthalpy	< 1.01	<10.0			< 1.45	22.4		
TFMS	1050	320	107%	Enthalpy	< 18.4	<25.0			157	<25.0		

Notes

RPD=relative persent difference. RPD's are only calculated when a PFAS analyte is detected by both laboratories.

RPD is calculated as: $RPD = \frac{|Sample\ 1 - Sample\ 2|}{\left(\frac{Sample\ 1 + Sample\ 2}{2}\right)}$

[1] Comparison between samples collected on different days. Enthalpy data collected on 9/17/2021 and 3M EHS sample collected on 9/18/2021.

Cell Shading Key

Grey	Non-detection; value below the LOD.
Yellow	Detected value above the LOD.
Blue	PFAS detected by one lab, but not the other. If the detection was a true detection, the lab that did not detect the PFAS would not have detected the PFAS based on the level of the LOD.
Red	PFAS detected by one lab, but not the other. If the detection was a true detection, however, both labs could have identified the PFAS based on the LODs. Or, the value represents a false-positive detection.

EXHIBIT C

Approval Letter

MINNESOTA POLLUTION CONTROL AGENCY

Duluth Office | 525 Lake Avenue South | Suite 400 | Duluth, MN 55802 | 218-723-4660

800-657-3864 | Use your preferred relay service | info.pca@state.mn.us | Equal Opportunity Employer

May 17, 2023

VIA EMAIL

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Cottage Grove, MN 55106

RE: 3M Cottage Grove Wastewater Treatment Facility
Plans and Specification Approval
Building 150 and Building 151 Project
NPDES/SDS Permit Number MN0001449

Dear Shane Symmank, Christopher Bryan, Darren Schwankl and Alma Allen-Webb:

The Minnesota Pollution Control Agency (MPCA) is hereby granting approval of the plans and specifications listed above. The approved proposal is for the construction and operation of wastewater treatment facilities. The approval is pursuant to Minn. Stat. chs. 115 and 116, as amended.

The plans/specifications and related information indicate that the project will consist of pumping and filtration equipment, as well as an ion exchange media regeneration system. The systems are designed to treat facility wastewater (WW) and stormwater/groundwater/non-contact cooling water (SW/GW/NCCW) separately. Chemical feed and storage, flocculation, prefiltration, clean-in-place systems (CIPs) and solids handling are all included in Building 150 and Building 151. Design criteria of the treatment systems is based on the 3M Cottage Grove *PFAS Treatability Study* dated December 22, 2021, which included the following:

	SW/GW/NCCW	**WW**
Reverse Osmosis System		
Feed pressure	123 psi	126 to 184 psi
Permeate flux	14 GFD	12 GFD - set point
Recovery (% to permeate)	85%	85% - set point
Observed TDS rejection	93% to 99%	96%
Membrane type	SUEZ AK 4040TM (low energy)	SUEZ AK 4040TM
Active area	85 s.f.	85 s.f.

	SW/GW/NCCW	WW
Granular Activated Carbon System		
Empty bed contact time (EBCT)	60 min across 2 vessels	60 min across 2 vessels
Hydraulic loading (HLR)	0.9 gpm/s.f.	0.9 gpm/s.f.
Media type	Calgon F 400 (bituminous coal)	Calgon F 400
Anion Exchange System		
Empty bed contact time (EBCT)	60 min across 2 vessels	60 min across 2 vessels
Hydraulic loading (HLR)	0.9 gpm/s.f.	0.9 gpm/s.f.
Media type # 1	SORBIX A3F (regenerable)	SORBIX A3F (regenerable)
Media type #2	CalRes 2301	CalRes 2301

Design elements of the treatment systems include, but are not limited to:

	SW/GW/NCCW	WW
Reverse Osmosis System		
Feed temp	ambient	ambient
Recovery (% to permeate)	85% (target)	85% (target)
NaCl Rejection	not specified	not specified
Membrane type	SUEZ AG-400-FR H	SUEZ AG-400-FR H
Active area	400 s.f.	400 s.f.
Stages/Banking Arrangement	3 stages, 24/12/6	3 stages, 9/6/3
Elements per housing	6	6
Total elements per skid	252	108
Total active area per skid	100,800 s.f.	43,200 s.f.
Design Flux	14 GFD (Treatability Study)	11.6 GFD (specified)
Design flow/skid	1150 gpm (1.65 mgd)	410 gpm (0.59 mgd)
Design flow w/5 skids	5750 gpm (8.28 mgd)	2050 gpm (2.95 mgd)
Granular Activated Carbon System		
Treatment trains	4	2
Vessels per train	2	2
Vessel diameter	10 ft.	10 ft.
Media type	Calgon DSR C 8x30 (reactivated)	Calgon DSR C 8x30
Mass of Carbon/vessel	20,000#	20,000#
Density (backwashed/drained)	~26 #/c.f.	~26 #/c.f.
EBCT across 2 vessels	60 min. (Treatability Study)	60 min. (Treatability Study)
Design flow/train	192 gpm (0.27 mgd)	192 gpm (0.27 mgd)
Design flow w/3 trains	576 gpm (0.83mgd)	-
Surface loading rate	2.4 gpm/s.f.	2.4 gpm/s.f.

Anion Exchange System		
Treatment trains	7	3
Vessels per train	3	3
Vessel diameter	6 ft.	6 ft.
Media type #1	SORBIX A3F (regenerable)	SORBIX A3F (regenerable)
Media type #2	SIR-110-MP (regenerable)	SIR-110-MP (regenerable)
Volume of AIX/vessel	360 c.f.	360 c.f.
EBCT across 3 vessels	60 min. (Treatability Study)	60 min. (Treatability Study)
Design flow/train	135 gpm (0.19 mgd)	135 gpm (0.19 mgd)
Design flow w/2 trains	-	270 gpm (0.39 mgd)
Design flow w/5 trains	675 gpm (0.97 mgd)	-
Surface loading rate	4.8 gpm/s.f.	4.8 gpm/s.f.

Electrical, mechanical, and associated appurtenances are also included in the project. The plans and specifications are signed/certified and dated November 6, 2022, February 13, 2023, and February 24, 2023. The *Design Basis Reports* for Building 150 and Building 151 are dated October 24, 2022, March 28, 2023, and April 14, 2023. *Design Basis Reports Addenda* for Building 150 and Building 151 are dated March 28, 2023, May 3, 2023, May 10, 2023, and May 11, 2023. Based on the 3M Cottage Grove *PFAS Treatability Study* dated December 22, 2021, design flows for Building 150 and Building 151 are listed above.

The MPCA's officers, employees and agents review, comment upon, and approve plans and specifications for the limited administrative purpose of determining whether there is reasonable assurance that the treatment systems when constructed, will comply with the regulations and criteria of the MPCA. This approval shall not in any way relieve the Permittee or the engineer of responsibility, nor shall it make the MPCA responsible for the technical adequacy of the engineer's work. This approval shall not relieve the Permittee from complying with all conditions and requirements of the National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permit and shall be retained by the Permittee with the permit.

The Permittee is responsible for obtaining an NPDES Stormwater Permit, separate from the above-mentioned wastewater discharge permit, for any construction project which disturbs a surface area of one acre or more. To obtain a copy of the Construction Stormwater Permit application, go to the MPCA website and the stormwater program webpage at: http://www.pca.state.mn.us/water/stormwater/stormwater-c.html or to request a paper application call the MPCA Front Desk at 651-296-6300 or 800-657-3864 and ask to speak to the Construction Stormwater Administrative Lead.

Any alterations or additions to the treatment system's approved plans and specifications must be submitted to the MPCA as a Plan and Specification Addendum and be approved by the MPCA prior to bid opening. Significant alterations or additions to the treatment system's approved plans and specifications, proposed after the award of the contract, must be submitted as a change order and approved by the MPCA. Significant change orders are defined as contract deviations which:

1. substantially alter the type of treatment process, or its efficiency, versatility, or reliability; and/or

2. alter the approved project schedule affecting the initiation of operation date.

Significant change orders require prior approval from the MPCA, before the work can be done. Verbal approval may be agreed to if the work is of an emergency nature.

All change orders shall be retained by the Permittee for review by the MPCA. Each change order shall include an execution date, a complete description of the change, and signatures from the Permittee's authorized representative, the engineer, and the contractor.

Regulations may change regarding administrative requirements in effect at the time of this approval.

A final inspection of the treatment facility shall be performed by MPCA staff when all construction is complete except for minor weather-related components. The Permittee should request in writing that a final inspection be performed when it believes construction is complete.

One copy of "as-built" plans and specifications, also known as record drawings, shall be submitted. The as-built documents must be submitted in a format approved by the MPCA. The factsheet titled: "Wastewater Treatment Facility Construction Record Documents, As-built Submittal Requirements" contains specific information regarding the required format of the submittal. The document is located on the MPCA web page at: https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-87.pdf.

Any questions regarding this approval should be directed to me at 218-302-6651.

Sincerely,

Scott Knowles

This document has been electronically signed.

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EXHIBIT D

Arcadis Expert Report

3M Cottage Grove

Final

Technical Review of 3M Cottage Grove Advanced Wastewater Treatment System

August 2024

Final – Technical Review of 3M Cottage Grove Advanced Wastewater Treatment System

August 2024

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1 Scope of Work

The law firm of Hogan Lovells retained Arcadis[1] on behalf of 3M to provide technical review and comment on the capabilities of the advanced wastewater treatment system currently under construction at 3M Chemical Operations LLC's Cottage Grove facility (the Facility), specifically in connection with the intervention and compliance limits proposed by the Minnesota Pollution Control Agency (MPCA) draft permit MN0001449 (Draft Permit). The proposed treatment system is intended to be installed at a site in Cottage Grove, Minnesota to treat industrial wastewater before being discharged to an unnamed creek in the Mississippi River watershed.

The following sections comprise Arcadis' technical review of the per- and polyfluoroalkyl (PFAS) Treatability Study Report (Treatability Report) submitted to MPCA by Emerging Compounds Treatment Technologies (ECT2) and Barr on behalf of 3M (ECT2 and Barr 2021) as well as the Design Basis Report (BOD) submitted to MPCA by ECT2 and Toltz, King & Day (TKDA; ECT2 and TKDA 2023). MPCA approved these submissions. This technical review includes the following details:

- A summary of applicable permitting considerations as specified in the Draft Permit;
- An overview of the existing and proposed treatment systems;
- A summary and analysis of the Treatability Report data relevant to the Draft Permit;
- A comparison of the proposed treatment system to accepted industry standards;
- An assessment of whether the proposed treatment system can meet the ultra-low PFAS limits specified in the Draft Permit; and
- A summary of the technical review findings.

[1] The CVs of the authors of this Report are attached as **Appendix A**.

2 Regulatory Framework

2.1 Overview of Draft Permit

Relevant to this analysis, the Draft Permit sets Facility discharge limits for perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorohexanesulfonic acid (PFHxS). Sampling locations are displayed in **Figure 2-1** and **Figure 2-2** (MPCA 2024). Section 4 of the Draft Permit provides a summary of stations and station locations including effluent to surface water stations SD001, SD002, and SD003. As shown on **Figure 2-1**, SD001 encompasses process and sanitary effluent; SD002 includes non-contact cooling water (NCCW), groundwater (GW), and industrial stormwater (ISW); and SD003 includes outfalls from SD001 and SD002 combined. Additionally, the Draft Permit includes a description of internal waste streams WS001 and WS002 as shown on **Figure 2-2**. WS001 is sampled after the process and sanitary anion exchange (IX) lag vessel and before mixing into SD001 at Building 151. WS002 is sampled after the NCCW, GW, and ISW IX lag vessel and before mixing into SD002 at Building 151. Note that the current treatment system includes no further treatment after WS001 and WS002.

Water Quality-based Effluent Limitations (WQBELs), Compliance Limits, and Intervention limits, are displayed in **Table 2-1**. Each of these limits have a specific role under the Draft Permit. The WQBELs are limit values derived by MPCA based upon its analysis of levels required to ensure achievement of the State's designated uses. The Compliance Limits are values adopted by MPCA that are deemed acceptable to demonstrate compliance with certain WQBELs that are below the limits of quantitation of MPCA's preferred laboratory analytical method (EPA Method 1633). The Intervention Limits are values applied at specific sampling locations, exceedances of which trigger specified actions by operators of the wastewater treatment system.

Section 5.69.128 of the Draft Permit defines compliance limits (CLs) as follows:

> *"Compliance limit (CL)" shall mean: The value deemed as in compliance with the Daily Maximum and Monthly Average PFAS limits. The monthly average and daily maximum PFOS WQBELs are below the reporting limits (limits of quantitation) achievable when analyzing treated effluent at Cottage Grove. For PFOS, a statistical analysis of the actual reporting limit wastewater at Cottage Grove sampling stations SD001 and SD002 is 2.2 ng/L. For PFOA and PFHxS, the actual reporting limit is 2.1 ng/L. For these three parameters, any effluent value less than or equal to the numbers above will be considered in compliance with the daily maximum limit; and any monthly average effluent value equal to or below the numbers above will be considered to be in compliance with the monthly average limits.*

Section 5.33 of the Draft Permit provides the following intervention limit requirements:

- Sampling requirements in the case of an intervention limit is exceedance (e.g., resample the monitoring station within 2 days of receipt of sample results indicating exceedance);
- Evaluation of the significance and probable cause of the exceedance including a review of media changeout schedule;
- Proposed immediate corrective action to prevent future exceedances;
- Proposed change in monitoring schedule (e.g., increased sampling frequency, additional analytes, additional monitoring points); and.
- Submission of an intervention limit exceedance evaluation report within 30 days of receipt of sample results indicating exceedance

The Draft Permit indicates that an exceedance of an intervention limit does not constitute a permit violation; however, failure to respond to the intervention limit exceedances as described above constitutes a permit violation.

In summary, exceedances of PFHxS, PFOS, and PFOA above 2.1, 2.2, and 2.1 nanograms per liter (ng/L), respectively, would constitute a permit violation, as shown in **Table 2-1**. Section 5.73.198 of the Draft Permit provides additional effluent limitations and requirements and describes WQBELs as follows:

> *Water quality-based effluent limits shall be dependent on receiving water, discharge volume, in-stream flow volume, and discharge time, duration and location. The MPCA shall notify the Permittee if it is determined that additional requirements, more or less stringent limits, and/or monitoring are appropriate for a specific water body. The MPCA's letter notifying the Permittee of these additional requirements… shall then become a part of the enforceable requirements applicable through this permit for the specific discharge point and the Permittee shall comply with these requirements.*

Note that the Treatability Report uses the term limit of detection (LOD), while the Draft Permit uses limit of quantitation (LOQ). Arcadis received the following communication from John Berry, representing ECT2, addressed to Christopher Bryan, representing 3M, which summarizes an explanation provided by representatives of Enthalpy Analytical on the use of LOD versus LOQ:

> *The LOQ is effectively determined by the range of concentrations calibrated on the instrument. The LOD can be determined in numerous ways, the most common of which is to spike samples and use statistical methods to determine a limit of detection. However, in some cases, such as when a method is new, an LOD study will not have yet been executed, in which case the LOD will be set to the same value as the LOQ. This is the case for the PFAS Treatability Study for Cottage Grove dated December 22, 2021.*

The terms LOD and LOQ are not synonymous, but they may have the same value depending on the circumstances. For the purposes of this discussion, we will use LOQ to refer to analytical limits (i.e., any occurrence of LOD from the Treatability Report cited herein will be replaced with LOQ for terminology consistency).

It is important to note that the intervention limits and WQBELs specified in the Draft Permit are well below the CLs also specified in the Draft Permit as well as the LOQs found in the Treatability Report for PFOS, PFOA, and PFHxS. Currently, the lowest LOQs for PFAS compounds analyzed via common analytical methods (e.g., United States Environmental Protection Agency [USEPA] Method 1633, 537.1, 8421) are typically in the single digit parts per trillion (ppt) order of magnitude (OOM). This contrasts with the intervention limits and WQBELs specified by the Draft Permit, which are one to three OOMs lower, making them effectively unenforceable.

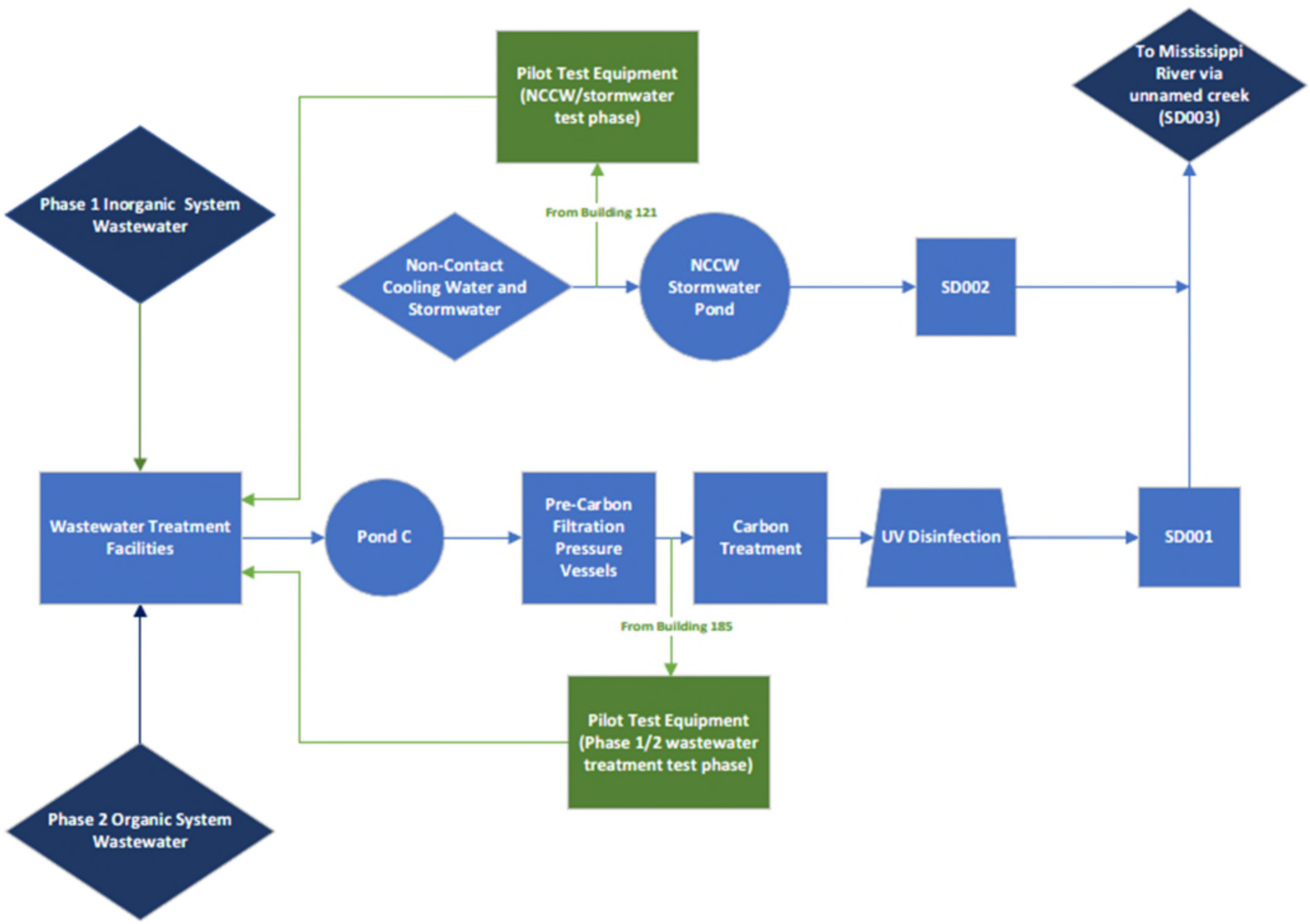


Figure 2-1 Pilot Test Source Water Locations

Source: ECT2 and Barr 2021, Figure 2.2

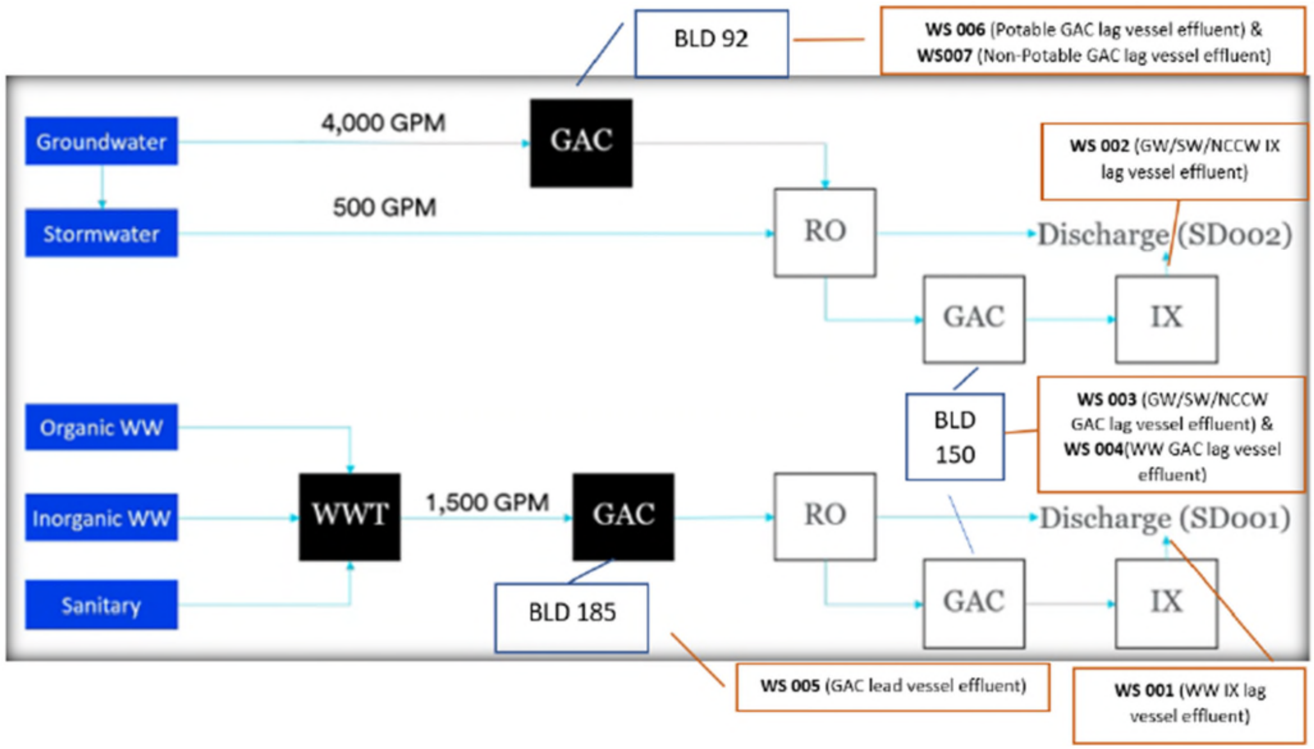


Figure 2-2 Locations of Internal Waste Streams (WS) Stations in Process Flow
Source: MPCA 2024, Figure 7

Table 2-1 Intervention limits, WQBELs, CLs, and LOQs (MPCA 2024).

Analyte	Intervention Limits[1]		WQBELs[2,3]		Compliance Limits[3]	LOQ Range[4]
	Daily Maximum (ng/L)	Calendar Month Average (ng/L)	Daily Maximum (ng/L)	Calendar Month Average (ng/L)	(ng/L)	(ng/L)
PFHxS	0.0298	0.0171	0.0056	0.0032	2.1	<1.93 – <2,390
PFOS	0.27	0.155	0.066	0.038	2.2	<1.41 – <7,311
PFOA	0.117	0.069	0.022	0.013	2.1	<0.122 – <2,210

Notes:
1 Draft Permit intervention limits for PFOA, PFOS, and PFHxS at sampling locations WS001 and WS002 as shown on **Figure 2-2**.
2 Draft Permit WQBELs for sampling locations SD001, SD002, and SD003 as shown on **Figure 2-1**.
3 Enforceable CLs, exceedances of which would constitute a violation of the Draft Permit.
4 LOQ ranges as specified in the Treatability Report.

3 Overview of Treatment Systems

This section provides a brief description of pertinent existing water treatment systems and a summary of the proposed PFAS treatment systems.

3.1 Existing Treatment System Overview

3M currently operates an existing wastewater treatment plant (WWTP). Process wastewater generated from production facilities, pilot production wastewaters, and sanitary wastewater are treated at the facility WWTP. These waters are treated at three separate WWTP systems, referred to as Phases, depending on their relevant liquid characteristics. The Phase 2 treatment system processes organic wastewater from manufacturing processes while the Phase 1 treatment system processes effluent from Phase 2, inorganic wastewater from manufacturing, and landfill leachate. The effluent of Phase 1 is then routed to a granular activated carbon (GAC) system, followed by ultraviolet light, before discharge at Outfall SD001. The Phase 3 treatment system previously treated scrubber wastewater from a former 3M hazardous waste incinerator at the Facility and currently treats drainage from drying beds, incinerator decommissioning waters, and select stormwater collected at the Facility. Effluent from the Phase 3 treatment system is routed to a separate GAC system to treat PFAS before discharge at Outfall SD001 (MPCA 2024).

In addition to the process streams identified above, 3M also manages NCCW, ISW, and GW at the Facility. Both NCCW and ISW were previously discharged to an unlined NCCW retention pond before discharge. Contaminated GW from the 3M Cottage Grove Facility, as well as the Woodbury Disposal site, is extracted from extraction wells and treated through a GAC system. Effluent from this GAC system is used throughout the Cottage Grove Facility for cooling water, process water, and other building/site water requirements. The following block diagram (**Figure 3-1**) shows the current WWTP process flows (MPCA 2024).

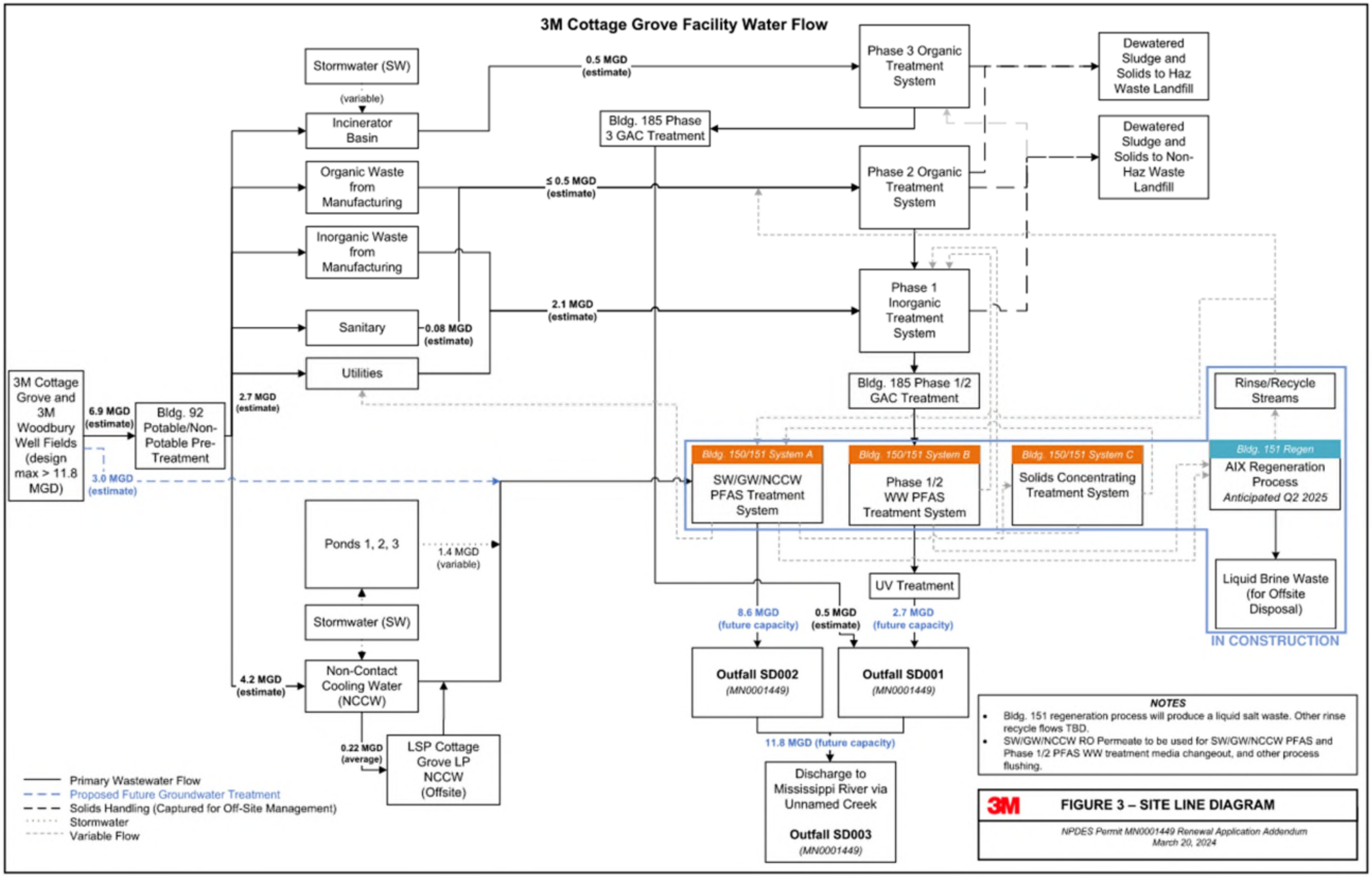


Figure 3-1 WWTP Process Flow Diagram

Source: MPCA 2024, Figure 5

3.2 Proposed Treatment System Overview

3M has proposed to install an advanced wastewater treatment system (AWWTS), which encompasses two discrete PFAS treatment systems (Systems A and B) and a third IX resin regeneration and regenerant recovery and concentration system. A fourth system (System C) includes a solids concentrating treatment system for System A solids management. Together, these treatment systems will treat approximately 11 million gallons per day (MGD) of GW (from the Cottage Grove Facility and Woodbury disposal site well fields), ISW, NCCW (System A) and Phase 1/2 treatment system effluent (System B). Because the design basis of System C is focused on solids management and not direct PFAS treatment, it is not further discussed herein. As discussed herein, the AWWTS incorporates a best-in-class approach to consistent treatment of PFAS and management of PFAS waste materials, based on the particular characteristics of the composition of the 3M wastewater. When first operated, the AWWTS will represent almost four years of testing, design, and construction at a cost of approximately $275,000,000.

The following sections provide a narrative of the process streams and a description of the process units/technologies included in the design for each system.

3.2.1 Systems A and B

Influent water for System A includes GW, ISW, and NCCW with a design flow rate of 8.28 MGD. Influent water for System B includes WWTP Phase 1/2 effluent with a design flow rate of 2.95 MGD. Although the resulting treatment processes are generally the same for both systems, due to the different characteristics of the water in the process streams, 3M designed two separate treatment systems to allow for optimum design and operability. Had the source waters been combined and routed to a singular system, the unique differences in the water chemistry, flow rates, and pre-treatment requirements may have resulted in inconsistent operation of the combined system. In general, both systems include the following unit processes (ECT2 and Barr 2021):

- Pre-filtration:
  - Pre-filtration for System A, which appears to contemplate potential treatment for algal growth in NCCW pond; and
  - Pre-filtration for System B includes the existing glass filter media before the existing GAC treatment system for Phase 1/2.
- Ultra Filtration (UF):
  - UF is being used to protect the reverse osmosis (RO) membranes from excessive fouling. UF backwash streams will be sent to a solids-concentration system, and concentrated solids will be returned to the existing WWTP.
- RO:
  - Three RO stages are included in the design to enable a wider range of PFAS recovery in light of the PFAS composition of 3M's effluent.
  - RO concentrate will be treated using GAC and regenerable IX resin. The treated RO concentrate will be combined with the RO permeate and discharged to Outfalls SD001 and SD002, respectively.
- GAC:
  - In the treatment configuration utilized, GAC adsorption will be optimized to remove primarily long-chain PFAS from the RO concentrate stream before IX treatment. Short chain PFAS compounds will

also be removed during this treatment step, however, the design intent of this step is for the removal of long chain PFAS compounds.

- IX Resin:
  - In the treatment configuration utilized, regenerable IX resin will be optimized to remove short-chain PFAS from the RO concentrate. Long chain PFAS compounds will also be removed during this treatment step, however, the design intent of this step is for the removal of short chain PFAS compounds.
  - Each IX resin "train" will consist of three adsorbent vessels connected in series. The first vessel will contain SORBIX A3F IX resin. The second and third vessels will contain a "secondary high-capacity microporous media."

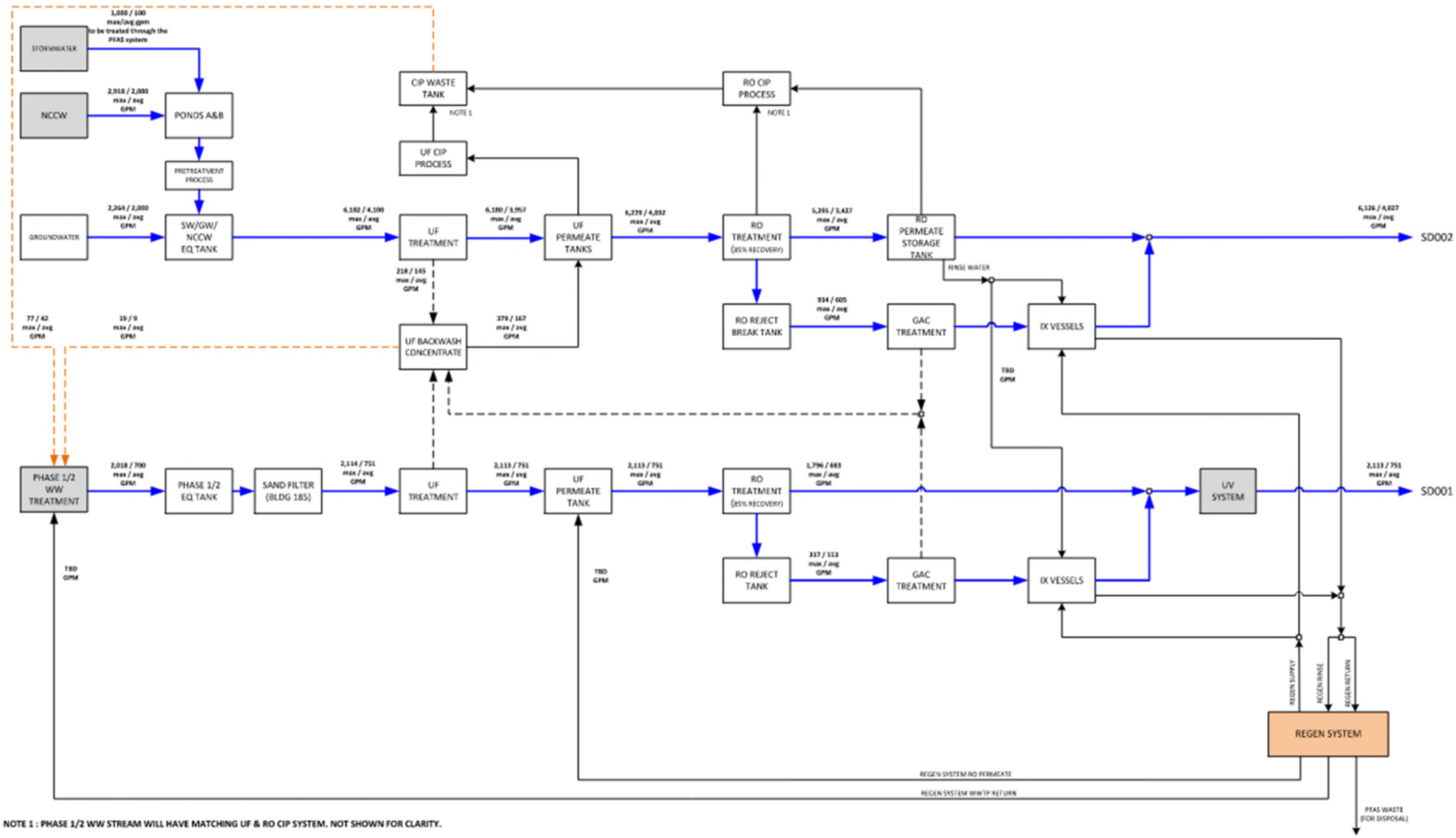
Table 3-1 provides a summary of the PFAS removal technologies included in the AWWTP (MPCA 2024):

Table 3-1 AWWTP PFAS Removal Technology Design Basis

Parameter	System A	System B
Reverse Osmosis System		
Recovery (% to permeate)	85%	85%
Active Area (ft^2)	400	400
Stages / Total Elements Per Skid (5 skids)	3 / 252	3 / 108
Total active area per skid (ft^2)	100,800	43,200
Design Flux (GFD) / Design Flow Rate (gpm)	14 / 5,750	11.6 / 2,050
GAC		
Treatment Trains/ Vessels per Train	4/2	2/2
Vessel Diameter (ft)	10	10
Mass of GAC/vessel (lbs)	20,000	20,000
Empty Bed Contact Time/vessel (mins)	30	30
Total Design Flowrate (gpm)	576	192
Surface Loading Rate (gpm/ft^2)	2.4	2.4
IX Resin		
Treatment Trains/ Vessels per Train	7/3	3/3
Vessel Diameter (ft)	6	6
Volume of IX resin/vessel (ft^3)	360	360
Empty Bed Contact Time/vessel (mins)	20	20
Total Design Flowrate (gpm)	675	270
Surface Loading Rate (gpm/ft^2)	4.8	4.8

Abbreviations and Acronyms:
ft = feet
ft^2 = square feet
ft^3= cubic feet
GFD = gallons per square foot per day
gpm = gallons per minute
mins = minutes

Source: MPCA 2024



NOTE 1 : PHASE 1/2 WW STREAM WILL HAVE MATCHING UF & RO CIP SYSTEM. NOT SHOWN FOR CLARITY.

Figure 3-2 ***Block Flow Diagram of Treatment Systems Included in Systems A and B***
Source: ECT2 and Barr 2021, Large Figure 5

3.2.2 IX Resin Regeneration, Regenerant Recovery and Concentration System

As noted above, use of GAC, IX resin, and RO is based on site-specific features and the PFAS composition in 3M's effluent. To remove PFAS from the RO concentrate, the concentrate passes through both GAC and regenerable IX resin, as indicated in Section 4.2.1. To provide consistent and reliable treatment of PFAS, while minimizing waste disposal of PFAS-laden adsorbent materials (i.e., single-use IX resin or GAC), a regenerable IX resin was selected. This process also allows for a unique operational approach, as the timing between IX regenerations can be tailored to specific PFAS compound effluent concentrations. For the AWWTS, this operational approach is centered around regenerating IX resin once short-chain PFAS compounds, such as trifluoroacetic acid (TFA) and perfluorobutyric acid (PFBA), are likely to first be detected in the IX resin effluent. Operating under this approach offers several benefits, two of which are:

1. Removing and treating the bulk of the PFAS mass, which is primarily composed of short-chain PFAS compounds; and
2. Ensuring treatment of longer-chain PFAS, such as PFHxS, PFOS, and PFOA, as these compounds are removed more efficiently than their shorter-chain counterparts.

This innovative process has been deployed to a limited extent in the United States (Wastewater Digest 2021) and Australia (Wastewater Digest 2020), typically at rates on the order of 50 to 200 gpm. The AWWTS represents a significant expansion in scale of this technology, of which there are no other known regenerable IX systems of this size in the world outside of 3M.

The regeneration process consists of removing individual treatment vessels from operation and pumping a mixture of solvent, water, and salt through the vessels to desorb and remove the PFAS compounds, thereby restoring the capacity of the resin to continue to treat PFAS. After the PFAS compounds have been removed, the IX resin is rinsed with treated water (RO permeate) and the vessels are then placed back in normal treatment service for continued PFAS removal. The spent regenerant solution is then processed through a solvent recovery system to recover the solvent for reuse in the system. The still bottoms (STB) are processed through a STB RO unit and a brine concentrating unit, which concentrates the salt and PFAS into a smaller volume that is subsequently collected and disposed of off-site.

RO permeate from the STB RO system will be routed back to the head of the WWTP for further treatment. The STB RO reject will be processed through a thin film evaporator. The evaporator boils off water and other light-end materials from the STB RO reject, producing a concentrated liquid of salt and PFAS. Evaporator overhead vapors are condensed, subcooled, and recycled back to the Phase 1 WWTP with the RO permeate from the STB RO. The concentrated brine exits the evaporator and is pumped to a storage tank for off-site disposal at a hazardous waste site. **Figure 3-2** is a block flow diagram showing how the regeneration system is incorporated into the design for Systems A and B (ECT2 and Barr 2021, Large Figure 5).

4 Data Summary

In connection with its application for a construction permit, 3M submitted the Treatability Report to MPCA. As stated in Section 1.2 of the Treatability Report, the purpose of the Treatability Study was to assess the efficacy of treating PFAS in wastewater at the Facility using commercially available technologies. The Treatability Study was not designed to discern operational limits for PFAS in the treatment system effluent. This section provides a summary of the pilot study data presented in the Report (ECT2 and Barr 2021).

Two different source waters were tested during the pilot testing phase of the Treatability Study, including NCCW/SW effluent (SD002), which was sampled before the NCCW and SW pond, and phase 1/2 WW, which was sampled between the pre-carbon filtration pressure vessels and existing carbon treatment system, as shown on **Figure 2-1**. **Table 4-1** presents a summary of the 16 PFAS compounds analyzed by Enthalpy Analytical. The dominant compounds detected, making up more than 90 percent of the PFAS mass in the NCCW/SW and Phase 1/2 WW streams, include TFA, trifluoromethanesulfonic acid (TFMS), perfluorophosphonic acid (PFPA), bis(trifluoromethane)sulfonimide (HQ-115), and PFBA.

Table 4-1 Summary of the 16 PFAS Compounds Analysed by Enthalpy Analytical

Group No.[1]	Abbreviation	Full Name
Group 1		
1	TFA	Trifluoroacetic acid
2	TFMS	Perifluoromethanesulfonate
3	2,2,3,3-TFPA	2,2,3,3-Tetrafluoropropionic acid
4	2,3,3,3-TFPA	2,3,3,3-Tetrafluoropropionic acid
5	PFPA	Perfluoropropionic acid
6	HQ-115	Methanesulfonamide, 1,1,1-trifluoro-N-[(trifluoromethyl)sulfonyl-
7	PFBA	Perfluorobutyric acid
8	PFPeA	Perfluoropentanoic Acid
Group 2		
9	PFBS	Perfluorobutanesulfonate
10	PFPeS	Perfluoropentanesulfonate
11	PFHxA	Perfluorohexanoic acid
12	PFHpA	Perfluoroheptanoic acid
13	PFHxS	Perfluorohexanesulfonate
14	PFHpS	Perfluoroheptanesulfonate
15	PFOA	Perfluorooctanoic acid
Group 3		
16	PFOS	Perfluorooctanesulfonate

Notes:

1 Groups 1, 2, and 3 were established in the Treatability Plan based on the number of carbon atoms, the number of fluorinated carbons, and the physical characteristics of the PFAS. These groups were established to estimate the treatability of specific PFAS for which publicly available treatability information is not available.

Source: ECT2 and Barr 2021, Table 2.4.

Table 4-2 summarizes the PFAS results from samples collected at multiple locations including the pilot influent UF feed, UF permeate, RO permeate, RO concentrate, lag GAC effluent, lag CalRes ion exchange resin effluent (IX2), and lag SORBIX ion exchange resin effluent (IXR2) during the NCCW/SW pilot test phase. At a high level, these results show the efficacy of PFAS removal using the different technologies. PFHxS, PFOS, and PFOA are highlighted yellow in **Table 4-2** for clarity. Note that all three compounds identified in the Draft Permit are shown as non-detect (ND) in the pilot influent UF feed, rendering the results inconclusive as far as the pilot treatment system's ability to achieve the Draft Permit compliance limits. Of the three compounds, PFOS has the lowest LOQ range of <200 – <2,000, which is two OOMs higher than the Draft Permit Compliance Limit shown in **Table 2-1**. This indicates that, even if there was PFHxS, PFOS, and/or PFOA detected in the pilot influent UF feed and the IX2 and IXR2 effluent remained ND, there is no assurance that the pilot effluent would meet the Draft Permit compliance limits for discharge.

Table 4-3 provides a summary of split samples taken during the NCCW and SW test phases and analyzed by 3M's Global EHS Laboratory (3M Lab). HQ-115 and PFBA were detected separately in the two RO permeate samples collected. For the Enthalpy Analytical samples shown in **Table 4-3**, no PFAS were detected in the corresponding RO permeate split samples. Eighteen different PFAS (FBSA, FOSA, HQ-115, PECHS, PFBA, PFBS, PFES, PFHpA, PFHpS, PFHxS, PFHxA, PFOA, PFPA, PFPeA, PFPeS, PIBA, TFA, and TFMS) were detected at concentrations above LOQs in the RO concentrate samples. For the corresponding Enthalpy Analytical split samples, only six PFAS were detected (PFPA, PFBA, PFPeA, PFBS, HQ-115, and TFMS). These observations may be attributed in part to the lower LOQs found in the 3M Lab samples.

PFHxS, PFOS, and PFOA are highlighted yellow in **Table 4-3** for clarity. In contrast to the Enthalpy results, in which all three compounds identified in the Draft Permit were reported as ND in the pilot influent UF feed sample, only one of the three compounds (PFOS) was reported as ND in the pilot influent feed, rendering the results inconclusive as far as the pilot treatment system's ability to achieve the Draft Permit PFOS compliance limit. However, PFHxS and PFOA were detected in the influent at 54.6 and 62.8 ng/L, respectively, and were ND in the RO permeate, IX2, and IXR2 samples. These results indicate that the pilot treatment system may be able to achieve the Draft Permit PFHxS and PFOA compliance limits. These results provide more assurance than the Enthalpy results, but the LOQs for all three compounds in the 3M Lab results are higher than the corresponding compliance limits. For instance, of the two compounds detected in the influent, PFOA has the lowest LOQ range of <9.6 – <19.2, which is four to nine times higher than the Draft Permit compliance limit shown in **Table 2-1**. This indicates that it is inconclusive whether the pilot effluent would meet the Draft Permit compliance limits for discharge.

Table 4-4 shows a summary of the PFAS results from samples collected at multiple locations during Phase 1/2 WW pilot test phase. PFHxS, PFOS, and PFOA are highlighted yellow in **Table 4-4** for clarity. Note that two of the three compounds identified in the Draft Permit, PFHxS and PFOA, are shown as ND in the pilot influent UF feed, rendering the results inconclusive as far as the pilot treatment system's ability to achieve the Draft Permit compliance limits for those two compounds. PFOS was detected in the pilot influent UF feed at up to 1,360 ng/L. The PFOS LOQs for the IXR2 samples ranged from <1.60 ng/L to <200 ng/L. Because 1.6 ng/L is below the Draft Permit compliance limit for PFOS, this provides some assurance that the pilot effluent would meet the Draft Permit compliance limits for discharge of PFOS as shown in **Table 2-1**.

Table 4-2 Summary of PFAS Concentrations during the NCCW/SW Pilot Test Phases

PFAS	Units	NCCW/SW Concentration Ranges (minimum and maximum)							
		LOQ Range	Pilot Influent UF feed	UF Permeate	RO Permeate[6]	RO Concentrate	Lag GAC Effluent (GAC2)	Lag CalRes Effluent (IX2)	Lag SORBIX Effluent (IXR2)
Sum of 16 Analyzed PFAS[7]	ng/L	--	ND–27,000	7,790–99,000	ND–6,200	47,400–795,000	ND–225,000	ND–21,900	ND–52,000
Group 1									
TFA	ng/L	<2.29–<69,853	ND	ND	ND	ND–**14,900**	ND–**4,750**	ND–**17,900**	ND
TFMS	ng/L	<346–<10,000	ND–**10,800**	**1,600–11,400**	ND–**1,310**	**14,900–174,000**	ND–**195,000**	ND	ND
2,2,3,3-TFPA	ng/L	<1,000–<17,897	ND	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<752–<14,840	ND	ND	ND	ND	ND	ND–**2,790**	ND–**1,890**
PFPA	ng/L	<8.42–<51,058	ND–**7,520**	**1,390–5,910**	ND	ND–**44,900**	ND–**51,700**	ND–**16,000**	ND–**21,200**
HQ-115	ng/L	<2.61–<10,000	ND–**27,000**	ND–**82,700**	ND–**6,200**	**13,500–480,000**	ND–**8**	ND	ND
PFBA	ng/L	<191–<1,910	ND–**8,060**	**398–8,450**	ND–**70**	**7,890–76,600**	ND–**76,100**	ND	ND–**38,100**
PFPeA	ng/L	<212–<2,120	ND–**561**	ND–**717**	ND	**1,240–10,100**	ND	ND	ND
Group 2									
PFBS	ng/L	<444–<4,440	ND–**12,900**	ND–**17,700**	ND	ND–**17,100**	ND	ND–**19**	ND
PFPeS	ng/L	<31.1–<2,580	ND	ND–**41**	ND	ND–**811**	ND	ND–**36**	ND
PFHxA	ng/L	<241–<2,410	ND	ND–**61**	ND	ND–**2,660**	ND	ND	ND
PFHpA	ng/L	<152–<1,520	ND	ND	ND	ND–**40**	ND	ND	ND
PFHxS	ng/L	<239–<2,390	ND	ND	ND	ND–**5,610**	ND	ND	ND
PFHpS	ng/L	<169–<1,690	ND	ND	ND	ND–**222**	ND	ND	ND
PFOA	ng/L	<221–<2,210	ND	ND	ND	ND–**11,200**	ND	ND	ND
Group 3									
PFOS	ng/L	<200–<2,000	ND	ND	ND	ND–**11,800**	ND	ND	ND

Notes:
1. Data are from Enthalpy Analytical.
2. ng/L = nanograms per liter (equivalent to parts per trillion or ppt)
3. LOQ = limit of detection
4. ND = non-detect or below LOQ
5. Bold values are concentrations detected above the LOQ.
6. During test phase NCCW_D only (95% RO recovery). TFMS, HQ-115, PFBA were detected in the RO permeate.
7. Sum of 16 Analyzed PFAS only includes the PFAS detected at concentrations above the LOQ.

Source: ECT2 and Barr, 2021, Table 3.3

Table 4-3 Summary of PFAS Concentrations in Split Samples during the NCCW/SW Pilot Test Phases

PFAS	Units	NCCW/SW Concentration Ranges (minimum and maximum)—Split Samples Only						
		LOQ Range	Pilot Influent UF Feed (n=1)	UF Permeate (n=4)	RO Permeate (n=2)	RO Concentrate (n=5)	Lag CalRes Effluent (IX2) (n=1)[5]	Lag SORBIX Effluent (IXR2) (n=1)[5]
Group 1								
TFA	ng/L	<200	**3,360**	**3,040–3,320**	ND	**17,000–21,600**	**19,800**	**19,800**
TFMS	ng/L	<25.0	**3,160**	**1,280–3,140**	ND	**8,560–14,600**	ND	ND
2,2,3,3-TFPA	ng/L	<500	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<1,000	**1,210**	ND	ND	ND	ND	ND
PFPA	ng/L	<50.0	**3,180**	**1,800–3,300**	ND	**9,840–16,200**	ND	**4,320**
PFES	ng/L	<25.0	**73.2**	ND–**71**	ND	**74.8–322**	ND	ND
HQ-115	ng/L	<10.0	**236**	**256–4,440**	ND–**111**	**1,430–74,000**	ND	ND
PFBA	ng/L	<10.0	**8,000**	**482–8,120**	ND–**25.2**	**8,700–36,800**	ND	ND
PIBA	ng/L	<100	**123**	ND–**109**	ND	**139–334**	ND	ND
PFPeA	ng/L	<10.0	**502**	ND–**526**	ND	**560–2,140**	ND	ND
Group 2								
PFBS	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSA	ng/L	<10.1	ND	ND	ND	ND–**13.4**	ND	ND
PFBS	ng/L	<10.0	**142**	ND–**147**	ND	**546–13,800**	ND	ND
PFPeS	ng/L	<9.4	**45**	ND–**44.2**	ND	**96.8–256**	ND	ND
MeFBSA	ng/L	<39.4–<44.0	ND	ND	ND	ND	ND	ND
FBSE	ng/L	<45.6–<51.0	ND	ND	ND	ND	ND	ND
MeFBSAA	ng/L	<44.8–<50.0	ND	ND	ND	ND	ND	ND
MeFBSE	ng/L	<17.9–<20.0	ND	ND	ND	ND	ND	ND
PBSA	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSEE-Diol	ng/L	<44.8–<50.0	ND	ND	ND	ND	ND	ND
FBSEE-DA	ng/L	<9.0–<10.0	ND	ND	ND	ND	ND	ND
FBSAA	ng/L	<100	ND	ND	ND	ND	ND	ND
PBSA-DC	ng/L	<10.7–<12.0	ND	ND	ND	ND	ND	ND
PFHxA	ng/L	<10.0	**173**	ND–**182**	ND	**204–740**	ND	ND
PFHpA	ng/L	<10.0	**27.2**	ND–**28**	ND	**34.4–82.2**	ND	ND

Table 4-3 Summary of PFAS Concentrations in Split Samples during the NCCW/SW Pilot Test Phases

PFAS	Units	NCCW/SW Concentration Ranges (minimum and maximum)—Split Samples Only						
		LOQ Range	Pilot Influent UF Feed (n=1)	UF Permeate (n=4)	RO Permeate (n=2)	RO Concentrate (n=5)	Lag CalRes Effluent (IX2) (n=1)[5]	Lag SORBIX Effluent (IXR2) (n=1)[5]
PFHxS/PFHS	ng/L	<10.0–<20.0	**54.6**	ND–**35.6**	ND	**94.2–300**	ND	ND
PFHpS	ng/L	<10.0	ND	ND	ND	ND–**23.6**	ND	ND
PHSA-C	ng/L	<89.5–<100	ND	ND	ND	ND	ND	ND
PFOA	ng/L	<9.6–<19.2	**62.8**	ND–**69.4**	ND	**173–324**	ND	ND
Group 3								
FOSA/PFOSA	ng/L	<10.0	ND	ND	ND	ND–**45.2**	ND	ND
PFOS	ng/L	<8.3–<9.3	ND	ND	ND	ND	ND	ND
PECHS	ng/L	<9.2	**14.5**	ND	ND	**31.2**–**76.2**	ND	ND

Notes:

1. Data from 3M Global EHS Laboratory.
2. No data available from GAC effluent.
3. n = the number of split samples collected at the specified location.
4. ND = non-detection
5. Sample collected after 212 bed volumes treated across the lag vessel.

Source: ECT2 and Barr, 2021, Table 3.14.

Table 4-4 Summary of PFAS Concentrations during the Phase 1/2 WW Pilot Test Phase

PFAS	Units	Phase 1/2 WW PFAS Concentration Ranges (minimum and maximum)							
		LOQ range	Pilot Influent UF Feed	UF Permeate	RO Permeate	RO Concentrate	Lag GAC Effluent (GAC2)	Lag CalRes Effluent (IX2)	Lag SORBIX Effluent (IXR2)
Sum of 16 Analyzed PFAS[5]	ng/L	--	97,800–202,000	74,800–181,000	1,420–3,180	1,064,000–2,31,000	6,500–1,780,000	ND–11,000	ND–12,400
Group 1									
TFA	ng/L	<700–<23,461	ND	ND	ND	ND	ND	ND	ND
TFMS	ng/L	<18.4–<1000	**65,900–166,000**	**46,900–145,000**	**1,050–3,090**	**827,000–1,850,000**	ND–**1,770,000**	ND	ND–**290**
2,2,3,3-TFPA	ng/L	<373–<19,129	ND	ND	ND	ND	ND	ND	ND
2,3,3,3-TFPA	ng/L	<122–<31,656	ND	ND–**1,610**	ND	ND–**7,300**	ND–**7,920**	ND	ND
PFPA	ng/L	<20.8–<63,771	ND–**2,420**	ND–**10,100**	ND–**34**	ND–**44,000**	ND–**105,000**	ND–**11,000**	ND–**12,400**
HQ-115	ng/L	<0.734–<102	**17,000–24,100**	**13,400–20,800**	**92–157**	**128,000–259,000**	ND–**8**	ND–**20**	ND–**21**
PFBA	ng/L	<8.17–<1,053	**1,500–3,160**	**1,740–2,960**	ND–**10**	**12,400–26,500**	ND	ND	ND
PFPeA	ng/L	<12.5–<1,062	ND	ND–**111**	ND–**5**	ND–**680**	ND	ND	ND
Group 2									
PFBS	ng/L	<4.43–<2,219	**2,870–16,200**	**3,570–15,200**	ND–**84**	**34,800–143,000**	ND	ND	ND
PFPeS	ng/L	<1.75–<1,288	ND	ND	ND–**80**	ND–**848**	ND	ND–**37**	ND
PFHxA	ng/L	<0.718–<2,087	ND	ND	ND	ND–**127**	ND	ND	ND
PFHpA	ng/L	<0.612–<1,056	ND	ND	ND	ND	ND	ND	ND
PFHxS	ng/L	<1.93–<1,194	ND	ND–**33**	ND	ND–**5,540**	ND	ND	ND
PFHpS	ng/L	<2.17–<3,375	ND	ND	ND	ND–**102**	ND	ND	ND
PFOA	ng/L	<0.122–<221	ND	ND–**34**	ND	ND–**5,080**	ND	ND	ND
Group 3									
PFOS	ng/L	<1.41–<7,311	ND–**1,360**	ND	ND	ND–**8,940**	ND	ND	ND

Notes:

1. ng/L = nanograms per liter (equivalent to parts per trillion or ppt)
2. LOQ = limit of detection
3. ND = non-detect or below LOQ
4. Bold values are concentrations detected above the LOQ.
5. The Sum of 16 Analyzed PFAS only includes the PFAS detected at concentrations above the LOQ.

Source: ECT2 and Barr 2021, Table 3.9. Data are from Enthalpy Analytical.

Table 4-5 summarizes the PFAS rejection efficiencies of the RO membrane for the eight PFAS compounds found at concentrations above the LOQ in the UF permeate during the three NCWW test phases (ECT2 and Barr 2021). PFAS reject efficiencies refer to the mass of PFAS eliminated from the RO permeate by the RO membrane as defined in Section 1.4 of the Treatability Report (see Equation 1). Where the RO permeate PFAS concentration was below the LOQ, the reject efficiency was calculated using the nominal LOQ value. In these cases, the reject efficiency is shown as greater than (>) the calculated rejection efficiency, meaning that the actual reject efficiency is likely greater than the value calculated using the LOQ.

$$(1)\quad Reject\ Efficiency\ \% = \frac{RO\ Influent\ PFAS\ Conc. - RO\ Permeate\ PFAS\ Conc.}{RO\ Influent\ PFAS\ Conc.} \times 100\%$$

Table 4-5 NCCW/SW RO PFAS Reject Efficiencies by Test Phase

PFAS Rejection Efficiencies[3]	Test Phase		
	NCCW_A (n=7)[4]	NCCW_B (n=5)[4]	NCCW_D (n=1)[4]
PFPA	>49.6%–>75.5%	>50.7%–>74.0%	--[7]
PFBA	>94.4%–>97.7%	>52.0%–>86.9%	99.7%
PFPeA	>24.6% –>70.4%	--[5]	>0%[6]
PFHxA	--[5]	--[5]	--[7]
PFBS	--[6]	>97.5%[6]	--[7]
PFPeS	--[5]	--[5]	--[7]
HQ-115	>64.9%–>98.8%[6]	>35.9%–>91.5%	97.0%
TFMS	>66.6%–>91.2%	>37.5%–86.0%	95.5%

Notes:

1. The "-- " symbol indicates not applicable; the reject efficiency could not be calculated because the RO influent (UF permeate) PFAS concentration was below the LOQ.
2. The ">" symbol indicates that the concentration in the RO permeate was below the LOQ.
3. This table summarizes only data reported by Enthalpy Analytical.
4. The number of samples shown (n) indicates the number of paired samples collected within 4 hours of each other from the RO influent (UF permeate) and the RO permeate.
5. The reject efficiency could not be calculated in at least one sample because the RO influent (UF permeate) PFAS concentration was below the LOQ.
6. >0% indicates that the reported concentration in the RO permeate was below the LOQ, and the concentration in the RO influent was equivalent to the nominal LOQ value.
7. The PFAS were detected in the RO influent, and concentrations were below the LOQ in the RO permeate, but the PFAS reject efficiency is not reported because the nominal LOQ value in the RO permeate was greater than the detected concentration in the RO influent.

Source: ECT2 and Barr 2021, Table 3.4

Table 4-6 summarizes the PFAS reject efficiencies of the RO membrane during the 1/2 WW testing phase. However, only PFAS compounds that were observed at concentrations above LOQs in the UF permeate are summarized. Where the RO permeate PFAS concentration was below the LOQ, the reject efficiency was calculated using the nominal LOQ value. In these cases, the rejection efficiency is shown as greater than (>) the calculated rejection efficiency, meaning that the actual rejection efficiency is likely greater than the value calculated using the LOQ.

Table 4-6 Phase 1/2 WW RO PFAS Reject Efficiencies

PFAS Rejection Efficiencies	Phase 1/2 WW Test Phase (n=3)[2]
2,3,3,3-TFPA	--[3,4]
PFPA	>51.0%–98.2%[3]
PFBA	>84.4%–99.7%[3]
PFPeA	95.5%[3,4]
PFOA	>55.6%[3]
PFBS	>85.4%–99.1%
PFPeS	--[3]
PFHxS	--[3,4]
HQ-115	98.8%–99.4%
TFMS	96.9%–98.1%

Notes:

1. The “>” symbol indicates that the concentration in the RO permeate was below the LOQ.
2. The number of samples shown (n) indicates the number of paired samples collected simultaneously from the RO influent (UF permeate) and the RO permeate.
3. In at least one sample, the reject efficiency could not be calculated because the RO influent (UF permeate) PFAS concentration was below the LOQ.
4. In at least one sample, PFAS was detected in the RO influent, and concentrations were below the LOQ in the corresponding RO permeate. The PFAS reject efficiency is not reported because the nominal LOQ value in the RO permeate was greater than the detected concentration in the RO influent.

Source: ECT2 and Barr 2021, Table 3.10

Table 4-7 summarizes the number of bed volumes to the first detection of breakthrough for each of the NCCW/SW test phases. **Table 4-5** and **Table 4-7** do not include PFOS, PFOA, or PFHxS because the analytical results for these compounds were ND throughout the NCCW/SW phases of testing. This indicates that the resin and GAC changeout schedule should be driven by the breakthrough of compounds shown in Groups 1 and 2, which are anticipated to break through before the compounds specified in the Draft Permit. As such, it is not recommended to monitor PFOA, PFOS, and PFHxS to determine the performance of the GAC and/or IX systems. Arcadis recommends considering compounds that were shown to have low bed volumes (BVs) before breakthrough and also detected at high concentrations in the influent stream; TFMS, PFPA, and PFBA make up about 70 percent of the total detections in the influent stream as analyzed by 3M Global EHS Laboratory in **Table 4-3**. Additionally, breakthrough of TFMS was observed for GAC1 and GAC2, breakthrough of PFBA was observed at all sample locations aside from IX2, and breakthrough of PFPA was observed at all sample locations. Thus, TFMS, PFPA, and PFBA would be appropriate surrogate compounds to drive the media changeout schedule; however, operational experience and/or additional data may suggest monitoring of additional compounds.

Table 4-7 Bed Volumes to First Detection of Breakthrough for NCCW/SW Test Phases

PFAS[5]	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX (IXR1)	Lag SORBIX (IXR2)
NCCW_A – BVs to Media Column Breakthrough, up to 1,639 BVs across the Lead Vessel						
Group 1						
TFMS	295	148	not observed	not observed	not observed	not observed
2,3,3,3-TFPA	not observed	not observed	487	244	487	244
PFPA	295	148	679	580	487	340
HQ-115	1,838	not observed	not observed	not observed	not observed	not observed
PFBA	295	148	1,159	not observed	679	484
PFPeA	1,159	not observed	not observed	not observed	not observed	not observed
NCCW_B – BVs to Media Column Breakthrough, up to 471 BVs across the Lead Vessel						
Group 1						
TFA	--[6]	--[6]	not observed	not observed	INT	not observed
2,3,3,3-TFPA	--[6]	--[6]	135	116	135	164
PFPA	--[6]	--[6]	471	not observed	183	212
PFBA	--[6]	--[6]	not observed	not observed	231	not observed
NCCW_D – BVs to Media Column Breakthrough, up to 238 BVs across the Lead Vessel						
Group 1						
TFA	INT	INT	293	INT	not observed	not observed
TFMS	46	23	not observed	not observed	not observed	not observed
HQ-115	94	147	not observed	not observed	not observed	not observed
PFPA	46	23	293	INT	not observed	not observed
PFBA	94	119	not observed	not observed	not observed	not observed
Group 2						
PFBS	not observed	not observed	not observed	INT	not observed	not observed
PFPeS	not observed	not observed	not observed	INT	not observed	not observed

Notes:

1. Not observed = breakthrough was not observed up to the BVs tested.
2. INT = intermittent detections, but a consistent breakthrough curve was not apparent.
3. BV is a unitless measure of the volume of water treated through a media filter; it is equal to the volume of water treated divided by the volume of the media bed. As a result, BVs shown for lag columns are half those shown for lead columns on a given date because the same flow has gone through twice as much media by the time it reaches the lag column effluent compared to lead column effluent. However, BVs shown for IX do not consider upstream GAC volume.
4. The first breakthrough is defined as the first detection above LOQ, with subsequent measurements consistently as high or higher.
5. For PFAS not listed in this table, breakthrough was not observed during the test phases.
6. BVs to breakthrough of the GAC columns are not shown for NCCW_B because the media beds were not changed out between test phases NCCW_A and NCCW_B. If breakthrough was observed during NCCW_B, the BV to breakthrough is shown under NCCW_A to reflect continuous GAC operation through the two phases.

Source: ECT2 and Barr 2021, Table 3.6

Table 4-8 summarizes the number of bed volumes to the first detection of breakthrough for the Phase 1/2 WW test phase. **Table 4-8** shows that no breakthrough of PFOS, PFOA, or PFHxS was observed at any of the sample points throughout testing. This indicates that the resin and GAC changeout schedule should be driven by the breakthrough of compounds shown in Group 1, which are anticipated to break through before the compounds specified in the Draft Permit. As such, PFOA, PFOS, and PFHxS are not appropriate compounds to use for determining the performance of the GAC and/or IX systems. Arcadis recommends considering compounds that were shown to have low BVs before breakthrough and also detected at high concentrations in the influent stream; TFMS and PFPA were detected in the influent stream at 3,160 ng/L and 3,180 ng/L, respectively, as analyzed by 3M Global EHS Laboratory in **Table 4-3**. Additionally, breakthrough of TFMS was observed for GAC1, GAC2, IXR1, and IXR2, while breakthrough of PFPA was observed at all sample locations. Thus, TFMS and PFPA would be appropriate surrogate compounds to drive the media changeout schedule.

Table 4-8 BVs to First Detection of Breakthrough for the Phase 1/2 WW Test Phase

PFAS[5]	Lead GAC (GAC1)	Lag GAC (GAC2)	Lead CalRes (IX1)	Lag CalRes (IX2)	Lead SORBIX (IXR1)	Lag SORBIX (IXR2)
BVs to Media Column Breakthrough, up to 496 BVs across the Lead Vessel						
Group 1						
TFMS	8	28	not observed	not observed	434	INT
2,3,3,3-TFPA	INT	INT	not observed	not observed	not observed	not observed
PFPA	112	49	INT	INT	242	200
HQ-115	INT	INT	INT	INT	INT	INT
PFBA	194	not observed	not observed[6]	not observed	not observed	not observed
PFPeA	not observed[6]	not observed	not observed[6]	not observed	not observed	not observed
Group 2						
PFBS	not observed	not observed	not observed[6]	not observed	not observed	not observed
PFPeS	not observed	not observed	not observed[6]	INT	INT	not observed
PFHpA	not observed[6]	not observed	not observed[6]	not observed	not observed	not observed
PFHxS	not observed[6]	not observed	not observed[6]	not observed	not observed	not observed
PFHpS	not observed	not observed	not observed[6]	not observed	not observed	not observed
PFOA	not observed[6]	not observed	not observed[6]	not observed	not observed	not observed
Group 3						
PFOS	not observed	not observed	not observed[6]	not observed	not observed	not observed

Notes:

1. Not observed = breakthrough was not observed up to the BVs tested.
2. INT = intermittent detections, but a consistent breakthrough curve was not apparent.
3. BV is a unitless measure of the volume of water treated through a media filter. It is equal to the volume of water treated divided by the volume of the media bed. As a result, BVs shown for lag columns are half those shown for lead columns on a given date because the same flow has gone through twice as much media by the time it reaches the lag column effluent compared to lead column effluent. However, BVs shown for IX do not consider upstream GAC volume.
4. The first breakthrough is defined as the first detection above LOQ, with subsequent measurements consistently as high or higher.
5. For PFAS not listed in this table, breakthrough was not observed during the test phase.
6. One sample had low detections of multiple PFAS, but seven of eight did not have later detections or breakthroughs, suggesting possible sample contamination. As a result, any PFAS only detected in this sample were judged not to have broken through. These samples were from lead GAC column at 56 BVs and lead CalRes column at 386 BVs.

Source: ECT2 and Barr 2021, Table 3.12

Table 4-9 presents an initial estimate of the full-scale system's treatment capacity in terms of effluent water quality. To generate this estimate, it was assumed that the full-scale system effluent would consist of 85 percent RO permeate water and 15 percent IX lag vessel effluent. As shown in the highlighted rows of the table, the lowest LOQs for PFHxS, PFOS, and PFOA are 5 ng/L, 15 ng/L, and 4 ng/L, respectively – all of which are higher than the Draft Permit compliance limits shown in **Table 2-1**. This indicates that, based on the Treatability Study, we do not have assurance that the proposed full-scale treatment system will meet the Draft Permit compliance limits.

Table 4-9 Estimated Treated Effluent Water Quality Based on Treatability Study

Source Water (Test Phase)	NCCW/SW (NCCW_B)			Phase 1/2 WW (WW)		
# of BVs	98	212	212	97	241	241
IX Resin	SORBIX/CalRes	SORBIX	CalRes	SORBIX/CalRes	SORBIX	CalRes
General Chemistry[1]						
Calcium	62			54		
Iron+ Manganese	<0.055			<0.055		
TOC	3.6			3.5		
TDS	367			1,150[7]		
TSS	<10			14[3]		
pH	5.9–8.6			6.3–8.6		
PFAS[4]						
Sum of 16 Detected PFAS[5]	--	4,218	3,570	1,807	3,385	2,069
Group 1[6]						
TFA	< 700	**< 3,140**[6]	**< 3,140**[6]	< 700	**< 2,150**[6]	**< 1,775**[6]
TFMS	< 1,000	< 498	< 498	**< 1,811**[6]	< 276	< 276
2,2,3,3-TFPA	< 1,000	< 500	< 500	< 2,406	< 500	< 500
2,3,3,3-TFPA	< 752	< 1,000	< 1,000	< 740	< 1,000	< 1,000
PFPA	< 700	**< 691**[6]	< 50	< 700	**< 1,039**[6]	<98[6]
HQ-115	< 1,000	< 83	< 83	133[6]	< 104	< 104
PFBA	< 191	<11[6]	<11[6]	< 260	< 10	< 10
PFPeA	< 212	< 10	< 10	< 17	< 10	< 10
Group 2[6]						
PFBS	< 444	<16[6]	<16[6]	< 9	< 36	< 36
PFPeS	< 258	< 9	< 9	< 2	< 9	< 9
PFHxA	< 241	< 10	< 10	< 2	< 10	< 10
PFHpA	< 152	< 10	< 10	< 24	< 10	< 10
PFHxS	< 239	< 10	< 10	< 5	< 10	< 10
PFHpS	< 169	< 10	< 10	< 6	< 10	< 10
PFOA	< 221	< 18	< 18	< 15	< 18	< 18

Table 4-9 Estimated Treated Effluent Water Quality Based on Treatability Study

Source Water (Test Phase)	NCCW/SW (NCCW_B)			Phase 1/2 WW (WW)		
Group 3[6]						
PFOS	< 200	< 9	< 9	< 4	< 9	< 9

Notes:

1. Effluent concentrations are estimated as a weighted average of RO permeate concentrations and IX lag column effluents and not intended to include regeneration waste. BVs indicated are for lag vessels. The early BV is generally before breakthrough and thus similar for both resins, while IX effluent concentrations varied among resins at higher BVs.
2. General chemistry is based on water quality sampling events for NCCW_B and WW test phases and is not expected to vary significantly by IX BV.
3. Effluent total suspended solids (TSS) concentration is biased by IX effluent TSS concentration measured at 59 to 71 milligrams per liter (mg/L). That concentration is unlikely to have passed through all four media vessels and may reflect precipitation of minerals between sampling and analysis.
4. PFAS data for end-of-pilot samples (236 BVs for NCCW phase and 241 BVs for WW phase) reflect 3M data, which typically had lower detection limits than Enthalpy data. The initial sample for each water source is Enthalpy data because 3M did not collect data for these events.
5. Sum of 16 PFAS detected only includes parameters detected above Enthalpy LOD for that sample.
6. Values for which one of the source readings was above LOD are bolded. For weighted averages with a different LOD, the LOD indicated here is the weighted average of LODs. For weighted averages with one sample above LOD, the LOD indicated here is the weighted average of the LOD and the detection.
7. Estimated total dissolved solids (TDS) for treated Phase 1/2 WW includes 60 mg/L of NaCl added with regeneration waste brine recycled back to Phase 1/2 WW influent.

Source: ECT2 and Barr 2021, Table 3.16

In summary, the analytical results provided in the Treatability Report indicate that these combined treatment technologies are effective at removing a variety of PFAS, including short-chain compounds; however, these data do not provide sufficient evidence to support a conclusion that the proposed treatment system will meet the Draft Permit WQBELs or Intervention Limits for PFHxS, PFOS, and PFOA due to limitations in analytical capabilities (i.e., the LOQs in almost all of the laboratory results reviewed in the Treatability Study were higher than the limits specified in the Draft Permit). Furthermore, the Treatability Report results suggest that PFHxS, PFOS, and PFOA are not appropriate compounds to monitor for purposes of ensuring compliance with the ultimate discharge limits. Instead, Arcadis recommends monitoring compounds that were shown to have low BVs before breakthrough and detected at high concentrations in the influent stream (i.e., TFMS, PFPA, and PFBA) to drive the media changeout schedule.

5 PFAS Removal Technology Review

This section provides a comparison of the proposed treatment system to accepted industry standards, documented industry performance of the proposed technologies, and an assessment of whether the proposed treatment system can meet the ultra-low PFAS limits specified in the Draft Permit.

5.1 Technology Selection and Industry Acceptance

Arcadis reviewed the design and capability of 3M's proposed AWWTS and compared it against other available technologies for treating PFAS in water. In many PFAS treatment applications the industry standard is to use a single technology such as GAC, IX resin, or RO (among others) to remove PFAS. In drinking water, the industry standard has been to use GAC or IX resin. EPA has also noted that while RO also meets the definition of Best Available Technology under the Safe Drinking Water Act, EPA "does not anticipate water systems will select this technology to comply with the rule, largely due to the challenges presented by managing the treatment residuals from this process." 89 Fed. Reg. 32532, 32654 (Apr. 26, 2024). As the water chemistry becomes more complicated due to site-specific issues such as (i) effluent with a much more complex PFAS composition (including type and concentration), (ii) the presence of co-contaminants (e.g., metals, volatile organic compounds, 1,4-dioxane) and/or (iii) background chemistry (e.g., elevated concentrations of salts, organic matter, solids), a treatment train approach involving multiple technologies has also been deployed in limited situations. In addition, because of the inherent challenges involved in treating PFAS, including treating PFAS to parts per trillion levels and minimizing the handling of concentrated PFAS waste (e.g., spent GAC, IX resin, concentrated brine), the use of multiple technologies can provide a more reliable and sustainable treatment process.

In the case of the AWWTS, 3M selected RO as the primary PFAS treatment technology. RO was selected in large part due to its ability to remove a broad spectrum of PFAS (i.e., both short- and long-chain) compounds present in 3M wastewater effluent that are atypical compared to most water treatment scenarios, including drinking water. A challenge with RO resides in the PFAS removal mechanism relying on size exclusion which rejects PFAS, ions, and some water and results in a low-volume (when compared to the RO permeate) stream of concentrated PFAS brine (salt) liquid waste. To remove PFAS from this low-volume concentrated PFAS stream, 3M has proposed to install GAC treatment followed by regenerable IX resin. The GAC treatment train is optimized and operated to remove long-chain PFAS compounds, such as PFOS and PFOA, while the regenerable IX resin is optimized and operated to remove short-chain PFAS compounds such as TFA and PFBA. In conventional IX resin systems, once the IX resin is no longer capable of providing PFAS treatment, the IX resin is removed, sent off site for disposal, and new IX resin is placed within the treatment vessel. In the case of the AWWTS, a regenerable IX resin system is proposed to be installed, which offers three significant benefits:

- The IX resin's ability to treat PFAS can be restored in place, ensuring continuous treatment.
- Spent regenerant solution (see Section 4.2.2) is distilled and re-used.
- PFAS-containing waste is further concentrated, and its volume is reduced.

The Interstate Technology and Regulatory Council (ITRC), in their 2023 PFAS Technical/Regulatory Guidance Document (ITRC 2023), has identified RO, GAC, and IX resin as field-implemented liquids treatment technologies. The ITRC goes on further to explain field-implemented technologies as being:

- Implemented in the field by multiple parties at multiple sites, and the results have been well-documented in practice or peer reviewed literature; and

- Applied to a variety of PFAS-impacted media including drinking water (regardless of source), surface water, groundwater, wastewater, stormwater, or landfill leachate.

An evaluation prepared for the MPCA by Barr Engineering Co. and Hazen and Sawyer entitled Evaluation of Current Alternatives and Estimated Cost Curves for PFAS Removal and Destruction from Municipal Wastewater, Biosolids, Landfill Leachate, and Compost Contact Water (Barr and Hazen & Sawyer 2023) evaluated multiple PFAS separation and destruction technologies. In this evaluation, RO, GAC, and regenerable IX resin were retained as technologies to evaluate for PFAS-impacted liquids treatment due to their deployment at field scale, commercial availability, and demonstrated performance of removing at least 90 percent of at least one selected PFAS compound. The study set treatment targets at 5 ng/L, which is 127 to 138 percent higher than the proposed compliance limits and 3,126 to 29,140 percent higher than the proposed intervention limits. The study recognized that “targeting analytical reporting limits for removal in this Report is aggressive” and that “many beneficial projects may target mass removal of total PFAS or long-chain PFAS” (Barr and Hazen & Sawyer 2023).

Thus, given the summary of the pilot test data described in Section 3 herein, and the acknowledgement by the technical community (e.g., ITRC and MPCA) of these technologies’ real-world use in treating PFAS, 3M’s decision to use all three of these technologies for the AWWTP offers a robust and industry-exceeding solution to meet the particulars of 3M’s effluent composition. Furthermore, based on our expertise in designing, constructing, operating, and evaluating PFAS treatment systems, we are not aware of another equivalent-sized (i.e., 11 MGD) system that encompasses three discrete PFAS removal technologies and combines them in as innovative and sustainable a manner as the Cottage Grove AWWTS. That is, most PFAS systems simply focus on the removal of PFAS from water but do not contemplate waste treatment, management, and minimization to the scale done so by the AWWTS.

5.2 Documented Industry Performance

The focus of the review in this section is in relation to PFOA, PFOS, and PFHxS; the three PFAS compounds having proposed compliance and/or intervention limits that are at concentrations below their respective AWWTS influent concentrations (see Section 3). Other PFAS compounds will also be treated by the AWWTS; however, the analysis herein of documented industry performance for RO, GAC, and regenerable IX resin has been limited to PFOA, PFOS, and PFHxS.

The way by which technologies remove PFAS governs how they are evaluated in their treatment efficacy. RO, which treats PFAS via size exclusion, is typically evaluated by “percent rejection” or “rejection efficiency” as shown in Equation 1 in Section 4 – Data Summary.

It is generally accepted that this percent rejection efficiency will continue until the RO membranes require replacement at the end of their useful service lives, which is typically on the order of 2 to 5 years. GAC and regenerable IX resins, which remove PFAS by adsorptive processes, are typically evaluated on the duration of time during which the adsorbents remove PFAS to a level below a specified limit, such as a laboratory reporting or permit limit. This is commonly referred to as “bed volumes to breakthrough.” A BV is a measurement of volume of influent water equal to the volume of adsorbent media within an adsorbent reactor vessel. BVs to breakthrough for GAC and regenerable IX resins depend on the nature (chain length and functional group) and concentrations of the PFAS compounds, but typically are on the order of thousands to hundreds of thousands of BVs for PFOA, PFOS, and PFHxS. Typically, these sorts of BV capacities represent an operational timeline of months to a few years.

Table 5-1 was developed from information provided in the Barr and Hazen & Sawyer 2023 evaluation and summarizes the PFAS removal by technology.

Table 5-1 PFAS Removal Performance by Technology

PFAS Compound	RO (% Rejection)	GAC (BVs)	Regenerable IX (BVs)
PFHxS	>80 – 99	3,000 – 100,000	21,000
PFOS	>71 – 99	3,000 – 100,000	21,000
PFOA	>77 – 98	3,000 – 100,000	13,000

Source: Barr and Hazen & Sawyer 2023

5.3 Expected Technology Performance vs Draft Permit Conditions

As discussed in Section 4, 3M undertook a pilot study that evaluated treating PFAS-impacted water with RO, GAC, and regenerable IX resins. Samples were taken from the influent and effluent of each technology, which provides perspective on how the AWWTS is reasonably expected to perform at scale barring no significant differences, none of which are expected, of the treatment conditions (water chemistry and hydraulics) between the pilot study and full-scale systems. The differences between the pilot test conditions and the design basis are summarized in **Table 5-2** (ECT2 & Barr 2021 and MPCA 2024).

Table 5-2 Pilot Test and Full-Scale Design Basis Parameters

Unit Process	Design Parameter	Pilot Test System A	Design Basis System A	Pilot Test System B	Design Basis System B
RO	Flux	14 GFD	14 GFD	12 GFD	11.6 GFD
	RO Recovery	85%	85%	85%	85%
GAC	EBCT	60 minutes across two vessels	60 minutes across two vessels	60 minutes across two vessels	60 minutes across two vessels
	Surface Loading Rate	0.9 gpm/ft^2	2.4 gpm/ft^2	0.9 gpm/ft^2	2.4 gpm/ft^2
IX Resin	EBCT	60 minutes across two vessels	60 minutes across two vessels	60 minutes across two vessels	60 minutes across two vessels
	Surface Loading Rate	0.9 gpm/ft^2	4.8 gpm/ft^2	0.9 gpm/ft^2	4.8 gpm/ft^2

Note:
EBCT = empty bed contact time

Source: ECT2 & Barr 2021, MPCA 2024

Based on **Table 5-2**, there does not appear to be significant differences between the hydraulic conditions of the pilot tests and the full-scale design. The 1.5 gallons per minute per square foot (gpm/ft^2) and 3.9 gpm/ft^2 differences in surface loading rates for GAC and IX resin, respectively, between the pilot tests and full-scale design basis are not expected to impact PFAS removal performance.

As the pilot test and full-scale design conditions are relatively similar, it is thus expected that the treatment performance of the unit processes will be similar. **Table 4-2** and **Table 4-4** provide a summary of the pertinent analytical data, as analyzed by Enthalpy Analytical, collected during the pilot tests. **Table 4-3** summarizes the results of split samples analyzed by 3Ms Global EHS Laboratory. As shown in the data, effluent concentrations of PFOA, PFHxS, and PFOS in the RO permeate (future discharge locations SD 001 and SD 002), lag GAC (future discharge locations WS 003 and WS 004), and lag IX resin (future discharge locations WS 001 and WS 002) were routinely below their LOQs. It should be noted that, in many instances, the LOQs were elevated. A variety of factors can cause PFAS LOQs to be elevated and may include general water quality characteristics that interfere with the instrumentation's ability to measure PFAS in the single-digit parts per trillion concentration range.

As discussed in Section 3.1, the WQBELs for PFOA, PFHxS, and PFOS are below the LOQs of current commercially available PFAS analytical techniques, rendering their implementation impractical. In fact, in establishing the compliance limits for SD 001 and SD 002, the MPCA acknowledged this challenge and revised the compliance limits to be based on the achievable LOQs rather than WQBELs (MPCA 2024). However, this does not alleviate the fact that the WQBELs are below what has been demonstrated to be achievable by this or any other available technology. The same challenge applies to the intervention limits at WS 001 through WS 004, which are also lower than the LOQs for PFOA, PFHxS, and PFOS and therefore unmeasurable. Further, the Treatability Report does not support that the AWWTS can meet the compliance or intervention limits. The results in the Treatability Report do, however, indicate that these combined treatment technologies are effective at removing a variety of PFAS including short-chain compounds. It is inconclusive whether the proposed AWWTS will meet the Draft Permit WQBELs or intervention limits for PFHxS, PFOS, and PFOA due to limitations in analytical capabilities (i.e., the LOQs in almost all of the laboratory results were higher than the compliance and intervention limits specified in the Draft Permit).

The intervention limits, particularly with respect to WS 001 and WS 002 (IX resin effluent), present additional significant operational challenges due to the proposed regeneration schedule of the IX resin. Per the Design Basis Report (ECT2 and TKDA 2023), an estimated 18.2 discrete vessel regenerations will occur, on average, each week (12.6 for System A and 5.6 for System B). Once a vessel has been regenerated, it is placed back into service for normal water treatment operations. Because of this non-static operational philosophy, responding to intervention limit exceedances, even if the analytical methodologies were capable of reporting to these concentrations, would likely be infeasible due to the 3- to 4-week laboratory processing and reporting time required for PFAS samples. For instance, roughly 37.8 to 50.4 discrete vessel regenerations would occur on System A over a 3- to 4-week period. If there were to be an exceedance of the intervention limit, evaluating the root causes of the exceedance would be nearly impossible due to the turn-over in vessel orientation and duty. This regeneration schedule has been deliberately constructed to regenerate the IX resin once concentrations of short-chain PFAS are likely to be detected in the IX resin effluent. This has significant consequences for the treatment of PFOA, PFOS, and PFHxS, as these compounds did not break through the IX resin, except for one sample, during the treatability study. Thus, if the IX resin is regenerated at the onset of breakthrough of short-chain PFAS compounds, their longer-chain counterparts (i.e., PFOA, PFOS, and PFHxS) can be expected to be treated to levels below the LOQ.

6 Summary

The AWWTS represents approximately four years of testing, engineering, and construction at an approximate cost of $275,000,000, and was designed to provide reliable, sustainable, and maximum extent practicable levels of treatment of the Cottage Grove Facility water. The AWWTS, a state-of-the-art and industry-exceeding PFAS treatment system, incorporates three field-implemented PFAS removal technologies that will treat, on average, approximately 11 MGD. At the time of this evaluation, there are no other known water treatment systems of this complexity operating at this scale outside of 3M. While the AWWTS exceeds the industry standard for PFAS treatment, the proposed WQBELs and intervention limits in the Draft Permit have not been demonstrated to be achievable for the Cottage Grove Facility water with the technologies included. The proposed WQBELs and intervention limits are lower than the LOQs for commercially available analytical techniques and thus are not measurable. The results in the Treatability Report do, however, indicate that these combined treatment technologies are effective at removing a variety of PFAS including short-chain compounds. Further, the innovative design incorporates IX resin and allows for on-site regeneration of the IX resin, which has been designed to be performed at the onset of short-chain PFAS breakthrough, thus ensuring the sustained treatment of PFOA, PFOS, and PFHxS to below current LOQs.

7 References

Barr and Hazen & Sawyer. 2023. Evaluation of Current Alternatives and Estimated Cost Curves for PFAS Removal and Destruction from Municipal Wastewater, Biosolids, Landfill Leachate, and Compost Contact Water. Available at https://www.pca.state.mn.us/sites/default/files/c-pfc1-26.pdf.

ECT2 and Barr. 2021. PFAS Treatability Study, 3M Cottage Grove, MN Facility.

ECT2 and TKDA. 2023. Design Basis Report for Cottage Grove Water Stewardship Water Quality Project-Regeneration System.

ITRC. 2023. Per- and Polyfluoroalkyl Substances (PFAS) Technical/Regulatory Guidance. September. Available at https://pfas-1.itrcweb.org/wp-content/uploads/2023/12/Full-PFAS-Guidance-12.11.2023.pdf.

MPCA. 2024. Draft National Pollutant Discharge Elimination System and State Disposal System Permit MN0001449. State of Minnesota. Available at https://scs-public.s3-us-gov-west-1.amazonaws.com/env_production/oid333/did200071/pid_209149/project-documents/Draft%20Permit%20-%20Public%20Notice%20-%20MN0001449%20-%20202.pdf.

Wastewater Digest. 2020. RAAF Base Tindal, NT Australia. December 1. Available at https://www.wwdmag.com/water/article/10939321/ect2-raaf-base-tindal-nt-australia.

Wastewater Digest. 2021. Pease Site 8: Regenerable Resin System for Groundwater Remediation. May 6, 2021. Wastewater Digest. Available at https://www.wwdmag.com/wastewater-treatment/article/10939725/ect2-pease-site-8-regenerable-resin-system-for-groundwater-remediation.

Appendix A

Arcadis Resumes

COREY THERIAULT, P.E.

PRINCIPAL ENGINEER, TECHNICAL MANAGER, VP

EDUCATION
BS Chemical Engineering University of Maine, Orono 2000

YEARS OF EXPERIENCE
Total – 20+ years
With Arcadis – 6 years

PROFESSIONAL REGISTRATIONS
Professional Engineer
– ME, NH, OH, SC, WV

PROFESSIONAL ASSOCIATIONS
NEWEA / WEF
NSPE

Mr. Theriault is a design team manager and professional engineer with more than 20 years of professional experience in the areas of liquid processing, water and wastewater design, environmental management, and facilities and maintenance management. He has led and supported engineering design teams on many water and wastewater projects throughout the U.S and globally. He has managed an operations staff consisting of a facilities, maintenance and utilities department in an industrial manufacturing facility. Mr. Theriault has led the design engineering, construction and operation of polyfluoroalkyl substances (PFAS) systems at several current and former Department of Defence (DoD) installations as well as various commercial and industrial installations across the U.S.. He has led large-scale treatment installation and commissioning efforts at multiple facilities, and serves as the Arcadis Global Community of Practice Leader for PFAS Treatment Technology.

Project Experience

Foam Transition Support Services

Confidential Oil and Gas Client, Alaska

Arcadis performed PFAS cleaning activities on five emergency response vehicles for a confidential client. Vehicles included aircraft rescue and firefighting vehicles, ladder trucks and traditional fire engines. Managed the development team to develop and execute site- and vehicle-specific cleaning procedures. This project employed the Arcadis V171 cleaning agent for use during cleaning. Cleaning was performed across two mobilizations using water and Arcadis' proprietary biodegradable cleaning agent V171 and demonstrated successful reduction of long-chain PFAS in the final water rinse to below client-defined concentrations. Arcadis' collaboration with site personnel enabled more efficient cleaning, reducing per vehicle cleaning time by 30% during second mobilization. Client continues to engage Arcadis on performing similar PFAS cleaning activities across other sites.

CFB Greenwood-PFAS Foam Trial

Department of National Defence, Greenwood, NS

Contracted to support pilot testing for cleaning aircraft rescue and firefighting vehicles. Supervised the development of site-specific health and safety plan and PFAS cleaning work plan for pilot trial. This project included the application of Arcadis V171 cleaning agent for use during the pilot trial. Reviewed client-developed testing plan and pilot testing data. Trial showed successful PFAS removal by V171 cleaning agent.

SFO CSO-008 AFFF Services

San Francisco International Airport, San Francisco, CA

Arcadis was contracted by SFO Airport to provide on-call environmental services. As a part of this contract, Arcadis has performed two emergency spill response actions to clean up AFFF foam discharged during fire response activities. Water generated from clean-up activities was stored on site for subsequent treatment. Clean-up water was profiled, and commercially available treatment technologies were screened for cost-effectiveness. Adsorption technology was selected, and a temporary treatment system was mobilized using organoclay, granular activated carbon, and ion exchange resin. Water was successfully treated and discharged to on-site water treatment plant. Arcadis executed foam transition at on-site firehouse, consisting of AFFF removal and tank and piping infrastructure cleaning. Arcadis remains contracted with the client to perform future infrastructure cleaning and development of a foam management plan for the airport.

PFAS Solvent Decontamination Cleaning

Confidential Client, WI

Worked on a team to develop a specific solvent chemical for PFAS decontamination of equipment. Collaborated with Arcadis Australia for procedures and insight for an Arcadis proprietary solvent used for PFAS decontamination. Successfully procured and mixed solvent in U.S. under a condensed schedule for the client. Prepared a work plan to utilize the solvent onsite and managed health and safety concerns by organizing an exposure assessment. Provided technical support to field staff and contractors during decontamination efforts. Reviewed and analyzed PFAS data after decontamination utilizing TOP Assay method. Efforts were successful in decontaminating client process tank and contractor vacuum truck. Results were used for further proposals and solvent research and development.

Arcadis Fractionation Pilot System Design and Fabrication

Arcadis, North America

Led the engineering team through the development of a fractionation pilot skid design in partnership with Evocra, an Australian vendor of the technology. Arcadis funded the construction of the fractionation pilot system for operation at multiple client sites. Worked on a team to review shop drawings, process flow diagrams and other submittals. Attended weekly design calls with the fabricator to review questions and schedule. Helped manage purchase orders, change orders, and overall cost.

PFAS Groundwater Treatment Drinking Water Design, Pointe Des Chenes Campground

Public Works and Government Services Canada, Richmond Hill, ON

Provided senior review and collaboration with Arcadis Canada staff to advise on an evaluation of options for optimizing PFAS drinking water treatment for the Pointe Des Chenes campground. This involved a review of the existing treatment system operation, evaluation of the status quo operation, coordination of a bench scale Rapid Small Scale Column Test (RSSCT) of alternative GAC media and ion exchange resin, and development of a conceptual design for a recommended system upgrade. Prepared conceptual design options.

Livingston NJ - PFAS Study

Township of Livingston, NJ, Livingston, NJ

Led the development of a technical evaluation for the feasibility of granular activated carbon and ion exchange resin treatment targeting PFAS in drinking water wells. Evaluation consisted of determining feasibility of GAC and IX resin treatment for eight existing wells and the potential for combined treatment reducing systems to five. Evaluation included rapid small-scale column testing for GAC, empirical modeling for IX resin, and development of order of magnitude costing using WBS-based EPA cost models.

Town of Barnstable Mary Dunn Groundwater Treatment System

Town of Barnstable, MA

Provided management oversight of the review of existing PFAS GAC treatment systems for the Town of Barnstable Municipal Drinking Water Treatment system, specifically for Mary Dunn supply wells. The review was focused on reducing operations and maintenance cost associated with the treatment system while maintaining the current treatment efficiency. The team prepared a summary memo documenting the findings of the review as well as provided an outline of optimization measures to improve the performance of the GAC system and reduce costs.

Mass DOC PFAS Shirley MA Facility Treatment Evaluation

Massachusetts Department of Correction, Shirley, MA

Managed the technical team in the review of available pumping data of current water treatment system and PFAS concentrations detected for the Mass DOC Shirley facility. The team conducted a site visit to review the site layout, access limitations, or other restrictions. Utilized digital applications for site visit planning (tablets and FieldNow). Prepared a summary report of recommended design parameters and specifications for vendors to provide costs for the installation and maintenance of a proposed GAC treatment system for PFAS.

PFAS Industrial WWTP and AFFF Pilot Testing, Design, Biosolids Dewatering

Confidential Client, WI

Provided technical guidance on a PFAS technology evaluation for industrial wastewater streams affected by AFFF. Reviewed existing analytical data characterizing wastewater streams at the Site. The technology evaluation identified what treatment technologies were already implemented onsite, their success at treating PFAS, and evaluating other technologies to consider for PFAS treatment. This report was provided to the technical review team and client which led to further bench-scale testing and pilot work.

Coordinated bench-scale treatability study for AFFF impacted industrial wastewater for the following technologies: granular activated carbon adsorption, anionic ion exchange resin adsorption, foam fractionation, clarification (electrocoagulation/polymer), and membrane filtration. Prepared a bench-scale work plan, budget, and schedule. Worked with the Arcadis field and design team to draft procedures for collecting onsite wastewater considering PFAS specific requirements. Provided technical support to field staff collecting and sampling wastewater onsite. Coordinated logistics and testing procedures across three different vendors performing testing including the Arcadis Treatability Lab. Coordinated analytical samples and third-party laboratory work. Prepared a results summary report for the different bench-scale tests and provided recommendations on PFAS treatment technology for pilot and full-scale design. Assisted Arcadis technical staff in developing first-of-its kind fractionation bench scale systemfor this project specifically, including drafting P&IDs, procedures, and calculations.

Prepared a dewatering scope of work for contractor bidding to dewater over 2 million gallons of sludge (biosolids) impacted with PFAS. Provided technical support for procurement and bidding including design and breakthrough calculations for PFAS in GAC/resin. Provided technical support to field staff performing the dewatering work. Prepared a technical memo highlighting results of the biosolids evaluation and recommendations for managing it.

PFAS Guidance Document Development

Various Industrial Clients, Various U.S. Locations

Supervised a team in the development of programmatic strategy documents providing tools for rapid response to identified PFAS site impacts. Strategy documents consisted of a technical evaluation for the state of PFAS treatment technologies for liquid and solid matrices, a toxicological memorandum identifying relevant regulatory standards and the science behind them, a best-available technology costing memorandum for understanding the relative impact of PFAS treatment costs compared to other contaminants, and a guidance tool for picking the most likely treatment technologies to assess based on site-specific parameters.

PFAS Landfill Leachate Treatment - Fractionation Bench Testing

Michigan Department of Environmental Quality, Trenton, MI

Provided technical guidance to prepare a PFAS Bench Testing Work Plan for the DSC McLouth Steel Gibraltar Countywide Landfill (CWLF) Superfund Site (Site) located in Gibraltar, Michigan. Coordinated and provided technical support for the PFAS fractionation bench testing specifically with the Arcadis Treatability Lab during testing.

PFAS Groundwater Treatment Bench Testing and Design for Industrial Site

Confidential Client, Michigan

Managed the technical team in the deveopment of a GAC system optimization study to help meet PFAS discharge objectives for the current system. This included treatability bench-scale testing for GAC rapid small-scale column testing, anion exchange resin modeling, and PQ-Osorb novel media adsorbent testing. Provided review of a technical memo technical memo of all treatability testing results including laboratory reports and summary data tables, breakthrough curves, a comparison of treatment efficiency, operational considerations and cost estimates. This also included conceptual design options including process flow diagrams, design calculations, and cost estimates.

PFAS Treatment Technology Evaluations

Various Industrial Clients, Various U.S. Locations

Managed the development of treatment technology evaluations for various industrial clients across the U.S. for treatment and destruction of per- and polyfluoroalkyl substances (PFAS) waste streams. Evaluations included various tasks of review, such as conceptual site models, operations data, historical investigation reports and design data. Evaluations included capital and operating costs to establish comparative basis for life-cycle cost analysis, as well as site specific criteria such as footprint, utilities, permitting restrictions, risk, and liability.

Lake City AAP PFAS Water Quality Management Plan

US Army Corps of Engineers - Kansas City District, Independence, MO

Provided overview of technical support preparing water quality technical treatment evaluation for PFAS and 1,4 Dioxane treatment at the Lake City Army Ammunition Plant Site in Jackson County, Missouri. Developed a list of emerging and developed treatment technologies that may be effective for PFAS and 1,4 dioxane treatment of expected influent water. Treatment technologies targeted PFAS, 1,4 dioxane, and non-target constituents that may interfere with treatment. This evaluation included the state of practice for each technology, required pre- and post-treatment considerations, and its applicability to the subject water stream (e.g., short-chain vs. long-chain PFAS, poly- vs. perfluorinated alkyl substances). The evaluation provides proposed treatment trains based on known water quality parameters, and recommendations on which technologies to consider in the bench-scale phase.

Remedial Concept Designs

United States Air Force, Various U.S. Locations

Provided per- and polyfluoroalkyl substances (PFAS) site investigations at 11 BRAC Bases throughout the continental United States (Castle AFB, California; Chanute AFB, Illinois; Loring AFB, Maine; KI Sawyer AFB, Michigan; Wurtsmith AFB, Michigan; Pease AFB, New Hampshire; Griffiss AFB, New York; Plattsburgh AFB, New York; Kelly AFB, Texas; Reese AFB, Texas; and General Mitchell ARS, Wisconsin). Performed site investigations at 157 AFFF areas located at 11 BRAC installations in eight states. In addition, the project included implementation of pilot-scale groundwater treatment systems using ion exchange resin remediation technology based on the promising results of a bench-scale test, which led to the design of large-scale groundwater treatment plants.

Interim Treatment System Design for PFAS removal

Alpha Associates, Lakewood, New Jersey

Provided treatment system design and construction oversight for an Interim Remedial Measure (IRM) treatment system for PFAS removal from groundwater. Site was an industrial site with PFAS measurements as high as 9 milligrams per liter (mg/L [ppm]). Treatment system consisted of granular activated carbon (GAC) and bag filters for pretreatment and anionic exchange (AIX) resin with extended contact time for treatment.

Industrial WWTP PFAS Mass Balance

Confidential Oil & Gas Client, Michigan

Developed simplified Waste Water Treatment Plant (WWTP) system schematic for process flow of waste water at the site. Used the process flow to develop a wet and dry weather sampling plan. Data was collected at all major unit operations within the treatment facility to develop a PFAS fate and transport model through the treatment process. A mass balance was developed to document the assumptions used in the calculations and establish the waste streams most appropriate for targeted PFAS treatment efforts.

County Wide Landfill Leachate PFAS Treatment Testing

Michigan Department of Environmental Quality

Provided technical guidance to prepare a PFAS bench testing work plan for the DSC McLouth Steel Gibraltar Countywide Landfill (CWLF) Superfund Site (Site) located in Gibraltar, Michigan. Coordinated and provided technical support for the PFAS fractionation bench testing specifically with the Arcadis Treatability Lab during testing of raw landfill leachate. Bench-scale testing was performed in December 2020 to test three main technologies: foam fractionation, granulated activated carbon (GAC) filtration, and membrane filtration (Ultrafiltration, Nanofiltration, and Reverse Osmosis). From the bench results, fractionation and GAC plus ion exchange (IEX) resin was chosen for a pilot-scale study which concluded in December 2021. Coordinated the deployment of the Arcadis Fractionation Pilot System at the site working with local field staff and contractors. Provided on-site training of the operation of the system to onsite staff and continued to provide technical support to field staff during pilot operations. The pilot scale was able to reduce PFAS to non-detectable levels, and the results are being used to compare and confirm waste generation rates and the overall cost effectiveness for full-scale implementation of fractionation.

PFAS Groundwater Treatment Bench Testing & Design for Industrial Site

Confidential Client, MI

Provided technical guidance for GAC system optimization to help meet PFAS discharge objectives for the current system. Coordinated treatability bench-scale testing for GAC rapid small-scale column testing, anion exchange resin modeling, and PQ-Osorb novel media adsorbent testing. Prepared a technical memo technical memo of all treatability testing results including laboratory reports and summary data tables, breakthrough curves, a comparison of treatment efficiency, operational considerations and cost estimates. Prepared conceptual design options including process flow diagrams, design calculations, and cost estimates. Provided input and review of presentation to client.

PFAS Surface Water Ditch Treatment System Pilot Testing

Confidential Client, WI

Provided engineering design guidance on an existing PFAS treatment system for surface water. Reviewed existing analytical chemistry data, flow rates, and operations manuals to prepare a pilot design utilizing innovative Osorb Media and Fractionation treatment for PFAS treatment to integrate with the existing ditch treatment system. Prepared a conceptual design and cost estimate for the Osorb Media and fractionation pilot and maintained coordination among field staff and design team.

Industrial Wastewater PFAS Mass Balance and Conceptual Design

Confidential Client, MN

Reviewed background of existing industrial facility's operations to create a water mass balance for the facility related to flowrates and PFAS mass loading. Reviewed other proposed water management designs and prepared a PFAS treatment conceptual design for the facility utilizing the mass balance to focus on areas where treatment would be most effective to reduce overall mass loading.

PFAS Treatment Guidance Tool Development for Oil and Gas Refinery

Confidential Client, MI

Provided technical guidance to prepare an evaluation tool for assessing treatment options for PFAS in different refinery waste streams and the associated costs. Developed a list of emerging and developed treatment technologies effective on the defined waste streams including treatment technologies targeting both PFAS and non-target constituents that may interfere with PFAS treatment. Prepared an evaluation that included typical treatment trains for each defined waste stream, and the effectiveness of each unit process on both PFAS and non-target water quality parameters. The guidance document lets the client respond quickly and appropriately in the event of a PFAS-related event or enforcement.

PFAS Industrial WWTP Treatment Conceptual Design

Confidential Client, PA

Provided technical guidance and calculations to prepare an end-of-pipe PFAS treatment high level cost estimate and design for an existing 10 MGD treatment system. Prepared a PowerPoint presentation to present conceptual design to client.

PFAS Mass Balance- Oil and Gas Refinery

Confidential Client, MI

Provided technical design support to prepare mass balance calculations for a refinery impacted by PFAS in their waste streams. Assisted in the preparation of tables and calculations for over 40 different mass balance streams through various refinery processes and equipment. Identified where PFAS was coming in through storm and industrial sewers and where PFAS was coming out in solids and permeate. Prepared visual aids and flow diagrams for a presentation to the client. Prepared a draft summary report of the findings for the client.

WWTP ZLD Evaluation
Confidential Client, AL

Led a team to prepare an evaluation of wastewater pollution control technologies report (report) to document the feasibility study that was completed to evaluate wastewater pollution control technologies to mitigate or eliminate the discharge of PFAS for zero liquid discharge (ZLD). This feasibility study evaluated treatment technology options, including granular activated carbon, reverse osmosis, ion-exchange and a partial- or complete closed-loop configuration for the Decatur PFAS-related processes. The evaluation of possible configurations included aspects of technical feasibility, economic feasibility, energy consumption, and the potential for media shifting of pollutants.

PFAS Industrial WWTP Membrane/Fractionation Pilot Testing
Confidential Client, IL

Coordinated pilot testing work for PFAS industrial wastewater testing. Provided technical support and procurement of Nanofiltration (NF) and Reverse Osmosis (RO) pilot skid equipment for a pilot test to treat wastewater effluent at the site in Illinois. Coordinated Arcadis field staff at start-up and provided technical O&M support for client self-performed operation of the 3 month pilot. This pilot provided proof-of-concept for potential wastewater treatment technologies and valuable site-specific information that will help define viability for the tested technology. Prepared and won an additional scope proposal and coordinated fractionation bench-testing at the Arcadis Treatability Lab. Provided analysis of the fractionation data and prepared a summary of results memo and PowerPoint. Presented results directly to the client.

WWTP PFAS Data Evaluation and Carbon Pilot Testing
Confidential Client, AL

Reviewed existing WWTP data from multiple sources to identify the extent of PFAS concentrations in different waste streams. Prepared a working index of multiple historical data sources from client and worked with team to use data for updating conceptual PFAS treatment designs.

Designed a carbon bed pilot system to test various carbon conditions for PFAS treatment efficiency at the site. Coordinated design drawings, equipment list, submittal review, and construction at the site. Performed site visits for locating the pilot equipment and performed site visits to provide owner start-up and commissioning support. Provided ongoing technical support and data analysis during the pilot test expected to last up to 12 months. Provided technical support on preparing monthly reports on facility production logs with over 50 different facility processes and charts and data analysis on PFAS compounds related to those facility processes. Coordinated with multiple analytical laboraories including client owned lab to perform calibration studies and review accuracy of PFAS analytical results.

PFAS Industrial WWTP Design
Confidential Client, IL

Managed the development of a PFAS technology evalaution specific to an industrial site for WWTP effluent. Evaluated and recommend technologies most appropriate for pilot testing. Developed a pilot test plan, including: process flow diagrams, equipment specifications and sizing, vendor recommendations, operating procedures, sampling and analysis plan. Reviewed client and vendor-generated information, such as detail design drawings, vendor proposals, and pilot equipment submittals. While the client assumed responsibility for final design, construction, and execution of the pilot test, Arcadis engineers provided support during operation of the pilot through technical consultation and data analysis. Worked as task lead and primary engineer preparing designs, reports, and powerpoint presentations. Interfaced with the client on weekly basis for 6+ months during the course of the project. Using data from the pilot test, a PFAS treatment options development evaluation was prepared with sufficient detail to allow a meaningful comparison of technology, feasibility, and costs. Presented the options, answered questions, gained stakeholder input, and aligned on the preferred alternative for further refinement. Prepared a conceptual design report for the single selected alternative including; process flow diagram of selected alternative; A preliminary major equipment list with equipment sizing, materials of construction, utility requirements, and other pertinent information required for obtaining estimates of cost; Major equipment layout diagrams; Engineer's estimate of probable construction cost (AACE Class 4; -20% to +30%); and estimate of operating and maintenance costs. Coordinated multiple teams as task lead and organized all different data for preparing the final report. Delivered final conceptual design report to client meeting all scheduled deadlines and expectations.

Pease Air Force Base Site 8 PFAS Interim Mitigation System

United States Air Force, Portsmouth, New Hampshire

Implemented an interim mitigation system as part of an Interim Remedial Action (IRA) to control migration of per- and polyfluoroalkyl substances (PFAS)-impacted overburden groundwater at Site 8 (former fire training area) to bedrock groundwater and downgradient private well receptors. Installed a 200-gpm groundwater extraction and treatment system at Site 8 that uses an innovative technology specifically designed for optimized PFAS treatment. Upon completion, the treatment plant was thought to be the first large-scale PFAS treatment plant in the country to use a nongranular activated carbon treatment solution. In addition, the treatment process uses in-place regenerable media that will result in a very limited waste stream. Besides the new groundwater treatment plant and building to house it, the IMS work included a new groundwater extraction well network of 11 new wells and associated trenching and piping to control migration of the PFAS plume. Will optimize and operate the plant for a one-year period after construction is complete.

Selected Publications and Presentations

McDonough, J., **Theriault, C**., Burdick, J., Quinnan, J. Myth Busting Treatment Options for PFAS Impacted Matrices. Society of American Military Engineers Joint Engineer Training Conference Tampa, FL May 7-9 2019.

Theriault, C., McDonough, J., Myth Busting Treatment Options for PFAS. Platform Presentation. New England Water Environment Association Annual Conference, Stowe, VT, October 8, 2018.

Theriault, C., Water Treatment Technologies for PFAS, Current and Next Generations, Platform Presentation, Texas Water Summit, Houston, TX, April 19, 2019

Theriault, C., Water Treatment Technologies for PFAS, Platform Presentation, American Water Works Association, Ohio Chapter, September 19, 2019

Theriault, C., McDonough, J., Water Treatment Technologies for PFAS, Current and Next Generations, Paper and Platform Presentation, International Water Conference, Engineers Society of Western Pennsylvania, November 12, 2019

KEITH FOSTER
PRINCIPAL GEOLOGIST

EDUCATION
BA Geology University of California, Berkeley 2011

YEARS OF EXPERIENCE
Total – 13 years

Keith specializes in leveraging his foundation in environmental geochemistry and hydrogeology and connecting them to understanding how constituents interact with the subsurface and evaluating treatment technologies for optimized remedial solutions. Recently, Keith has focused on the remediation of emerging contaminants and supporting the commercialization of water and vapor treatment technologies, using adsorptive media, to remove recalcitrant compounds such as per- and polyfluoroalkyl substances (PFAS), 1,4-dioxane, and traditional and specialty volatile organic compounds (VOCs). His focus on environmental media containing emerging contaminants has involved projects in the United States, Australia, Sweden, Germany, Taiwan and others.

Project Experience

PFAS Treatment Evaluation and Design, Air Force Plant 44, Tucson Arizona

Arcadis has been contracted to perform non-time critical removal action (NTCRA) evaluations and engineering related to PFAS contamination at the Site. Keith has overseen and evaluated bench-top studies using granular activated carbon (GAC), anion exchange resin (AIX resin), super fine powdered activated carbon (SPAC), and foam fractionation (FF) to treat PFAS impacted water from the Site. Keith has taken the results of the testing and implemented them into an Engineering Evaluation and Cost Assessment (EE/CA) where he provided conceptual designs and rough order of magnitude costs for constructing and operating the treatment systems using the various PFAS treatment technologies. Keith also has served as a process engineer on the project, aiding in the design of a 50 gpm and 1,200 gpm PFAS treatment system using AIX resin.

Various Clients, PFAS Feasibility Studies

As applications engineer, Keith evaluated feedwater characteristics of over 100 different feedwaters for suitability of IX, GAC, and membrane-based technologies for PFAS removal in consideration of various treatment goals (i.e., U.S. EPA Health Advisory Level [HAL], AU HAL, and various EU Regulations). He developed models based on pilot and full-scale data to determine media specific capacities for various PFAS compounds of interest. Also, Keith developed capital expenditure (CAPEX) and operating expenditure (OPEX) models to evaluate life cycle costs to determine optimal technology selection including single use IX, regenerable IX, GAC, and membrane-based solutions and he evaluated groundwater, surface water, process water, and landfill leachate feedwater streams. Keith designed multiple pilot tests comparing GAC and IX, side-by-side, and authored reports detailing process efficiency and rough order of magnitude CAPEX and OPEX costs.

Multiple Confidential Department of Defence Sites, PFAS-Contaminated Water, Australia

Keith served as the applications engineer as part of a team tasked with the design, delivery, and operation of ion-exchange (IX)-based treatment system to remove and remediate 200 gallons per minute (gpm) on average, of groundwater, surface water, and drinking water impacted with PFAS. Technologies deployed included single use AIX, regenerable AIX, GAC, catalytic media, solvent distillation, and pilot trials of membrane separation. Keith developed and deployed dashboard tools to evaluate process efficiency and make recommendations based on analytical and process trends.

Confidential Mining Client, PFAS and Light Non-Aqueous Phase Liquids (LNAPL) Contaminated Water, Australia

As an applications engineer, Keith designed an IX-based pilot treatment system to remove and remediate 100 gpm of LNAPL commingled with PFAS. He evaluated feedwater characteristics for suitability of various PFAS removal technologies and developed a process flow diagram and concept process and instrumentation diagrams. The treatment system included groundwater and LNAPL extraction equipment, LNAPL storage tank, oil/water separators, particulate filters, hydrocarbon filters, backwashable GAC filters, IX resin filters, and miscellaneous auxiliary equipment. The treated effluent required to be within some of the most restrictive PFAS discharge limits found in the world, including perfluorooctanesulfonic acid (PFOS) to 0.23 nanograms per liter (ng/L). Additionally, he developed step and constant rate aquifer pumping tests in consideration of highly weathered and fractured bed rock geology with active downgradient dewatering operations. Tests also included the use of vacuum imparted on the well annulus and within the well casing to maximize water and LNAPL recoveries. Keith modified the pilot testing program to combine aquifer testing activities to be concurrent with treatability studies, saving the customer approximately $500,000.

Keith also has acted as a third-party reviewer of hydrogeological and technology assessments across the customers mining portfolio. This work has also included supporting strategy development for managing portfolio-wide liabilities in soil, sediment, surface water, and groundwater.

Municipal Water District, Pilot Testing, Southern California.

As an applications engineer, Keith evaluated feedwater characteristics for suitability of IX, GAC, and membrane-based technologies for PFAS removal in consideration of the California Department of Drinking Water treatment goals for perfluorooctanoic acid (PFOA) and PFOS. He developed pilot-test design and sampling and analysis program. He provided on-site trouble shooting of pilot test unit and designed additional column tests to evaluate the fouling mechanisms of natural organic material, iron, manganese, and other constituents onto AIX and GAC. Keith synthesized data in order to understand media specific performance as a function of bed volumes processed and effluent water quality. Finally, Keith delivered a presentation to the municipality about the characteristics, distribution, and commercial available of PFAS treatment technologies.

PFAS Treatment Evaluation and Design, Multiple Sites, New Jersey.

Arcadis has been contracted to provide design engineering services for several impacted drinking water wells in New Jersey. Keith has served as an applications engineer providing sizing, hydraulic, and media recommendations to the project systems using the various PFAS treatment technologies.

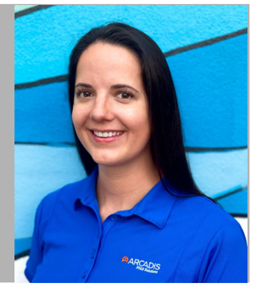
Municipal Water District, Pilot Testing, Southern California

Keith provided consulting expertise to a Southern California municipality as it relates to PFAS removal using IX and GAC. He provided training to municipality staff on PFAS and the design, construction, and operation of IX-based PFAS removal systems. He reviewed and commented on third party generated feasibility studies related to the treatment of PFAS in drinking water found in the City of Santa Ana supply wells. Additionally, Keith evaluated feedwater characteristics and make technology and process recommendations and worked alongside stakeholders to evaluate and design bench- and pilot-scale tests to evaluate various PFAS removal products on impacted City wells.

ARCADIS

LAUREN MARCH, PE

PROJECT CHEMICAL ENGINEER



EDUCATION
BS Chemical Engineering Ohio State University, 2017

YEARS OF EXPERIENCE
Total – 7 years

PROFESSIONAL REGISTRATIONS
Professional Engineer – FL

Ms. March is a chemical engineer with seven years of experience in environmental assessment and per- and polyfluoroalkyl substances (PFAS) destruction technology. She specializes in supercritical water oxidation (SCWO) system operation and test design of PFAS-contaminated water streams. Her experience with Arcadis ranges from media-based water treatment system design, full-scale fractionation system design, and PFAS destruction technology testing facilitation. Her laboratory experience includes both bench and industrial-scale projects in support of the evaluation of innovative remediation technologies.

Project Experience

Demonstration of Engineered Technologies for Evaluation and Treatment of PFAS

Engineer Research and Development Center & US Army Corps of Engineers, Mississippi

Arcadis is currently partnering with PCT Systems and University of Surrey to design, build, and test a sonolytic reactor, as well as supervising two SCWO technology vendors, General Atomics and 374Water, to destroy PFAS found in an aqueous film forming foam (AFFF) mixture for the Engineer Research and Development Center (ERDC) located in Vicksburg, MS. Contributed to destruction testing design by preparing and reviewing work plans. Coordinated with analytical laboratories and stack gas sampling subcontractors to execute a robust sampling plan. Collected operational data to develop a comprehensive cost model.

Supercritical Water Oxidation of Concentrates in a Centralized Destruction Approach

Defense Innovation Unit & Environmental Security Technology Certification Program, Virginia

Arcadis is currently partnering with Clean Earth and 374Water to test the “Hub-and-Spoke” concept by implementing a centralized regional waste receiving and destruction model for the Defense Innovation Unit (DIU) in association with the Environmental Security Technology Certification Program (ESTCP). Arcadis also holds a supervisory role, coordinating logistics for other destruction technology vendors, including Battelle/Revive, General Atomics, and Aquagga, to be co-located at specified Clean Earth Treatment, Storage, and Disposal Facility (TSDFs) for their respective full-scale demonstrations. Coordinated permitting and logistics with TSDF partner. Facilitated TSDF site walks for all performers. Contributed to destruction testing design by preparing and reviewing work plans for both bench-scale and full-scale testing. Contracted with analytical laboratories to execute a robust sampling plan. Collected operational data to develop a comprehensive cost model. Created a plan to rollout centralized destruction approach model to other TSDFs.

Fractionation System Design for Landfill Leachate Treatment

Michigan Department of Environment, Great Lakes, and Energy (EGLE), Michigan

Arcadis is currently designing a full-scale fractionation system to treat PFAS-impacted landfill leachate for the DSC McLouth Steel Gibraltar Countywide Landfill (CWLF) Superfund Site located in Gibraltar, MI. Contributed to process design by preparing and reviewing process flow diagrams and piping and instrumentation diagrams. Drafted a process controls and effect matrix. Anticipated and minimized risk through engineering and administrative controls via the Arcadis D-TRACK hazard analysis tool.

Destruction Feasibility Testing of PFAS-Impacted Water

Confidential Industrial Client, Illinois

Arcadis oversaw the feasibility testing and conceptual design development of PFAS destruction methods conducted by two commercial laboratory vendors to remediate an industrial waste stream for a confidential industrial client. Technologies considered included hydrothermal alkaline treatment (HALT) and photochemical treatment. Produced the proposal and bench-scale work plans, designed a sampling plan for each set of testing, facilitated vendor and client communication, prepared bench-scale results reports, and developed full-scale cost estimates and a pilot testing plan.

Foam Transition Support Services

East Hampton Village, New York

Arcadis was contracted to perform PFAS cleaning activities on two emergency response vehicles for East Hampton Village. This project employed the Arcadis V171 cleaning agent for use during cleaning. Generated a fluorine-free foam database including foam manufacturer and distributor identification, certifications, physical properties, cost, and lead time.

PFAS Remediation of Water Main

Confidential Industrial Client, Minnesota

Arcadis was contracted to treat an AFFF-impacted water main servicing an airplane hangar and office tower for a confidential industrial client. The treatment train consisted of granular activated carbon and anion exchange vessels in series. Designed a sampling plan, oversaw a field team, coordinated with treatment equipment vendors and on-site contractors, and managed and interpreted analytical data.

PFAS Annihilator™ System Operation and Test Design

Battelle Memorial Institute, Ohio

The objective of this project was to perform supercritical water oxidation of PFAS using a high pressure, high temperature bench-scale system producing carbon dioxide, water, and inert salts. Wrote standard operating procedures for system start up, operation, shut down, emergency shut down, and cleaning. Developed job hazard analyses for laboratory tasks. Designed test plans indicating pump flowrates, oxidant and neutralization dosage required, samples to be collected, and post-destruction analyses to be performed. Managed a laboratory team of eight individuals including training new team members on system operating and cleaning procedures, system troubleshooting, data processing, and scheduling tests and cleaning activities.

Water Conservation Program Management

Marine Corps Air Ground Combat Center (MCAGCC), California

Battelle was contracted by MCAGCC to perform water conservation activities including illicit discharge inspections, storm drain intrusion investigations, and community outreach. Prepared updates to the MCAGCC Emergency Response Plan. Conducted quarterly and semi-annual illicit discharge inspections of the Base and compiled data, findings and recommended next steps into associated reports. Planned, executed, compiled data, and wrote the report for a storm drain intrusion investigation. Collaborated with Battelle's geographic information systems (GIS) team to create site maps with previous and proposed investigation locations.

Agricultural Drift Tunnel (AgDT) and Humidome Testing

Battelle Memorial Institute, Ohio

This technology allows a client to generate repeatable application data to predict the results of open field testing and evaluate the drift potential of agricultural products in controlled, laminar flow wind speeds from 0 to 11 mph. Mixed pesticide product formulas from stock chemicals. Utilized laboratory equipment to test product viscosity, density, and surface tension. Operated the drift tunnel (e.g., prepared products for spraying and ran SprayTec analyses for each product). Prepared soil samples to be sprayed with product and incubated in the Humidome. Prepared Humidome samples for laboratory analysis.

Environmental Security Technology Services (ESTS) Task Order 10

Naval Facilities Engineering Systems Command (DoD – Navy), Washington

Battelle was contracted by the US Navy to perform environmental services under the ESTS contract awarded in 2016. Task Order 10 was executed at the Naval Undersea Warfare Center (NUWC) Division Keyport for site recharacterization of a Navy-owned landfill. Produced a sampling and analysis plan, site safety and health plan, and accident prevention plan. Facilitated direct push drilling and sediment sampling in support of groundwater well location selection. Oversaw hollow stem auger drilling, well installation and development. Conducted groundwater sampling, generated laboratory chains of custody and ensured compliant sample shipment. Analyzed laboratory results and summarized findings into a technical report.

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EXHIBIT E

Kaczynski Expert Report

Expert Report of 3M Employee Donald J. Kaczynski

Submitted in support of comments from 3M Company on draft NPDES Permit No.MN0001449

Professional Qualifications

I received a BS degree in Chemical Engineering from Michigan Technological University in Houghton, MI in 2005. Since 2005, I have worked in various chemical and oil and gas manufacturing facilities as a technical process and project expert. I joined 3M in February of 2021, and have been involved in the advanced water quality treatment review and design process since mid-2021. In late 2022 I became the Water Purification Technical Manager at 3M, where I engage with all facets of the Advanced Wastewater Treatment System under construction at Cottage Grove including R&D, engineering, operations, environmental, safety.

Background

The draft NPDES permit published by MPCA on July 1, 2024, (Draft Permit) establishes numerical concentration values designated as "intervention limits" for multiple PFAS at sampling locations designated as WS 001 and WS 002. Draft Permit, Section 7 at pages 319 – 321 and 323 – 325 sets limits for two groups of PFAS, one with limits that cannot be measured by current analytical methods, and one that can. The first group is comprised of PFOA, PFOS and Perflurohexanesulfonic acid in the following forms PFH1S, PFHS, and PFHxS (collectively referred to in this report as PFHxS). These limits are based upon a "grab" sample. The intervention limits are:

- PFHxS - 0.0171 ng/L calendar month average and 0.0298 ng/L as a daily maximum.
- PFOS - 0.155 ng/L calendar month average and 0.27 ng/L as a daily maximum.
- PFOA - 0.069 ng/L calendar month average and 0.117 ng/L as a daily maximum.

Draft Permit at Section 7, pages 319 – 321 (WS 001) and pages 323 – 325 (WS 002). These limits are all well below analytical limits of measurement and detection. Report of Rock Vitale of Environmental Standards dated August 27, 2024.

The second group of PFAS with intervention limits is comprised of PFBA, PFBS, and PFHxA. The limits for these chemicals are based upon grab samples. The intervention limits are:

- PFBA – 186,912 ng/L calendar month average and 323,808 ng/L as a daily maximum (WS 001 only)
- PFBS – 22,429 ng/L calendar month average and 38,856 ng/L as a daily maximum
- PFHxA – 32,897 ng/L calendar month average and 56,988 ng/L as a daily maximum.

These limits are capable of measurement with current analytical methods.

The Draft Permit sets out a series of actions (additional sampling, root cause analysis, reporting) triggered by exceedance of an intervention limit. The Draft Permit also requires evaluation of "the need for immediate corrective action to prevent pollutant levels from exceeding the intervention limits again."[1]

A third group of intervention limits appears in the Draft Permit at paragraph 5.69.111, "Annual O&M Deviation & WWTP Optimization Report." There the Draft Permit requires:

> The Permittee shall submit an Annual O&M Deviation & WWTP Optimization Report by March 31 of each year. The report shall also contain an evaluation of the WS 001 - WS 002 PFAS treatment performance relative to the following compounds and thresholds:
> PFHpS: 10 ng/L
> PFHxA: 10 ng/L
> PFPeS: 9.4 ng/L
> PFPeA: 10 ng/L
> PFPrA: 370 ng/L
> 2233-TFPA: 500 ng/L
> TFA: 10,700 ng/L
> TFMS: 25 ng/L

The permit further requires that "[i]f any of the treatment performance thresholds above are not achieved, the report shall address what, if any optimization steps the Permittee intends on implementing and in accordance with what timeline to achieve the performance thresholds above."

The treatment performance standards in the Draft Permit at paragraph 5.69.111 can be measured with current analytical methods.

The Draft Permit establishes the sampling locations SD 001 and SD 002 for determination of compliance with the limits on eventual discharge to the Mississippi River. Section 7 of the Draft

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[1] The intervention requirements provisions in full state:

> If an intervention limit is exceeded, the Permittee shall: A. Sample the monitoring station again within two days of receiving sample results if the previous samples at the monitoring location did not exceed the intervention limit and a sample hasn't already been taken since the sample with the associated intervention limit exceedance; B. Evaluate the significance and the cause of the intervention limit having been exceeded. The cause shall include a thorough review of the carbon changeout frequency of the GAC system and the ion exchange media regeneration and/or changeout frequency; C. Evaluate the need for immediate corrective action to prevent pollutant levels from exceeding the intervention limits again; and D. Evaluate the need for changes in monitoring, including but not limited to, increasing sampling frequencies, changing the characteristics monitored, installing additional monitoring stations, identifying appropriate shorter-chain sentinel compounds to monitor, identify the specific monitoring locations at which to monitor them in order to best understand what operation and maintenance actions might be needed, and to ensure such actions are reflected in the Cottage Grove O&M manual(s), and reducing pollutant loadings. [Minn. R. 7001].

Draft Permit at ¶ 5.33.5.

Permit at pages 119 – 123 (SD 001) and 144 – 148 (SD 002). The following “Compliance Limits” limits apply to eventual discharge to the Mississippi River:[2]

- PFHxS – 2.1 ng/L calendar month average and 2.1 ng/L as a daily maximum.
- PFOS – 2.2 ng/L calendar month average and 2.2 ng/L as a daily maximum.
- PFOA - 2.1 ng/L calendar month average and 2.1 ng/L as a daily maximum.

These are the enforceable discharge limits for the three identified PFAS. Each of these limits can be measured with current analytical methods

I. The Intervention Limits Do Not Promote Optimal Operation of the Advanced Wastewater Treatment System for Removal of PFOA, PFOS and PFHxS

While the Intervention Limits might appear to help ensure that the Advanced Wastewater Treatment System is operated to meet its design criteria, in actual operation they do not for PFOA, PFOS, and PFHxS. In fact, the Intervention Limits have a significant potential for at least creating work that does nothing to improve the quality of the ultimate water discharge and may undercut that goal. To explain why, it is necessary to have a brief description of the process for PFAS removal in the Advanced Wastewater Treatment System. A more detailed description of the System and its design is provided in the Arcadis Report dated August 28, 2024, that is submitted along with this report and the comments on the permit filed by 3M Company.

Relationship between the Intervention Limits and the Compliance Limits

In the Advanced Wastewater Treatment System, PFAS-containing water is initially treated in a process called reverse osmosis. Here water is forced through a membrane that prevents an exceptionally high percentage of PFAS from passing though. Reverse osmosis species rejection is driven by restricted transport through the membrane by size exclusion and affinity interactions; both of which help in ensuring various PFAS species stay in the reject. Extent of rejection is determined by species, water matrix, the membrane itself, and operating conditions. The treated water that passes through is called permeate and represents ~85 percent of the original volume of water directed to the RO. The remaining 15 percent of the original volume is called “reject” and contains the concentrated PFAS from the treated water. The reject is then sent to the granular activated carbon (GAC) and ion exchange (IX) systems for removal of PFAS. The water from the GAC and IX systems recombines with the permeate from the RO

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[2] The Draft Permit at paragraph 5.69.128 provides:

> "Compliance limit (CL)" shall mean: The value deemed as compliance with the Daily Maximum and Monthly Average PFAS limits. The monthly average and daily maximum PFOS WQBELs are below the reporting limits (limits of quantitation) achievable when analyzing treated effluent at Cottage Grove. For PFOS, a statistical analysis of the actual reporting limit wastewater at Cottage Grove sampling stations SD 001 and SD 002 is 2.2 ng/L. For PFOA and PFHxS, the actual reporting limit is 2.1 ng/L. For these three parameters, any effluent value less than or equal to the numbers above will be considered to be in compliance with the daily maximum limit; and any monthly average effluent value equal to or below the numbers above will be considered to be in compliance with the monthly average limits. [Minn. R. 7001]

system before being eventually discharged to the Mississippi River. Immediately prior to discharge the water is sampled at locations SD 001 and SD 002 to determine compliance with applicable permit limits.[3]

The Intervention Limits apply at the locations designated as WS 001 and WS 002. Water sampled at WS 001 and WS 002 is the effluent from the IX treatment systems. That water will not undergo further treatment before entering the river. It will, however, be diluted by the flow from the RO permeate. Water at sampling locations SD 001 and SD 002 is a combination of the system's RO permeate (~85% volume) and treated RO reject stream (~15% volume).

Comparing the expected dilutive factor attributable to the RO stream mixing with the water from the Advanced Treatment System components identified above, it is apparent that the intervention limits from Draft Permit, Section 7 at pages 319 – 321 and 323 – 325 are derived from the water quality based effluent limits (WQBELS) that MPCA developed for SD 001 and SD 002. Section 7 of the Draft Permit at pages 119 – 123 (SD 001) and 144 – 148 (SD 002). Stated differently, the WQBELS for PFOA, PFOS and PFHxS, PFBS, PFBS, PFHxA multiplied by a dilution factor attributable to the RO stream equals the intervention limits for these chemicals. For PFBS, PFBA, PFHxS, PFHxA, PFOA, the WS 001 and WS 002 Intervention Limits are ~5.33 times the WQBELs, which reflects a conservative estimate of dilution.[4]

Further, intervention limits for PFOA, PFOS and PFHxS are not calculated by applying a dilution factor to the Compliance Limits for those substances. Instead, MPCA appears to have applied a dilution factor to the WQBELs for those substances. The result is the calculated intervention limits for PFOA, PFOS and PFHxS that is (1) far below levels of detection (discussed further below); and (2) not tied to ultimate permit compliance for those substances.

II. The Intervention Limits Will Not Promote Optimization of PFAS Removal by the Advanced Water Treatment System and May be Counterproductive

The Advanced Wastewater Treatment System was designed to maximize removal of the total mass of PFAS in groundwater and wastewater. The largest portion of PFAS mass at the facility consists of short-chain PFAS (e.g., PFBA) and ultra-short chain PFAS (e.g., PFPrA). One reason why RO is a principle component of the System is because it is effective on these shorter chain molecules. The adsorptive treatment elements, IX and GAC, remove ultra short, short and long chain PFAS. In optimizing the removal efficiency of these elements of the System, the key concept is breakthrough.

[3] The discharge is to an unnamed creek that flows into the Mississippi River.
[4] MPCA's selected dilution factor is significantly less than the more likely dilution factor of 6.67 based upon a design estimate of an 85 to 15 permeate to reject ratio for the discharge stream. For reasons that are not explained in the Draft Permit or associated Fact Sheet, MPCA used a dilution factor of ~4.08 for PFOS. Given that the dilution of the flow from the IX and GAC treatment systems is from mixing with the permeate flow, there is no basis in logic or science that PFOS concentrations would be less diluted than the other PFAS.

At its simplest, breakthrough simply means that a specific PFAS is no longer being removed at a defined rate. The ultra short and short-chain PFAS will breakthrough the IX and GAC before PFOA, PFOS, and PFHxA. Therefore, the ultra-short and/or short-chain PFAS will dictate the timing for change-out of the GAC or regeneration of the IX resin. Because the ultra-short and short-chain PFAS will break through IX and GAC months before PFOA, PFOS, and PFHxS, the focus on removal of the shorter-chain PFAS means that we reasonably expect that the removal of the longer-chain PFAS will be continuously at or near the high-end of the capability of the Advanced Wastewater Treatment System (i.e., a very high removal rate). Because of this, the Intervention Limits for PFOA, PFOS and PFHxS are not needed or even useful to ensure optimal removal of those PFAS.

The management of breakthrough is complex and involves, among other things, developing the data necessary to be able to predict the timing of breakthrough of specific PFAS (e.g., development of breakthrough curves, logistics for material change out, etc.). Typically, IX and GAC systems are managed based upon data trends, rather than single sample results. One reason why the shorter chain PFAS are used to evaluate system optimization is because they breakthrough before the longer chain species and can act as 'sentinel compounds' for the longer chain PFAS. In other words, if changeout or regeneration is based on the breakthrough of sentinel compounds, good capture for the longer chain PFAS, which would breakthrough later, will be ensured.

Anticipated performance and PFAS removal are based on PFAS loading, flow rates, vessel and equipment design velocities/contact time, and extensive lab testing on absorption and desorption in the process. All this information has been combined to determine flowrates and expected bed volumes in the ion exchange before breakthrough of various PFAS species. 3M will work to maximize the PFAS capture capabilities of the system as more knowledge is gained as the system is run and the regeneration equipment capabilities are optimized.

The intervention limits for PFOA, PFOS, PFHxS at WS 001 and WS 002 are below the LOQ and cannot be measured. In fact, the Intervention Limits are so low that if a sample contains measurable PFOA, PFOS, or PFHxA, it will be at least an order of magnitude above the Intervention Limit. Because of this there is a genuine risk that any laboratory result indicating a measurable concentration could be a false positive result. False positive results in PFAS sampling have been observed on multiple occasions and are caused by interference from other analytes and ions in the sample, sampling error, or even laboratory error.

As previously stated, the longer chain PFAS components (PFOA, PFOS, PFHxS) that have Intervention Limits at sampling locations WS 001 and WS 002 have a very high affinity to the GAC/IX processes and will very efficiently be removed from the water to below the LOQ.[5] If/when samples would return a value above the LOQ for PFOA, PFOS, or PFHxS, without

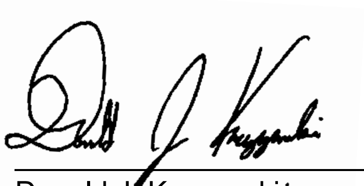
[5] The Intervention Limits proposed in the Draft Permit are so low that any sampling result with a value for PFOA, PFOS, or PFHxS that can be measured, i.e., above the LOQ, will be above the Intervention Limits and trigger the requirement to take the actions specified in the Draft Permit.

additional data indicating that breakthrough is occurring (e.g., other analyte results being elevated, significant unit upset, etc.), the result will almost certainly be a false positive that provides no diagnostic value for determining System performance because the System is expected to remove PFOA, PFOS, and PFHxS to well below the LOQ by the time water reaches WS 001 and WS 002.

The provisions of the Draft Permit requiring a prescribed set of actions when an Intervention Limit is exceeded establishes operational response that is inconsistent with accepted principles of water treatment system operation. With the constant switching of ion exchange trains in the process and multiple trains for each system in operation at any given time, each at a different phase of its breakthrough curve, a snapshot sample result does not tell the whole story of system performance. A sample that is pulled just before a "spent" ion exchange train is about to be removed from service has a higher probability of detecting certain PFAS analytes than a sample pulled shortly after a switch was made from a "spent" train to a "regened" train. In similar fashion, based on the anticipated timing of sample results for intervention limits, by the time a sample has shown an intervention limit was exceeded the process has almost certainly switched to running through a different set of ion exchange vessels, and will require no additional actions.

Finally, The Advanced Wastewater Treatment System is integrated both up and downstream of the various sampling points and any adjustment made in response to an Intervention Limit exceedance without properly anticipating the impacts elsewhere can have lasting results for days or weeks that could potentially result in more negative impacts. Therefore, when determining the correct response to an intervention limit exceedance (especially a one-off exceedance), more times than not, the response will be to "stick with the plan" while continuing to monitor performance. This is so because, for example, responding to an Intervention Limit exceedance by rotating an ion exchange bed out of the programmed sequence could lead to other beds having to stay on-line longer than planned. This adjustment to the System could result in an increase in other PFAS components breaking through the ion exchange system and being discharged.

Respectfully submitted,



Donald J. Kaczynski
Water Purification Technical Manager, 3M Chemical Operations
3M Cottage Grove, MN

EXHIBIT F

Written Correspondence Cited in Background section of 3M's Comments Letter

EXHIBIT F-1

Jan 12, 2024 Ltr from MPCA re PPN Draft Permit

Keith Schmuck

From:	Starr, Sarah (MPCA) <Sarah.Starr@state.mn.us>
Sent:	Friday, January 12, 2024 1:42 PM
To:	Eric Funk; Allen Chasteen; Alma Allen-Webb; Shane Symmank; Darren Schwankl; Christopher Bryan; Matthew Garrison; Andy Schulz; Keith Schmuck; Nick Nelson; Abby Morrisette
Cc:	Doucette, Elise (MPCA)
Subject:	[EXTERNAL] Pre-Public Notice of Draft Permit - 3M Cottage Grove NPDES-SDS Permit MN0001449
Follow Up Flag:	Follow up
Flag Status:	Flagged

January 12, 2024

Eric Funk, Site Director
3M Chemical Operations LLC
3M Cottage Grove Center
10746 Innovation Rd
Cottage Grove, Minnesota 55016-4600

RE: ***Pre-Public Notice Draft Permit***
3M Cottage Grove Center
NPDES/SDS Permit No. MN0001449
T27N, R21W, Section 27, Cottage Grove, Washington County, Minnesota

Dear Eric Funk:

The above-referenced National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit for your facility has been drafted in preparation for public noticing. In order to address any comments that you may have concerning the proposed conditions prior to public noticing, enclosed is a pre-public notice copy of the draft permit and fact sheet for your review.

Any changes or new requirements to the draft permit are outlined in the fact sheet. Please read through the enclosed material to ensure you are aware of any changes and/or updates that have been made to your draft permit.

Please submit the following items:

1. A technical report detailing the applicability or inapplicability of 40 CFR Part 417 – Soap and Detergent Manufacturing Point Source Category, particularly subparts K (SO3 Solvent and Vacuum Sulfonation Subcategory) and L (Sulfamic Acid Sulfation Subcategory), as this could impact the limits and monitoring requirements in the draft permit.

2. Additional chemical additive information regarding additive location/purpose (see chemical additives table in Appendix B of draft permit).

3. Updated (as applicable) maps, figures, and diagrams to replace any outdated versions used in the draft permit and fact sheet.

It is requested that you submit any comments you may have to us within fourteen (14) days of the date of this email. Once your pre-public notice review is complete the draft NPDES/SDS permit will be placed on public notice for 45 days.

The pre-public notice draft permit documents can be accessed at this link:
https://app.sharebase.com/#/folder/92754/share/185-r6Mwpnf7odaWIKzvdxekJqoc-0M

A summary of the PFAS site-specific criteria documents detailing the derivation of these site-specific criteria can be accessed at this url: https://www.pca.state.mn.us/business-with-us/site-specific-water-quality-criteria. To receive copies of the site-specific criteria technical derivation reports, please contact me.

If you have any questions regarding any of the terms and conditions of the permit, please contact me at 651-757-2335 or by email at sarah.starr@state.mn.us.

Sincerely,

Sarah Starr

This document has been electronically signed.

Sarah Starr
Environmental Specialist
Water Quality Permits
Industrial Division

Enclosures: Pre-PN Draft Permit, Fact Sheet

cc: Richard Allen Chasteen, Vice President, 3M
Alma Allen-Webb, Senior Environmental Specialist, 3M
Shane Symmank, WWT Process Engineer, 3M
Darren Schwankl, Civil Engineer-3M Facilities Engineering, 3M
Christopher Bryan, Global Water Resource Specialist, 3M
Matthew Garrison, Environmental Specialist, 3M
Andy Schulz, Operations Director, 3M
Keith Schmuck, Sr. Mgr. Environment – Global Chemical Operations, 3M
Nicholas Nelson, Vice President, Barr Engineering Co
Abby Morrissette, Vice President – Senior Environment Engineer, Barr Engineering Co

Sarah Starr
Environmental Specialist
Water Quality Permits
Industrial Division
520 Lafayette Road | St. Paul, MN | 55155
Phone: 651.757.2335
sarah.starr@state.mn.us | www.pca.state.mn.us

MINNESOTA POLLUTION CONTROL AGENCY

Our mission is to protect and improve the environment and human health.

EXHIBIT F-2

Jan. 22, 2024 Ltr from 3M to MPCA requesting extension

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

January 22, 2024

ELECTRONIC MAIL

Elise M. Doucette
Supervisor
Water Section - Industrial Division
Minnesota Pollution Control Agency
520 Lafayette Road North
St. Paul, MN 55155-4194

Subject: Request for Extension of Time to Comment on Draft National Pollutant Discharge Elimination System/State Disposal System Permit for 3M Chemical Operations LLC at Cottage Grove, Minnesota

Dear Ms. Doucette:

3M Company is in receipt of the 1422-page draft permit and the 139-page Fact Sheet MPCA has provided to initiate the process of reauthorizing the 2003 National Pollutant Discharge Elimination System/State Disposal System Permit No. MN0001449 for the 3M Cottage Grove Center facility. Since receipt of the draft documents on January 12, 2024, 3M has devoted considerable staff and consultant resources to a preliminary review of the documents to identify factual discrepancies, technical feasibility, and legal issues in preparation for discussions with MPCA that will be necessary to finalize this complex permit, for a very complex facility, and to resolve the novel issues it presents.

In view of the length and complexity of the documents and their likely impact on 3M operations at Cottage Grove and other locations, I am writing to request an extension of the 14-day period, currently scheduled to expire on January 26, 2024, for commenting on the draft permit and Fact Sheet. Initially, 3M will need at least thirty days to collect and develop its views on the draft permit by undertaking a detailed review of the draft permit's extensive monitoring and testing requirements, examining the bases for and operational impacts of numerous technology-based effluent limit (TBEL) and water quality-based effluent limits (WQBEL) effluent limitations, and evaluating the draft permit's likely impacts on the Cottage Grove, Woodbury and Oakdale remediation efforts and requirements. Once 3M has completed this process, we are hoping to work collaboratively with MPCA. Based on the foregoing, we anticipate the need for a six-month period of intense engagement and collaboration with MPCA in which significant issues can be discussed, and hopefully resolved, via bi-weekly technical meetings. Thus, 3M requests an extension of the comment period to seven months from the date 3M received the MPCA documents.

We are hopeful that the issues can be resolved in less time, in which case the comment period could be truncated, and 3M is committed to pursuing discussions with MPCA as diligently and expeditiously as possible. In our experience with complex permits, it is not uncommon to collaborate on permits for 12-24 months before public notice. However, we appreciate MPCA's desire to expeditiously issue this reauthorization of the Cottage Grove Facility's 2003 permit. 3M believes much can be accomplished in seven months, or perhaps less, and we expect the process to greatly reduce the need for 3M to submit a massive comment document on the draft permit, the need for MPCA to endure a lengthy public comment process requiring MPCA responses to extensive comments, and the likelihood of contested case proceedings and permit appeals.

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

3M's preliminary review has revealed a number of important issues and concerns arising from the draft permit. A few examples are:

- The PFOS limit for Pool 2 of the Mississippi River.
- The PFOS limit presents potentially very significant feasibility issues for 3M, including whether the ongoing pump-and-treat programs at Cottage Grove, Woodbury and Oakdale can remain viable as currently constituted.
- The draft permit's sampling and analytical requirements, including the justification for sampling stormwater basins in which water is to be captured for further treatment; the feasibility of sampling 57 locations for a list of 137 PFAS analytes on a very intensive cadence; the need for analysis of PFAS analytes for chemistries that 3M has not made or used at Cottage Grove; and the limitations of available commercial analytical capabilities.
- MPCA has not yet provided the basis for, and calculations associated with, a significant number of TBELs and WQBELs in the draft permit. To better understand the bases of these limits, 3M will want to review supporting information.

3M is committed to working with MPCA to raise and begin to address, as quickly as possible, all of the issues identified during 3M's review in the course of its proposed thirty-day evaluation period.

We would appreciate your consideration of the proposed process outlined above and your prompt attention to this request. 3M's team will be available to discuss the request with you and your team at any convenient time.

Please contact me at [redacted] if you have any questions regarding this report.

Sincerely,

[redacted]

Eric B. Funk
3M Cottage Grove Center Site Director

EXHIBIT F-3

Jan. 25, 2024 MPCA grants 3M extension

MINNESOTA POLLUTION CONTROL AGENCY

520 Lafayette Road North | St. Paul, Minnesota 55155-4194 | 651-296-6300

800-657-3864 | Use your preferred relay service | info.pca@state.mn.us | Equal Opportunity Employer

January 25, 2024

Eric Funk, Site Director
3M Chemical Operations LLC
3M Cottage Grove Center
10746 Innovation Rd
Cottage Grove, Minnesota 55016-4600
Sent Electronically

RE: ***Pre-Public Notice Draft Permit – Response to Extension Request***
3M Cottage Grove Center
NPDES/SDS Permit No. MN0001449
T27N, R21W, Section 27, Cottage Grove, Washington County, Minnesota

Dear Eric Funk:

The MPCA has reviewed the request for an extension of time to comment on the NPDES/SDS Pre-PN Draft Permit for 3M Chemical Operations LLC at Cottage Grove, MN (received January 22, 2024).

An extension is granted with a revised deadline of February 15, 2024. All comments shall be submitted in writing by the close of the new deadline.

If you have any questions, please contact Sarah Starr at 651-757-2335 or by email at sarah.starr@state.mn.us, or me at 651-757-2316 or by email at elise.doucette@state.mn.us.

Sincerely,

Elise M. Doucette

This document has been electronically signed.

Elise M. Doucette
Supervisor
Water Quality Permits
Industrial Division

CC: Richard Allen Chasteen, Vice President, 3M
Alma Allen-Webb, Senior Environmental Specialist, 3M
Shane Symmank, WWT Process Engineer, 3M
Darren Schwankl, Civil Engineer-3M Facilities Engineering, 3M
Christopher Bryan, Global Water Resource Specialist, 3M
Matthew Garrison, Environmental Specialist, 3M

Andy Schulz, Operations Director, 3M
Keith Schmuck, Sr. Mgr. Environment – Global Chemical Operations, 3M
Nicholas Nelson, Vice President, Barr Engineering Co
Abby Morrissette, Vice President – Senior Environment Engineer, Barr Engineering Co

EXHIBIT F-4

Feb. 5, 2024 3M's revised request for extension

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

February 5, 2024

ELECTRONIC MAIL

Katrina Kessler, Commissioner
Minnesota Pollution Control Agency
520 Lafayette Road
Saint Paul, Minnesota 55155

Subject: Revised Request for Extension of Time to Comment on Draft National Pollutant Discharge Elimination System/State Disposal System Permit for 3M Chemical Operations LLC at Cottage Grove, Minnesota

Dear Commissioner Kessler:

This letter is a request for (1) 90 additional days, through and including May 16, 2024, to collaborate with your staff on the draft National Pollutant Discharge Elimination System/State Disposal System Permit No. MN0001449 for the 3M Cottage Grove Center facility prior to publication of the draft, and (2) an opportunity for John Banovetz, Executive VP, Research and Development & Chief Technology Officer and Rebecca Teeters, Senior VP, Global Chemical Operations, to meet with you to personally express 3M's commitment to work with MPCA to develop a strong, protective permit whose terms implement MPCA's environmental goals in a manner that is achievable. 3M would appreciate an opportunity to share with you, and thereafter to the extent you may deem appropriate with your staff, the results of 3M's preliminary review of the draft to alert you to certain factual discrepancies we believe exist, discuss the technical feasibility of certain proposed requirements, and address other novel issues that 3M believes can most effectively and efficiently be addressed prior to the publication of this complex permit for this very complex facility.

As this discussion suggests, 3M is modifying its January 22, 2024 request for additional time. The 14-day comment period was extended on January 25, 2024 to February 15, 2024, pending further MPCA review of 3M's request to hold additional technical discussions to resolve concerns identified during the preliminary review. Based on discussions during our most recent meeting on February 2, 2024, 3M respectfully requests 90 additional days, or until May 16, 2024, to allow for meaningful engagement and collaboration with MPCA to discuss and hopefully resolve significant issues that 3M believes exist with the draft. 3M proposes to do so through a series of weekly technical meetings between 3M and MPCA representatives, which we propose to begin immediately.[1] Accordingly, 3M requests an extension of the comment period through and including May 16, 2024.

Examples of the issues that 3M would like to address with MPCA during the proposed technical meetings are:

1. The facility description, location maps and flow diagrams are out of date, contain inaccuracies, and include unnecessary detail (e.g., unit sizes and design criteria) that will

[1] As noted previously, a permit of this complexity typically requires 12-24 months of discussion between the agency and the permittee. However, based on MPCA's need for an expedited resolution, this timeline is quite short and assumes consistent and responsive engagement.

3M Chemical Operations
Cottage Grove Center
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Cottage Grove MN 55016-4600

constrain the flexibility 3M will need to adapt its treatment systems to address performance issues and to meet changing conditions.[2]

2. The draft permit significantly expands 3M's monitoring and analytical obligations.[3]

    a. The draft permit increases the number of sampling and monitoring stations from 5 to 60; including internal stations where 3M believes that sampling is not needed and could interfere with flexibility needed in operations.

    b. Over 100 PFAS analytes are included, some of which lack reference standards, quickly volatilize in water, or represent chemistries that have not been made or used at Cottage Grove.

    c. The draft permit, in 3M's view, increases the monitoring and reporting frequency beyond what is required to meet MPCA's environmental goals.

    d. Some of the new stations are duplicative, do not reflect the permit application, or would apply to streams that will undergo further treatment.

3. The draft permit's Compliance Schedule should, in 3M's view, be refined to ensure it is achievable and to minimize post-finalization requests for modification.[4]

4. New studies, reports and plans are set forth in the draft permit. Each of the following presents its own issues and questions:[5]

    a. annual source identification report.

    b. PFAS removal and dispersion report.

    c. instream characterization studies.

    d. underground piping integrity plan.

5. Once 3M has completed its review of recently provided information on the technical basis for numerous technology and water quality-based limits in the draft permit, 3M would like an opportunity to discuss with MPCA technical personnel the extent to which the assumptions and rationales for various limits are supported by the record and otherwise appropriate.[6]

---

[2] 3M estimates it will require 6 - 8 weeks to complete documentation updates, review changes and reach consensus.

[3] 3M estimates this will require 8 weeks, less if we are able to reach agreement quickly on a modified monitoring station proposal.

[4] 3M estimates 2 -3 weeks for this.

[5] Clarity on the requirements for each will help avoid future disagreements and/or request for modification. We expect this will require the full requested extension period to address.

[6] Clarity on the requirements for each will help avoid future disagreements and/or request for modification. We expect this will require the full requested extension period to address.

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

3M appreciates MPCA's desire to reauthorize the Cottage Grove Facility's 2003 permit and is committed to pursuing constructive discussions with MPCA as diligently and expeditiously as possible. 3M believes much can be accomplished during the requested extension period and we expect the process to reduce the need for 3M to submit extensive comments on the draft permit, the need for MPCA to endure a lengthy public comment process requiring MPCA responses to such comments, and the potential for disagreements to lead to contested case proceedings and permit appeals.

Please contact me at [redacted] if you have any questions regarding this submittal.

Sincerely,

Keith Schmuck, CSP
Sr. Environmental Manager
3M Global Chemical Operations

CC: Elise M. Doucette, Supervisor Water Section - Industrial Division
Minnesota Pollution Control Agency

EXHIBIT F-5

Feb. 15, 2024 3M's initial comments to PPN Draft Permit

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

February 15, 2024

Ms. Elise Doucette
Supervisor of Water Quality Permits Unit
Industrial Division
520 Lafayette Road North
St. Paul, MN 55155-4194

ELECTRONIC CORRESPONDENCE

Re: Pre-Public Notice Draft Permit Comments
3M Cottage Grove Center
NPDES/SDS Permit No. MN0001449
T27N, R21W, Section 27, Cottage Grove, Washington County, Minnesota

Dear Ms. Doucette:

This letter provides preliminary comments by the 3M Company (3M) on the Minnesota Pollution Control Agency's (MPCA) Pre-Public Notice Draft National Pollutant Discharge Elimination System (NPDES) / State Disposal System (SDS) Permit (PPN Draft Permit) for 3M's Cottage Grove Center (3M Cottage Grove). 3M shares MPCA's desire to bring this permit to resolution as quickly as possible and appreciates this opportunity to work with MPCA during the pre-public notice review period.

Importantly, 3M has made, and is making, significant changes to 3M Cottage Grove that should be reflected in a renewed NPDES permit. Since approximately mid-2021, 3M has been constructing a state-of-the-science advanced wastewater treatment system specifically designed to treat per- and polyfluoroalkyl substances (PFAS) in wastewater, stormwater and groundwater (hereinafter referred to as the "advanced wastewater treatment system"). 3M expects that the advanced wastewater treatment system will be online in Spring of 2025, representing a total capital investment of approximately 250MUSD. Late in 2022, 3M announced that it would cease all PFAS manufacturing by the end of 2025 and work to eliminate the use of PFAS across its product portfolio by the end of 2025. Both of the aforementioned developments will soon significantly alter 3M Cottage Grove's PFAS discharge profile and should be accounted for in any renewed permit for that facility.

This letter does not necessarily reflect all of 3M's concerns with the PPN Draft Permit's language and conditions. Rather, the comments outlined below are provided primarily to highlight the key areas of the PPN Draft Permit for which technical collaboration between 3M and MPCA would greatly enhance the accuracy and quality of the permit. Depending upon how these technical issues are ultimately addressed in the permit, they may resolve questions about whether MPCA's decisions comport with applicable law.

To that end, 3M respectfully proposes to work actively and expeditiously with MPCA to resolve the technical and factual issues presented by the PPN Draft Permit during a reasonable extension to the PPN Draft Permit comment period. 3M is proposing to meet at a frequency that the MPCA technical representatives can support to resolve the issues of concern highlighted below in a timely fashion, and we propose to begin immediately.

1 Intervention Limits

MPCA has not provided a legal basis for its inclusion of intervention limits in the PPN Draft Permit. Neither the Clean Water Act (CWA) nor state law authorizes MPCA to impose intervention limits for the purpose of evaluating technology or otherwise controlling the discharge of pollutants at the outfall for the reasons MPCA proposes. MPCA's suggestion that these data may prove useful in the future is insufficient justification for the imposition of intervention limits. Where the Agency is able to develop and apply effluent limitations at the outfall, no statutory or regulatory basis exists to impose intervention limits. Minn. R. 7001.1080, subp. 2, provides:

> Except as provided in subpart 3, the commissioner shall establish effluent limitations, standards, or prohibitions for each pollutant to be discharged from each outfall or discharge point of the permitted facility; except that if the commissioner finds that as a result of exceptional circumstances it is **not feasible to establish effluent limitations**, standards, or prohibitions which are **applicable at the point of discharge**, the commissioner shall establish effluent limitations, standards, or prohibitions for pollutants in internal waste streams at the point prior to mixing with other waste streams or cooling water streams.

Nothing in the PPN Draft Permit or Fact Sheet suggests it is not feasible to establish effluent limitations at the outfalls. Indeed, some intervention limits actually apply to parameters that also are limited at the outfall. For example, Internal Waste Streams WS 001 through WS 009 are upstream of either SD 001 or SD 002. All of the PFAS analytes that would be tested at these internal locations would be subject to effluent limitations at SD 001 and SD 002.

Moreover, there is no clear relationship between the numeric effluent limitations for these analytes at SD 001 and SD 002 and either the intervention limits listed at WS 001 and WS 002 in the PPN Draft Permit or the *de facto* limits at SD 001 and SD002 that, as a practical matter, these intervention limits would establish.

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

In addition, the PPN Draft Permit does not establish numeric effluent limitations at SD 001 and SD 002 for ten (10) PFAS parameters that have intervention limits, thus creating *de facto* limits for these ten (10) analytes at SD 001 and SD 002 that lack any of the technical and legal justification required by MPCA's rules.

1.1 De Facto Effluent Limitations – The PFOA Example:

The PPN Draft Permit proposes numeric effluent limitation for PFOA at SD 002 of 123 parts per trillion (ppt) for the monthly average and 214 ppt for the daily maximum. Flow at SD 002 is a combination of flow from WS 002 (AIX effluent) and the reverse osmosis (RO) permeate flow (which should be near non-detect for all PFAS). Not only does MPCA lack a legal basis under the rules to impose the intervention limit at WS 002 of 9.6 ppt, but that limitation clearly is not necessary to ensure that the numeric effluent limitations at SD 002 (123 ppt or 214 ppt) will be achieved. Further, since flow at SD 002 is a dilution of the water sampled at WS 002 with the RO permeate (which should be non-detect on all PFAS), the intervention limit at WS 002 of 9.6 ppt establishes a *de facto* effluent limit at SD 002 of 1.8 ppt, far below the numeric effluent limitation proposed for SD 002 (123 ppt or 214 ppt). This occurs because the PPN Draft Permit requires that 3M undertake serial, operational response actions each time the intervention limit is exceeded, resulting in concentrations downstream of WS 002 dictated by the intervention limit (prior to combining with the RO permeate flow) not the effluent discharge limitation proposed for SD 002. MPCA has not followed the required procedures in the rules for developing and justifying these *de facto* limits.

The same is true for five (5) of the six (6) PFAS that have numeric limits at SD 001 and SD 002 – PFBS, PFHxS, PFBA, PFHxA, and PFOA. The only analyte of the six (6) that differs is PFOS, due to the very low numeric limitation at SD 001 and 002, which 3M addresses below.[1]

1.2 Impact of Intervention Limits

Intervention limits will shift PFAS removal from anion exchange resin (AIX) to granulated activated carbon (GAC). This shift will lead to an increase in waste generation without improving the advanced wastewater treatment system's capability to achieve lower discharge limits. The following is a discussion of specific WS locations with intervention limits for PFAS treatment.

- WS 006 and WS 007: MPCA has not provided a legal basis for its inclusion of intervention limits for PFOS and PFOA at WS 006 and WS 007. These proposed intervention limits also are unnecessary because these locations are upstream of the 3M

[1] 3M is not suggesting, however, that intervention limits are warranted for PFOS. 3M maintains that MPCA lacks any legal basis to impose intervention limits.

Cottage Grove wastewater treatment plant (WWTP) and the advanced wastewater treatment system.

Additionally, the proposed intervention limits for PFOS and PFOA at WS 006 and WS 007 will increase the frequency of GAC change out from an average (between the potable and non-potable systems) of one carbon changeout every 90 days to an average of one change out every six days, with the potable system requiring change out every three (3) days. This will lead to an increase in annual carbon usage of over **10 million pounds** without reducing PFAS concentrations in SD 001 and SD 002 effluent. Additionally, this more frequent change out of GAC may not be practicable, as it is doubtful that the GAC vendors would be able to change out the GAC at these required frequencies.

- WS 003 and WS 004: MPCA has not provided a legal or technical basis for its inclusion of Intervention limits for PFOS and PFOA at WS 003 and WS 004. The advanced wastewater treatment system does not require the majority of the PFOS and PFOA to be removed by the GAC. The majority of the mass of these species, and almost all of the PFAS species, will be removed by the AIX. Additionally, the proposed intervention limits for PFOS and PFOA at WS 003 and WS 004 will increase the frequency of GAC change out at these points and lead to an increase in annual carbon usage of over **one (1) million pounds** compared with the current design estimates. The increased GAC change out will not assist in reducing PFAS concentrations in SD 001 and SD 002 effluent.

- WS 001 and WS 002: Ten (10) PFAS species have intervention limits at WS 001 and WS 002 but no numeric effluent limits at SD 001 and SD 002. MPCA has not provided a legal or technical basis for intervention limits for these species. Specifically, the intervention limits are unnecessary to achieve downstream numeric limits as there are no such limits for these species downstream at SD 001 and SD 002. The proposed intervention limits for these species also will lead to an increase in regeneration frequency that will increase the material usage, waste generated, and energy consumed. For example, the intervention limit for 2333-TFPA will lead to the following annual increases compared with current design estimates:
    - >5 million lbs of sodium chloride consumed
    - >500,000 lbs of ethanol consumed
    - >20 million lbs of brine waste generated
    - >5 million therms of natural gas used
    - >8 million kWh of electrical energy used

Moreover, the intervention limits are impracticable as they would require regeneration at a frequency faster than the system could process the regenerant, among other constraints.

1.3 Inappropriate Use of Intervention Limits on Adsorptive Processes

The use of intervention limits in the PPN Draft Permit to control adsorptive processes is inappropriate and unnecessary. Adsorption processes are inherently non steady state processes. Whether the decision to take action on a given GAC or AIX column is based on elapsed time or a measured concentration, this approach and action plan should be documented in the O&M Manual and not handled *ad hoc* by using an intervention limit. Typically, this decision will be based on a "sentinel" compound and will not require separate criteria for 16 or more species. For example, the operation of the AIX columns will be based on breakthrough of TFA, which happens in days. The advanced wastewater treatment system has 30 AIX vessels, each of which will be at some state of operation on the breakthrough curve, will be undergoing regeneration, or will be in standby, waiting to be put back into service. There will be several vessels undergoing regeneration per week which should be managed as a matter of normal operation. Therefore, the design of the system is extremely conservative and does not need to be controlled by these intervention limits. MPCA does not have authority to control these breakthroughs as prescribed in the intervention limits section, and doing so will arbitrarily interfere with rational operation of these systems.

2 PFOS Criteria Limits

As you know, 3M has been evaluating the likely impacts of the PPN Draft Permit's PFOS effluent limitation on the Cottage Grove, Woodbury and Oakdale remediation efforts and requirements. If the criterion is included in the final permit, 3M has serious doubts about its ability to continue with those efforts as presently constituted. The PFOS criterion underlying MPCA's proposed PFOS effluent limitation is seriously flawed and has resulted in the unrealistic effluent limitation in the PPN Draft Permit, which in turn raises fundamental questions about the feasibility of continuing to treat remediation groundwater.

MPCA relies on Minnesota's human health protective site-specific water quality criterion for perfluorooctane sulfonate (PFOS) published in December 2020 to impose water quality based effluent limits in the PPN Draft Permit. This criterion was developed after determining that the primary basis for concern is the potential for high exposure from consuming fish caught in Minnesota surface waters. The criterion does not appear to have been through a public comment period or subjected to scrutiny in another NPDES permit. 3M submits the following preliminary comments on the basis for this criterion.

2.1 Use of Non-Site-Specific Data

MPCA's reliance on data from sampling in waters elsewhere in the state, while not accounting for recent data specific to Pool 2 of the Mississippi River, is arbitrary and unsupportable. MPCA relies on Minn. R. 7050.0217 to 7050.0219 and 7052.0100 for authority to develop site-specific criteria for the Lake Superior Basin. MPCA rules provide that "a site-specific criterion so derived **is specific to the point source being addressed.**" Minn. R. 7050.0218 (emphasis added). The pre-public-notice draft Fact Sheet refers to the need for a site-specific criterion because PFAS are discharged from 3M Cottage Grove and the criterion is specific to the "point source being addressed and to protect water quality in Pool 2 of the Mississippi River for human health." Fact Sheet at 88.

Yet, the primary basis given for development of a chronic criterion for PFOS in the 2020 technical support document (TSD) is "the potential for high exposure to PFOS from consuming **fish caught in Minnesota's surface waters**." TSD at 6 (emphasis added). The underlying TSD largely relies on data from across the state outside of Pool 2 as the basis of the criterion. Specifically, the description of the data used to develop the bioaccumulation factor (BAF) in the TSD states the need to support an "interim state-wide BAF" and account for "bioaccumulation of PFOS in many species of fish caught and consumed in Minnesota." TSD at 15.

If the MPCA seeks to develop a standard protective of the entire state, then development of that standard should be conducted under the normal water quality standards development process of formal rulemaking, which provides an opportunity for input from stakeholders. MPCA has offered no cogent justification for using disparate data from other water bodies to impose a site-specific PFOS criterion for Pool 2.

- A site-specific criterion should be based on data from the receiving water body. The term "site-specific" has been understood to apply to specific water bodies or groups of water bodies related by common conditions and features such as lotic and lentic, shallow or deep, ecoregion, etc. The TSD does not describe any connection between the data used in development of the criterion and conditions in Pool 2 of the Mississippi River. The requirement of Minn. R. 7050.0218, subp. 2(A) that any "site-specific criterion so derived is specific to the point source being addressed" indicates that the rule is intended to be narrowly applied to the discharger and the receiving waters in question. This can only be accomplished by using site-specific data when it is available. Use of site-specific data is critical to developing site-specific criteria because several of the components described in the TSD (water concentration, fish tissue concentration, BAF, fish consumption rate) can significantly affect the outcome and vary by orders of magnitude.
- 3M provided its 2021 River data to MPCA that is specific to Pool 2, but those data have not been used; rather, this PFOS criterion is based on data from dissimilar waterbodies

elsewhere in the state. 3M and MPCA collaborated in conducting an Instream PFAS Characterization Study (IPCS) Work Plan (WESTON, 2021). MPCA received the results from this extensive study in June 2023. Data provided in this study would provide site-specific information for development of a site-specific criterion. It does not appear that any of these data were considered in deriving the site-specific PFOS effluent limitation set forth in the draft permit.

2.2 The PFOS Criterion is Scientifically Flawed

Even if it were appropriate under the regulations to rely on data from dissimilar waterbodies to develop the PFOS criterion and use it to establish a site-specific PFOS effluent limitation for 3M Cottage Grove, the basis for the PFOS criterion value is not scientifically sound. The proposed criterion value is out of sync with other published approaches, EPA's work, and norms for managing toxic pollutants under the Clean Water Act's NPDES program. While there may be additional issues that should be explored during a rule-making process, 3M has identified several key areas where the proposed criterion is not scientifically defensible.

- The bioaccumulation factor (BAF) selected by MPCA is five times more conservative than values published by others including EPA's Great Lakes Laboratory. It is inappropriate to use a BAF derived from disparate water bodies to derive site-specific effluent limitations because bioaccumulation of PFOS into fish can be highly site-specific. The accumulation of PFOS into fish can be significantly influenced by abiotic and biotic factors that can be specific to different aquatic systems. This is especially true of Pool 2 where PFOS concentrations in water and in fish have decreased over the last 10 years but not at the same rate. As a result, temporal differences in fish BAFs have been observed within Pool 2 and in Section 4 of Pool 2 where 3M Cottage Grove discharges to the Mississippi River. In this section of the Mississippi River, fish BAFs have been shown to be considerably below the 7,210 L/kg value used by the MPCA to derive its PFOS criterion. BAFs calculated in this section of the Mississippi River have continued to decrease as shown in the table below.

Species specific PFOS bioaccumulation factors (BAFs) for fish collected from Section 4 of Pool 2 in the Upper Mississippi River[a]				
Species	MPCA 2010[a]	3M 2011[b]	MPCA 2013[c]	3M 2021[d]
Bluegill	2990	880	1710	181
Carp	2520	-	1240	161
Freshwater Drum	7013	911	-	267
Smallmouth Bass	5060	1610	2990	320
White Bass	3290	1730	2522	838
Black Crappie	-	-	-	814
Walleye	-	-	-	297
All fish geomean	3880	1220	2000	338
[a] MPCA, 2010. Mississippi River Pool 2 Intensive study of perfluorochemicals in fish and water. 2009				

[b] Newsted et al. 2017
[c] MPCA, 2013. Perfluorochemicals in the Mississippi River Pool 2: 2012 Update
[d] Weston Solutions, Inc. June 29, 2023. Instream PFAS Characterization Study Final Report, Mississippi River, Cottage Grove, Minnesota. 2021.
BAF units are L/kg,
All fish data are fillet only

The geometric mean of all fish BAFs is 399 L/kg based on surface water and fish (fillets only) PFOS concentration data collected in 2021 for Reaches R01 and R02 (Pool 2) (Weston 2021). This BAF is approximately 18-fold less than the BAF used in the MPCA PFOS water quality criterion derivation. Given the temporal and spatial differences observed between the BAF values used by MPCA and the BAF values calculated for Pool 2, it is improper to use the MPCA criterion for developing effluent limitations to be applied in Pool 2. Site-specific data that represent current conditions at a site provide a far more accurate basis for developing defensible effluent limitations that comport with MPCA regulations.

- MPCA and the Minnesota Department of Health's (MDH) reliance on the toxicokinetic serum model assumptions that drive the WQC endpoint is overly conservative. Standard human health risk assessment procedures use conservative (i.e., health protective) assumptions to calculate risks or criteria; however, MPCA's compounding use of high-percentile parameters along with an unverified toxicokinetic (TK) blood serum model, to develop the PFOS water quality criterion is flawed. 3M recommends both that 1) the model be re-evaluated and validated prior to its use for setting water quality criteria, and 2) the model parameters be updated to reflect site-specific values. While it is important to recognize and incorporate early-life stage exposure when evaluating risks to human health, it is also critical to use proven methods for risk evaluation.

  The model applies a "mean upper percentile" and "upper percentile" (i.e., mean + 2 standard deviations) placental transfer factor for PFOS and breastmilk intake rate, respectively, resulting in a highly conservative exposure scenario. These factors are multiplicatively combined with many other conservative parameter estimates (including those discussed below) and BAFs, resulting in extremely low criteria that are not scientifically justifiable.

  Two examples of where site-specific model parameters should be incorporated are 1) the fish consumption rate, and 2) the relative source contribution. Other model parameters should also be examined to determine whether they can be made more site-specific.

  - **Fish consumption rate** – Fish consumption rates are known to be highly variable across individuals, and thus site-specific data should be used for criteria development that are specific to a given area or water body. Minn. R. 7050.0219 subp. 13 specifies that the fish consumption rate for adults (ages 16-70) is 0.43 g/kg-day. The PFOS exposure scenario that was input to the MPCA's TK tool was 0.94 g/kg-day for ages 16-50 and 0.43 g/kg-day from ages 50-54. MPCA's use of the resulting time-weighted consumption rate of 0.725 is 69% higher than the value stipulated by the regulation. MPCA's suggestion that this higher consumption rate for women of child-bearing age represents a reasonable maximum exposure (RME) scenario is based on the 90th percentile consumption rate of 66 g/day reported from a survey of North Shore Minnesotans. The reasonableness of assuming this consumption rate for the local population from Cottage Grove and surrounding areas (e.g., Twin Cities) is highly questionable, as MPCA has not determined whether fishing behaviors in these areas may be quite different from the population surveyed by MPCA.

As such, the extreme case selected by MPCA is neither site-specific nor consistent with the regulation. Moreover, MPCA acknowledges that the women surveyed from the North Shore were not asked whether the fish they consume are caught or store-bought, meaning that the consumption rate is likely to be grossly exaggerated by the inclusion of store-bought fish. For these reasons, the fish consumption rate should be reevaluated and made more site-specific and specific to caught fish.

- **Relative source contribution** – MPCA indicates that a default relative source contribution (RSC) value of 0.2 or 20% for fish tissue consumption is relevant for PFOS pursuant to Minn. R. 7050.0219. TSD at 17. This default value may be inaccurate for site-specific criteria development for PFOS in particular. For example, the Great Lakes Consortium for Fish Consumption Advisories (2019) proposed values to guide the derivation of fish consumption advisory levels. in its report, the consortium calculate that, based on conservative exposure assumptions, fish tissue consumption might correspond to between 77% and 93% of PFOS exposures (relative to background exposures based on NHANES data). Because fish diet was by far the dominant route of exposure, they indicate that "further consideration of . . . an RSC limit is not needed" meaning that the 0.2 default value is overly conservative in their estimation. MPCA should undertake a more detailed and site-specific consideration of the default 20% RSC, as it has a potentially significant influence on the PFOS criterion. Because PFOS has been phased out of consumer products, the majority of current and future exposures will likely be from dietary routes.

- MPCA has not documented the reliability of the data set it used; application of the Criteria for Reporting and Evaluating Exposure Datasets (CREED) (Di Paolo et al. in press) guidance would provide one approach to meeting this obligation. Minn. R. 7050.0219 subpart 3, provides that the data and information used to develop a water quality criterion must be approved by the MPCA commissioner, and that the commissioner must consider reliability of the data and information for the purpose to which the data and information are applied. The record does not include information showing MPCA has complied with Rule 7050.0219.

MPCA's PFOS BAF is fundamental to its PFOS chronic criterion calculation. The process for deriving BAFs used in the calculation of human health-based criteria is described in Rule 7050.0219(6). Subpart 6 identifies data reliability assessment as part of the derivation process, but it does not define the term "reliable." Neither does Rule 7050.0130. Consequently, Rule 7050.0219(7) applies. Subpart 7 states that terms not defined by subparts 1 through6 "shall be construed in conformance with the content, and in relation to the applicable section of the statutes pertaining to the matter, and current professional usage."

The regulatory language requires the commissioner to assess the reliability of the bioaccumulation data by reference to current professional usage. In this context, current professional usage demands a level of transparency and consistency with best practices that is lacking in the derivation of the PFOS chronic criterion. Current professional usage requires consideration of relevance (suitability for purpose) alongside reliability.

CREED provides a useful framework for how exposure datasets are assessed under current professional usage. CREED defines 19 reliability criteria and 11 relevance criteria that should be applied when data are used to support decisions that create environmental compliance obligations. Other frameworks for professional usage of environmental datasets also are organized around reliability and relevance but go beyond CREED.

3 PFAS Analyte List

3M has reviewed the proposed PFAS analyte list and has identified the following concerns regarding the list:

- Inclusion of PFAS compounds unrelated to current or historic operations at 3M Cottage Grove;
- Lack of approved analytical methods for some PFAS compounds listed;
- Volatility of PFAS compounds in water;
- Duplicative PFAS compounds;
- Historical non-detects of certain PFAS compounds; and
- Capabilities of commercial laboratories to analyze for PFAS compounds.

Each concern is discussed in more detail in the subsections below.

3.1. Inclusion of Unrelated PFAS Compounds

3M Chemical Operations
Cottage Grove Center
10746 Innovation Road
Cottage Grove MN 55016-4600

The PPN Draft Permit requires monitoring for 137 PFAS compounds, which includes approximately 40 PFAS that are not related to chemistries produced or used at 3M Cottage Grove currently or historically. Those PFAS are associated with materials derived from the products or processes of other PFAS manufacturers and are not consistent with the expected 3M chemistries derived from electrochemical fluorination (ECF) processes. Table 1, attached hereto, identifies the PFAS compounds that are not of 3M origin or use and are not reasonably expected to be present in the wastewater or stormwater discharges from the facility. Such compounds include PFAS from fluorotelomer (FT) production processes or are fluorinated ether acids (R_1-O-R_2-COOH) not of 3M origin.[2] Historical monitoring at 3M Cottage Grove that included analytical sample results for FT chemistries show that FTs were not detected in wastewater and stormwater discharges as far back as 2007. This includes 4:2 FTS (757124-72-4), 6:2 FTS (27619-97-2) and 8:2-FTS (39108-34-4). For the foregoing reasons, 3M requests that all PFAS compounds identified as “not 3M” in the column labeled “Reason to Remove” in Table 1 be removed from the permit.

3.2 Lack of Approved Analytical Methods and Standards for some PFAS Compounds Listed

MPCA lacks the authority to include any PFAS compounds that do not have an approved analytical sampling method under 40 C.F.R. Part 136 or state law. The PPN Draft Permit lists numerous PFAS compounds for which there are no approved analytical methods or available analytical reference standards. Some of the substances on the list were derived from non-targeted analysis (NTA) results for 3M Cottage Grove but were assigned Schymanski confidence levels of two (2) through five (5). The Schymanski levels two (2) through five (5) indicate that their tentative identities could be not verified due to lack of a reference standard for confirmation of the proposed molecular formula and/or structure. In some instances, the PFAS compounds in the list derived from NTA were only provided in the draft permit as molecular formulas, without CASRNs or any other identifier. Only compounds from NTA identified with a Schymanski level of one (1) have a reference standard available and were confirmed, and only those substances would be able to be reliably quantified against calibrants. In some instances, other PFAS in the list also do not have analytical reference standards available and should be removed. Table 1 identifies PFAS compounds for which a quantitation method cannot be possible because there is no analytical reference standard available. 3M requests that those PFAS be removed from the permit. 3M has already performed NTA for PFAS in stormwater, groundwater, and wastewater and determined 4H-PFBA, FHxSA and MEDSULF

[2] Other chemistries listed in the PPN Draft Permit may also fall into this category. Those listed here are the chemistries we have identified given the limited time available for review of the PPN Draft Permit.

at Schymanski Level 1. These PFAS have been incorporated into the wastewater sampling and monitoring program for 3M Cottage Grove.

3.3. Volatility of PFAS Compounds in Water

There are several PFAS substances that are not stable in water based on available data. Instability is identified as either hydrolytic breakdown of the compound that occurs too fast to afford reliable analysis of the collected samples, or substances having Henry's Law coefficients (air/water) such that they do not remain present in water. Guidance from EPA OPPTS 835.6100 provides a classification to characterize the potential for chemicals to volatilize from water based on the dimensionless Henry's Law air/water distribution ratio (Kh). Per EPA OPPTS 835.6100, if Kh dimensionless >10^{-3} the compound is considered volatile from water surface. Based on this guidance such a compound should be removed from the target analyte list as any analysis would be considered futile. The compounds experiencing instability or volatilization from water per OPPTS 835-6100 include:

- DIOFB (375-50-8), which is hydrolytically unstable in water.
- HFP (116-15-4), Kh dimensionless >10^{-3}
- PFSA Monomer (88190-28-7), Kh dimensionless >10^{-3}
- PBSF (375-72-4), Kh dimensionless >10^{-3}
- PMVE (1187-93-5), Kh dimensionless >10^{-3}
- TFE (116-14-3), Kh dimensionless >10^{-3}
- VDF (75-38-7), Kh dimensionless >10^{-3}

The compound MeFBSEA is a neutral PFAS that is poorly soluble in water and difficult to detect in water by LC/MS/MS analysis and traditionally has resulted in non-reportable results due to failed QCs. However, the potential degradation products of MeFBSEA as PFBSi, PFBA, PFBS, FBSA, and MeFBSAA are on the list to capture potential MeFBSEA, which should be removed from the list for direct measurement. 3M requests that the PFAS discussed in this section be removed from the PPN Draft Permit.

3.4 Duplicative PFAS Compounds

Many PFAS are listed twice (duplicated). Duplicates should be removed and the list consolidated to avoid redundant reporting. 3M requests that the following duplicates be removed from the PPN Draft Permit:

- PBSK (375-73-5) should be removed because PFBS (375-73-5) is already listed.
- TPBP:MeFBSA (332350-90-0) is a salt and both components TPBP and MeFBSA are analyzed individually since they are expected to dissociate in water.

- MeFBSA (68298-12-4) is listed separately already, we recommend listing TPBP:MeFBSA as only TPBP in the list for reporting reasons. TPBP is not a PFAS and 3M tests MeFBSA.
- PMPA/PFECAF (13140-29-9) is PFMPA, and is listed two more times as MTP/PFMPA (377-73-1). Recommend removing two of them and keeping just PFMPA (377-73-1).
- NaPFDoS (1260224-54-1) is duplicated on the list as PFDoS (79780-39-5), and the NaPFDoS should be removed from the list.
- NaPFDS (2806-15-7) is duplicated as PFDS (335-75-3), the NaPFDS item should be removed.
- LiTFMS (33454-82-9) is duplicated as TFMS/PFMeS (1493-13-6), the LiTFMS item should be removed.
- PFeCHS-K (67584-42-3) is duplicated as PECHS/PFECHS (335-24-0) and the PFeCHS-K should be removed.
- PFNS/PFNS-NA/LPFNS (68259-12-1) is duplicated as PFNS (68259-12-1), the PFNS/PFNS-NA/LPFNS item should be removed.
- 10:2 FTSA (120226-60-0) is duplicated as 10:2 FTS (120226-60-0), both should be removed because they are fluorotelomer compounds and non-3M chemistry, as noted earlier.

A related concern is that several PFAS have been included in monitoring historically at the site but have never been detected (in testing from 2007 through 2023) besides those three (3) non-3M chemistries described above (4:2, 6:2 and 8:2 FTSs). They include PFNS, PFDS, PFDoS, PFOSA-NO, ADONA, N-MeFOSAA, BPAF and PHSA-DC. These PFAS should be removed from the permit as 3M does not have reason to believe that such PFAS are present at 3M Cottage Grove.

3.5 Summary of PFAS to Remove from the Permit

Table 1, attached hereto, is the original list of PFAS provided by MPCA together with 3M's comments regarding the bases for removing PFAS from the PPN Draft Permit as discussed above. Table 2, attached hereto, is 3M's proposed final list of 65 PFAS analytes. The PFAS analytes on Table 2 each have an associated method (commercial or 3M-internal) and reference standard available to support laboratory analysis. 3M respectively requests that MPCA substitute the list of PFAS analytes identified in Table 2 for the list of PFAS analytes identified in Table 1.

4 Special Requirements

The PPN Draft Permit contains numerous special requirements. 3M comments on a number of those requirements in the discussion below.

4.1 Per- and Polyfluoroalkyl Substances Analyses

Requirement 5.72.62 of the PPN Draft Permit contains numerous requirements related to the sampling and analysis of PFAS at all monitoring locations. As proposed, the PPN Draft Permit would require 3M to collect 572 weekly samples, 60 monthly samples, 104 quarterly samples, and 18 annual samples, as well as to conduct laboratory analyses to generate approximately 72,098 data points annually. In addition to the significant sampling and testing burden imposed by the monitoring regime proposed by MPCA in the Draft PPN Permit, 3M has several additional concerns with other aspects of MPCA's proposed monitoring program as outlined in 5.72.62.

First, MPCA proposes to require 3M to deploy laboratory analytical methods for PFOS and PFOA with a level of quantitation (LOQ) of 2 ng/L in wastewater. However, we know from experience as well as from EPA's final proposed maximum contaminant levels for PFOA and PFOS in drinking water that it is not practical or even feasible to achieve an LOQ of 2 ng/L. *See* U.S. EPA, PFAS National Primary Drinking Water Regulation Rulemaking, 88 Fed. Reg. 18638, 18666 (March 29, 2023) (EPA determined that 4.0 ppt is the lowest concentration that PFOA and PFOS can be reliably quantified within specific limits of precision and accuracy during routine laboratory operating conditions).

Second, MPCA proposes to require 3M to conduct "[n]on-targeted PFAS analysis . . . [at a] minimum frequency of once per year . . . at all locations in this permit." But MPCA's proposal fails to recognize that 3M will shortly be exiting the manufacturing and processing of PFAS. As such, any PFAS present in the discharge from the site will be associated with legacy PFAS operations not ongoing operations. Therefore, repeated annual NTA of wastewater at all locations will offer little, if any, additional helpful information regarding compliance and treatment alternatives.

Third, the requirement to analyze and "have results finalized for potential submission to the MPCA within 30 days of sample collection" is unreasonable, impracticable, and physically impossible. At this time, even assuming that MPCA is requiring 3M to collect samples, analyze them, and certify the results on a standard cadence, the current commercial laboratory turnaround times for PFAS parameters are between 12 to 20 weeks. However, MPCA's proposal is even more impractical as it would require that 3M sample, analyze and certify samples results on an almost daily basis independent of any cadence to submit such results in accordance with the standard discharge monitoring report submission requirement. Because it is impracticable to comply with the 30-day turnaround time, 3M requests that this timeframe be removed or modified to reflect current laboratory capacity and capability.

4.2 PFAS Certification Statement and Annual Source Identification Report (5.72.63/64 and 6.61.6).

The requirement for an annual source identification report has no legal basis. 3M has an obligation under the NPDES program to meet its effluent limitations and properly operate its wastewater treatment system 3M demonstrates compliance with its wastewater permit by monitoring and reporting the quality and quantity of pollutants in its discharge. The requirement that 3M annually provide a source identification report, either at 3M Cottage Grove or other 3M sites, is without basis in law and does not appear to have an associated CWA compliance purpose. Therefore, 3M requests that this requirement be removed from the permit.

4.3 Annual Non-targeted Analysis (NTA) (5.72.72 and 6.61.9).

Only level-1 NTA identified PFAS are verified with a reference standard to conclusively determine their identity, so that subsequently they can be available for further analytical methods development and quantitation. Compounds identified as levels two (2) through five (5) are not verified by a reference standard because no standard is available. Those PFAS should not be on the permit because a reliable quantitation method would not be possible.

In addition, the NTA requirement should terminate after 2026. 3M Cottage Grove is in the process of phasing out all PFAS manufacturing and processing by the end of 2025. 3M proposes that NTA be discontinued after 2026 (one year after our PFAS phase out is complete). It would not be rational to expect identification of new PFAS after that time.

4.4 Instream PFAS Characterization Study (5.72.75 and 6.61.10-14).

The 2021 Mississippi River instream study is the single largest PFAS aquatic study performed to date. That study was highly resource intensive, required extraordinary effort over a relatively short period of time, and resulted in an extraordinarily large data set.

Based on our significant experience in completing the 2021 study, 3M respectfully requests that the inter-study time period for instream studies be extended to 10 years rather than 5 years. Fish-tissue concentrations have decreased significantly (~95%) in Pool 2 since 2005. Decreasing concentrations of PFAS also were observed in Pool 3. The decreased concentrations in fish tissues appeared to fit to pseudo-first order loss in each Pool. The estimated time for 50% reduction of PFOS for the different fish species ranged from 2 to 6 years for PFOS, and time for 90% reduction in concentrations ranged from 5 to 20 years, depending on species and Pool. Therefore, 10 years is a more optimal timeframe to capture at least one additional halving of the fish tissue concentrations, if not possibly two to three for some species, to support the strong trends and estimate future levels for PFAS in fish tissues.

4.5 Underground Piping Integrity Plan and Annual Underground Piping Report (6.61.16).

3M agrees with MPCA that the integrity of underground pipes at 3M Cottage Grove is of utmost importance. However, it is unlikely that 3M will be able to assess all such pipes within three years. 3M is only able to assess pipe during plant shutdowns when there is no flow. Plant shutdown happens once per year over Memorial Day weekend. Because of those restrictions, 3M requests that investigation of the high priority/high risk pipes be assessed within three (3) years, and all other pipes within five (5) to ten (10) years. 3M has previously conducted a study of the underground piping system and identified which piping systems are higher risk.

4.6 O&M Manual Requirements (5.72.86-97 and 6.61.18-24).

3M submits the following comments on the PPN Draft Permit O&M requirements:

- The deadline to submit the O&M Manual should be revised. Rather than a fixed date, the deadline for completing revision of the O&M Manual should be 60 days after the advanced wastewater treatment system startup date in the compliance schedule (see Section 7).
- The requirement to submit updates to the O&M Manual within 30 days of making any changes will cause an undue and unnecessary administrative burden. Numerous changes are to be expected in the course of optimizing the advanced wastewater treatment system, and it is more reasonable to require submission of manual updates on an annual basis.
- The requirement to submit an annual O&M Deviation Report is extremely broad and ambiguous. Given the flexible and evolving nature of an O&M Manual, this requirement should be revised to characterize deviations much more precisely in order to focus narrowly on significant deviations.

3M requests clarification as to the PPN Draft Permit's requirement to provide reports of deviations from O&M requirements. The O&M Manual and associated SOPs for 3M Cottage Grove describe conditions and procedures for normal operation, and they make clear that variations will occur. The practice of varying operational procedures when necessary therefore constitutes an integral component of the O&M Manual; varying operational procedures is a normal practice under the O&M Manual, not a deviation from the O&M Manual. The O&M Manual strives for a balance between providing clear instructions to operators and allowing flexibility to alter operations, usually after consultation with supervisors and other 3M professionals, when necessary to address abnormal conditions. Necessary operational changes will cover a wide range of topics and degrees of alteration from normal operating procedures.

3M believes it would be unnecessary and burdensome to log and report every operational change or adjustment, no matter how minor, as a deviation from the normal condition described in the O&M Manual. The draft permit should make clear that operational changes constitute reportable deviations only when such changes may impact compliance with discharge limitations. 3M believes this topic would benefit from detailed discussion with MPCA technical staff prior to finalizing the draft permit for public notice.

4.7 River Monitoring Associated with Remediation Activities (Section 5, Requirement 5.72.100-5.72.101).

Requirement 5.72.101 of the PPN Draft Permit states that the results of any river monitoring of fish, water, or sediment associated with remedial activities also must be submitted with the NPDES reporting requirements. The permit relies on Minn. R. 7001 as the justification for this requirement. Minn. R. 7001 does not appear to support this request, and, therefore, 3M requests clarification as to MPCA's specific authority to require river monitoring associated with remedial activities as part of NPDES compliance.

5 Monitoring Stations

The PPN Draft Permit requires sampling at an excessive number of monitoring stations. The 2003 version of NPDES Permit No. MN0001449 contains five (5) surface discharge monitoring locations. The PPN Draft Permit contains 56 monitoring stations – 25 surface discharge (SD) stations, four (4) surface water (SW) monitoring stations, and 27 waste station (WS) monitoring stations. Based on our review of the PPN Draft Permit monitoring stations, 3M recommends that the proposed permit be modified to remove a number of monitoring stations.

5.1 SD Locations

3M requests that three (3) SD locations be removed from the permit for the reasons set forth below:

- SD 009 – SD 009 is not a source of direct discharge: Stormwater flows at and to this location are routed to Catch Basin 3J/3T and then to the WWTP where they are treated prior to discharge through SD 001. Overflow from Catch Basin 3J/3T is monitored at SD 020.
- SD 028 – 3M plugged SD 028. Stormwater is captured at this location (Catch Basin 3Y) and then routed to the WWTP for treatment prior to discharge through SD 001.
- SD 029 – No runoff from operational areas is routed to this location.

5.2 Internal Monitoring Stations

WS 001-007 of the PPN Draft Permit contains internal monitoring stations associated with the advanced wastewater treatment system. 3M requests that these stations be removed from the permit, as MPCA has not demonstrated any rational basis or legitimate purpose for requiring monitoring at these locations. As discussed above, the inappropriateness of applying intervention limits based on results from these monitoring stations undermines MPCA's rationale for the stations themselves.

5.3 Monitoring Stations Associated with Stormwater Basins

WS 008-019, 021-22, and 24-27 are internal monitoring stations associated with the 3M Cottage Grove lined stormwater basins. 3M requests that these stations be removed from the permit. Each of these stormwater basins has a permitted overflow location, a liner, and infrastructure to collect all stormwater for further treatment through the wastewater treatment system. None of these stations is associated with a direct discharge or related compliance requirements. MPCA did not provide a reasonable basis or sufficient justification for the inclusion of these stations as required in 40 C.F.R. § 122.45(h) and Minn. R. 7001.1080, subp. 2 (see Section 1).

6 Contaminated Groundwater Pump-out

The following comments are provided based on a review of the PPN Draft Permit, Section 5, Requirements 5.78.203 through 5.78.232, all of which pertain to the Facility's Groundwater Treatment Plant (GWTP). Comments have been grouped together by overall theme and include specific references to requirement where removal or edits are requested.

6.1 TBELs Apply at the Point of Discharge

Requirements 5.78.205 through 5.78.207 are related to the implementation of best available technology (BAT) to treat groundwater. These requirements are not clear as to the physical location at which technology-based effluent limitations (TBELs), such as BAT, are to be applied.

The GWTP is located in Building 92. The GWTP employs GAC treatment processes. Water treated in Building 92 is ultimately stored in primary storage reservoirs at Building 93 and is then used for various on-site manufacturing processes, such as non-contact cooling water, or is sent for reuse. In no case does the GWTP discharge directly to a surface water other than after reuse and comingling with process wastewaters for discharge via SD 001 or SD 002.

Requirement 5.78.207 specifies that a TBEL will be applied "at the point of discharge from the treatment system." If that is MPCA's intent, the requirement is incorrect in two respects. First, the requirement relies on 40 C.F.R. § 125.3. That regulatory provision requires application of TBELs "prior to or at the point of discharge." The CWA defines "discharge of pollutants" to be the addition of pollutants to navigable waters. 33 U.S.C § 1362(12). As noted above, effluent from the GWTP is not discharged to navigable waters until it arrives at SD 001 or SD 002. Those outfalls are the presumptively correct location for application of permit limits based upon TBELs. Second, while in a literal sense the point at which effluent exits the GWTP certainly is "prior to" the eventual discharge of that commingled effluent at the outfalls, in the overall context of the treatment systems at 3M Cottage Grove, the exit from the GWTP is an internal location at which MPCA's authority to apply effluent limitations is subject to regulatory limitations. Minn. R. 7001.1080, subp. 2 provides that it is proper to apply limitations to internal streams only in "exceptional circumstances" when the commissioner finds that developing effluent limitations at the point of discharge is not feasible. 3M is unaware of any such finding by the commissioner.

6.2 GWTP Design and Startup Requirements are No Longer Relevant

Requirements 5.78.208, 5.78.226, and 5.78.229 all pertain to GWTP design or startup. These requirements are no longer relevant. Design drawings and specifications for the GWTP were submitted to MPCA and approved on April 12, 2012. The GWTP has been commissioned and operational since 2013. 3M requests removal of Requirements 5.78.208, 5.78.226, and 5.78.229.

6.3 Removal of Inapplicable Conditions

Requirements 5.78.210, 5.78.212, 5.78.214 through 5.78.216, 5.78.218, and 5.78.219 are not applicable to GWTP operations. At present, these requirements are not applicable or reflective of site operations. 3M requests the removal of all permit items not currently applicable to the facility, such as these, to avoid unnecessary content in an already lengthy permit and potentially detract from relevant permit terms and conditions. 3M requests removal of requirements 5.78.210, 5.78.212, 5.78.214 through 5.78.216, 5.78.218, and 5.78.219.

6.4 Removal of Potentially Redundant Requirements

Requirements 5.78.225 through 5.78.227 include details specific to GWTP operation. Details on GWTP operation and maintenance are best kept in the Treatment Operations Plan, as required in 5.78.228, to avoid duplicative content and the potential need for permit modifications based on operational or maintenance changes that are not significant and do not result in the discharge of a new pollutant or a significant increase to an existing pollutant. 3M requests removal of requirements 5.78.225 through 5.78.227.

7 Compliance Schedules

Requirement 5.71.54 states that 3M must have the proposed wastewater treatment system fully operational by September 30, 2024, and must submit a notice of initiation of operation to MPCA by that date. 3M requests that MPCA clarify which proposed wastewater treatment system is being addressed.

There have been changes in the commissioning timeline for the proposed advanced wastewater treatment system that need to be accounted for in the PPN Draft Permit. The proposed

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advanced wastewater treatment system will be installed and operating by spring of 2025. 3M anticipates that there will then be a period of time after the proposed advanced wastewater treatment system comes online that must be dedicated to making operational adjustments to optimize the performance of the system. Therefore, 3M requests that Requirement 5.71.54 be revised as follows: "As soon as possible and no later than March 31, 2025, the Permittee shall initiate startup to cause the proposed advanced wastewater treatment system to become operational. The Permittee shall submit notice of initiation of operation within 90 days of initiating startup operations."

8 Chemical Additives

The following comments are provided based on a detailed review of the PPN Draft Permit, Section 5, Requirements 5.78.401, pertaining to chemical additives.

8.1 Use Approval Timeframe

Requirement 5.82.401 states that:

> "Permittee shall request approval for an increase or new use of a chemical additive at least 60 days, or as soon as possible, before the proposed increase or new use."

The 60-day notification requirement places significant and undue constraint on 3M's processes. In order to effectively operate the new and complex advanced wastewater treatment system, 3M needs additional flexibility to adapt to changing conditions and achieve the best possible environmental outcomes. As such, 3M requests that this notification requirement be revised to:

- 15-day notification for new chemicals
- 5-day notification for increases in previously approved chemicals

These revised timelines are consistent with MPCA's July 2023 *Chemical Additive Review Guidance*[3]. In that document, MPCA states its commitment to "giving 90% of permittees notification of approval or disapproval within 5 business days, assuming all information was correct and complete at time of submission." 3M's proposed notification timelines are in keeping with the sense of urgency reflected in this statement in MPCA's guidance.

[3] MPCA, *Chemical Additive Review Guidance* (July 2023) at 22, available at https://www.pca.state.mn.us/sites/default/files/wq-wwprm2-12.pdf.

8.2 Approved Chemical Additives in Appendix B

There have been inaccuracies identified in the list of chemical additives provided in Appendix B. 3M has a current list of all chemical additives approved for use by MPCA. A corrected list will be supplied to MPCA in an application addendum.

9 Effluent Limits Derivation

The order of the following comments corresponds to their respective location in Section 7. Limits and Monitoring in the PPN Draft Permit.

9.1 Global Comment – Change in Receiving Water

It appears that the PPN Draft Permit has reconsidered the designation of the Unnamed Creek as the final receiving water, rather than the Pool 2. Based on 7Q10 of 0.0, this essentially results in no adjusted values for river flowage versus discharge flow. 3M requests clarification as to how and when Unnamed Creek got its water designation as 2b, 3, 4, 5 and 6. This designation is not justified as Unnamed Creek is not used as a source for drinking water or for recreational purposes, including fishing for human consumption.

9.2 Global Comment – Technology Based Effluent Limit Application

3M appreciates MPCA's reasonable, common-sense application of technology based effluent limitations in the PPN Draft Permit.

9.3 Global Comment – Water Quality Based Effluent Limit Derivations

MPCA includes sampling data for many parameters in its toxics reasonable potential calculation Excel spreadsheets; however, sampling data were not provided for some parameters for SD 001, including mercury, and all parameters for SD 002. 3M was also unable to verify the sampling data MPCA used for the reasonable potential (RP) and water quality based effluent limit (WQBELs) calculations, as these data did not match 3M's discharge monitoring report data. 3M requests the following information from MPCA:

- A complete list of sampling results for each parameter for which MPCA has completed an RP and WQBEL calculation.
- The source of each sample result (i.e., DMR, provided by 3M in the renewal application, provided to 3M on [insert date] for [insert rationale], etc.).

9.4 Comment 4. Hexavalent Chromium and Trivalent Chromium Monitoring, SD 001

MPCA determined total chromium does not have RPE[4]. 3M recognizes the WQC is for hexavalent chromium; however, it is unnecessary to routinely sample for hexavalent and trivalent chromium due to the RPE determination for total chromium. 3M requests that MPCA add this sampling requirement for their next permit renewal; but not as a routine permit requirement at SD 001.

9.5 Comment 5. Free Cyanide Monitoring, SD 001

MPCA determined total cyanide does not have RPE[5]. 3M recognizes the WQC is for free cyanide; however, it is unnecessary to routinely sample for free or amendable cyanide due to the RPE determination for total cyanide. 3M requests that MPCA add this sampling requirement for their next permit renewal; but not as a routine permit requirement at SD 001.

9.6 Comment 6. Hardness Monitoring, SD 001

3M requests that MPCA remove hardness monitoring from SD 001. 3M completes routine hardness monitoring for its whole effluent toxicity tests at SD 003; therefore, this requirement is redundant.

9.7 Comment 7. Total Lithium, Total Residual Oxidants, and Specific Conductance Monitoring, SD 001

3M requests that MPCA remove total lithium, total residual oxidants, and specific conductance monitoring from SD 001 because these parameters do not have associated water quality criteria.

9.8 Comment 9. Total Dissolved Solids (TDS) Monitoring, SD 001

3M requests that MPCA remove TDS monitoring from SD 001 because the sample collected for the permit renewal application was below the applicable water quality criterion.

9.9 Comment 11. Total Silver Monitoring, SD 001

3M requests that MPCA remove total silver monitoring from SD 001 because the sample collected for the permit renewal application was below the laboratory detection limit.

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[4] MPCA used hexavalent chromium water quality criteria and total chromium data for the RPE.
[5] MPCA used free cyanide water quality criteria and total cyanide data for the RPE.

9.10 Comment 13. Chloride Monitoring, SD 002

3M requests that MPCA remove chloride monitoring from SD 002. The sample collected for the permit renewal application was below the applicable water quality criterion.

9.11 Comment 14. Hardness Monitoring, SD 002

3M requests that MPCA remove hardness monitoring from SD 002. 3M completes routine hardness monitoring for its whole effluent toxicity tests at SD 003; therefore, this requirement is redundant.

9.12 Comment 15. Free Cyanide Monitoring, SD 002

The permit renewal sampling result for total cyanide at SD 002 was below the laboratory detection limit. 3M recognizes the WQC is for free cyanide; however, it is unnecessary to routinely sample for free or amendable cyanide due to below detection sample result at SD 002. 3M requests that MPCA add this sampling requirement for their next permit renewal; but not as a routine permit requirement at SD 002.

9.13 Comment 18. Total Lithium, Total Residual Oxidants, and Specific Conductance Monitoring, SD 002

3M requests that MPCA remove total lithium, total residual oxidants, and specific conductance monitoring from SD 002 because these parameters do not have associated water quality criteria.

9.14 Comment 19. TDS Monitoring, SD 002

3M requests that MPCA remove TDS monitoring from SD 001 because the sample collected for the permit renewal application was below the applicable water quality criterion.

10 Toxicity Requirements

Section 5.6.22 of the PPN Draft Permit prescribes a timeline of two weeks for repeating a test that is suspect for being invalid for quality control reasons. 3M requests that MPCA clarify whether the two-week deadline is in regard to effluent sample collection, test initiation, or test termination. Given that chronic testing takes seven to eight days to complete, there is concern that 3M would not be able to collect and ship a sample fast enough to have the test completed within two weeks. If the test is required to be initiated or effluent sample collected within two weeks, please specify this in the permit. If the requirement is to have the test completed within two weeks, 3M requests this be changed to accommodate the extended testing period required for chronic testing. There is also limited space available at the contract labs, and if other tests are running there may not be enough space to repeat a test within the two-week window. 3M suggests that the language either specify what component needs to be completed within two-weeks and/or the time frame be expanded to reflect the length of chronic testing.

11 Incinerator Closure

The PPN Draft Permit does not address the unique circumstances presented by the closure work that is ongoing at the 3M Cottage Grove Corporate Incinerator (3M Incinerator) and the potential for wastewater discharges associated with such work. Importantly, the PPN Draft Permit does not address or otherwise consider the RCRA regulatory hazardous waste requirements that attach to the generation of such wastewater.

The RCRA Closure Work Plan - 3M Hazardous Waste Storage and Treatment Facility covered under EPA ID MND006172969 was submitted to MPCA on April 7, 2022. While the 3M Incinerator was in operation, wastewater impacted by incinerator residuals was conveyed to the WWTP and treated in the segregated treatment train designated as Phase 3 prior to discharge. Decontamination wastewater from the 3M Incinerator residual-impacted surfaces will have similar properties to the 3M Incinerator process wastewater, and 3M proposed in the closure plan that wastewater associated with this work would continue to be processed through the existing Phase 3 wastewater system.

Once approved, the plan would require that wastewater generated during decommissioning be routed for treatment through the existing Phase 3 wastewater system. Under the closure plan, the Phase 3 wastewater would be combined with Phase 1 and 2 wastewater prior to their discharge though SD 001. 3M's Phase 3 wastewater will continue to undergo tertiary treatment deploying GAC in Building 185. Because of incinerator-related RCRA requirements, Phase 3 wastewater will not be routed to the new advanced water treatment system. Based on the foregoing, 3M seeks to ensure that the permit fully reflects the operational approach described above.

12 Reconcile Requirements of Enforcement Documents with the PPN Draft Permit

In the PPN Draft permit, MPCA does not reconcile requirements of the reissued permit with existing compliance obligations embodied in the December 14, 2022 Administrative Order (AO) and the January 22, 2021 Notice of Violation (NOV). Existing obligations relate to PFAS source identification, revision of the facility's PFAS monitoring protocol, amendment of operation and maintenance manuals, implementation of intervention limits, stormwater sampling and management, wastewater treatment, and numerous other detailed requirements at 3M Cottage Grove. These existing obligations obviously overlap considerably with requirements set forth in the PPN Draft Permit. Many of these obligations are completed or of short duration and should not be included in the permit. It is critical that inconsistencies and duplications be identified, discussed, and reconciled before the draft permit is issued so that

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3M and MPCA have a clear, mutual understanding of compliance obligations after the renewal permit is issued.

13 Facility Description, Location Maps, and Flow Diagrams

The facility description, location maps, and flow diagrams in Sections 1, 2 and 3 of the PPN Draft Permit contain numerous inaccuracies. It appears that the materials in this section of the permit were developed based on various 3M submittals that have since become outdated.

Many changes have occurred at the facility since the April 15, 2021 renewal application that have been communicated to MPCA during regular updates but that have not been fully captured in the PPN Draft. In addition, the facility description contains excessive details that will curtail 3M's effective operation of the on-site treatment systems. 3M will supply updated diagrams and facility description information to MPCA in a permit application addendum separate from this comment letter, but 3M believes face-to-face discussions also are necessary for MPCA to fully appreciate the significant, and complex, changes that are ongoing at the facility.

14 Closing

3M appreciates the opportunity to review and provide comments on the PPN Draft Permit No. MN0001449. 3M would like to re-emphasize the importance of meaningful engagement and collaboration with MPCA to develop an accurate and representative PPN Draft Permit. 3M is proposing to meet at a frequency that the MPCA technical representatives can support to resolve the issues of concern highlighted below in a timely fashion, and we propose to begin immediately. 3M respectfully requests that the PPN Draft Permit comment period be extended to allow 3M and MPCA time needed to resolve the issues addressed in this comment letter.

If you have any questions regarding the comments outlined above or the additional information that will be provided in separate permit application addendum, please feel free to contact Keith Schmuck, Sr. Environmental Manager, by phone at [redacted] or email at [redacted].

Sincerely,

[redacted]

Keith Schmuck, CSP
Sr. Environmental Manager
3M Global Chemical Operations

cc: Sarah Starr

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
1	Perfluoro-2-ethoxyethanesulfonic acid (PFEESA)	PFEESA	PFEESA	113507-82-7	not 3M	Y (Eurofins 537.1[mod])	N
2	10:2 Fluorotelomer sulfonic acid (10:2 FTSA)	10:2 FTSA	10:2 FTS	120226-60-0	DUPLICATE, not 3M	Y (Eurofins 537.1[mod])	N
3	Sodium 1H,1H,2H,2Hperfluorododecanesulfonate (10:2) (10:2 FTS)	10:2 FTS	10:2 FTS	120226-60-0	not 3M	Y (Eurofins 537.1[mod])	N
4	Perfluoro-2-(perfluoromethoxy)propanoic acid (PMPA / PFECA F)	PMPA / PFECA F	PFMPA	13140-29-9	not 3M?	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
5	Perfluoro-3,6-dioxaheptanoic acid (PFECA-B / NFDHA)	PFECA-B / NFDHA	NFDHA	151772-58-6	not 3M	Y (Eurofins 537.1[mod])	N
6	4:2 Fluorotelomer alcohol (4:2 FTOH)	4:2 FTOH	4:2 FTOH	2043-47-2	not 3M	Y (Eurofins 537.1[mod])	N
7	Perfluoro-4-(2-sulfoethoxy)pentanoic acid (R-PSDA / BPFESA)	R-PSDA	R-PSDA	2416366-18-0	not 3M	Y (Eurofins 537.1[mod])	N
8	Fluoro[perfluoro-2-(perfluoro-2-sulfoethoxy)propoxy] acetic acid (Hydrolyzed PSDA / 49 Byproduct 5)	Hydrolyzed PSDA / 49 Byproduct 5	Hydrolyzed PSDA	2416366-19-1	not 3M	Y (Eurofins 537.1[mod])	N
9	1,1,2,2-Tetrafluoro-2- [(1,1,1,2,3,3,4,4- octafluorobutan-2-yl)oxy]ethane-1-sulfonic acid (R-PSDCA / Byproduct 6)	R-PSDCA / Byproduct 6	R-PSDCA	2416366-21-5	not 3M	Y (Eurofins 537.1[mod])	N
10	Perfluorooctadecanoic acid (PFODA)	PFODA	PFODA	16517-11-6		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
11	4-(2-Carboxy-1,1,2,2-tetrafluoroethoxy)- perfluoropentanoic acid (R-EVE)	R-EVE	R-EVE	2416366-22-6	not 3M	Y (Eurofins 537.1[mod])	N
12	Perfluoro-2-ethoxypropanoic acid (PEPA)	PEPA	PEPA	267239-61-2		Y (Eurofins 537.1[mod])	N
13	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	6:2 FTS	6:2 FTS	27619-97-2	not 3M, have tested and not detected	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
14	2- (Perfluorooctyl)ethanoic acid (8:2 FTCA)	8:2 FTCA	8:2 FTCA	27854-31-5	not 3M	Y (Eurofins 537.1[mod])	N
15	Perfluoro-3,6-dioxa-4- methyl-7-octene-1-sulfonic acid (PS Acid / PFESA BP 1)	PS Acid / PFESA BP 1	PS Acid	29311-67-9	not 3M	Y (Eurofins 537.1[mod])	N
16	1-Butanesulfonic acid,1,1,2,2,3,3,4,4,4-nonafluoro-potassium (PBSK)	PBSK	PFBS	375-73-5	DUPLICATE	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
17	3:3 Fluorotelomer carboxylic acid (3:3 FTCA)	3:3 FTCA	3:3 FTCA	356-02-5	not 3M	Y (Eurofins 537.1[mod])	N
18	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	8:2 FTS	8:2 FTS	39108-34-4	not 3M, have tested and not detected	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
19	Perfluoro-3,5-dioxahexanoic acid (PFO2HxA)	PFO2HxA	PFO2HxA	39492-88-1	not 3M	Y (Eurofins 537.1[mod])	N
20	Perfluoro-3,5,7-trioxaoctanoic acid (PFO3OA)	PFO3OA	PFO3OA	39492-89-2	not 3M	Y (Eurofins 537.1[mod])	N

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
21	Perfluoro-3,5,7,9-butaoxadecanoic acid (PFO4DA)	PFO4DA	PFO4DA	39492-90-5	not 3M	Y (Eurofins 537.1[mod])	N
22	Perfluoro-3,5,7,9,11-pentaoxadodecanoic acid (PFO5DA)	PFO5DA	PFO5DA	39492-91-6	not 3M	Y (Eurofins 537.1[mod])	N
23	2- (Perfluorohexyl)ethanoic acid (6:2 FTCA / FHEA)	6:2 FTCA / FHEA	6:2 FTCA	53826-12-3	not 3M	Y (Eurofins 537.1[mod])	N
24	2-(Perfluorodecyl)ethanoic acid (10:2 FTCA / FDEA)	10:2 FTCA / FDEA	10:2 FTCA	53826-13-4	not 3M	Y (Eurofins 537.1[mod])	N
25	2- (Perfluorohexyl)ethanol (6:2 FTOH)	6:2 FTOH	6:2 FTOH	647-42-7	not 3M	Y (Eurofins 537.1[mod])	N
26	Perfluoro-2-methoxyaceticacid (PFMOAA)	PFMOAA	PFMOAA	674-13-5	not 3M	Y (Eurofins 537.1[mod])	N
27	2- (Perfluorooctyl)ethanol (8:2 FTOH)	8:2 FTOH	8:2 FTOH	678-39-7	not 3M	Y (Eurofins 537.1[mod])	N
28	Perfluoro-3-[1-(ethenyloxy)propan-2-yl]oxypropanoic acid (EVE Acid)	EVE Acid	EVE Acid	69087-46-3	not 3M	Y (Eurofins 537.1[mod])	N
29	2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	8:2 FTUCA	8:2 FTUCA	70887-84-2	not 3M	Y (Eurofins 537.1[mod])	N
30	2H-Perfluoro-2-octenoic acid (6:2) (6:2 FTUCA)	6:2 FTUCA	6:2 FTUCA	70887-88-6	not 3M	Y (Eurofins 537.1[mod])	N
31	2H-Perfluoro-2-dodecenoate (10:2 FTUCA)	10:2 FTUCA	10:2 FTUCA	70887-94-4	not 3M	Y (Eurofins 537.1[mod])	N
32	5-(1,2,2,2- Tetrafluoro)ethoxyperfluoro-3-oxa-4-methylpentanesulfonic acid (Hydro-PS Acid / PFESA BP 2)	Hydro-PS Acid / PFESA BP 2	Hydro-PS Acid	749836-20-2	not 3M	Y (Eurofins 537.1[mod])	N
33	7:2 s Fluorotelomer alcohol (7:2 FTOH)	7:2 FTOH	7:2 FTOH	24015-83-6	not 3M	Y (Eurofins 537.1[mod])	N
34	Perfluoro(2-((6-chlorohexyl)oxy)ethanesulfonic acid) (9ClPF3ONS / F53B Major)	9ClPF3ONS / F53B Major	9ClPF3ONS	756426-58-1	not 3M	Y (Eurofins 537.1[mod])	N
35	2-(Perfluorobutyl)-1-ethanesulfonic acid (4:2 FTS)	4:2 FTS	4:2 FTS	757124-72-4	not 3M, have tested and not detected	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
36	11-Chloroperfluoro-3-oxaundecanesulfonic acid (11Cl-PF3OUdS / F- 53B Minor)	11Cl-PF3OUdS / F- 53B Minor	11Cl-PF3OUdS	763051-92-9	not 3M	Y (Eurofins 537.1[mod])	N
37	2,2,3,3-Tetrafluoro-3- [1,1,1,2,3,3-hexafluoro- 3-(1,2,2,2-tetrafluoroethoxy)propan-2-yl]oxypropanoic acid (Hydro-EVE Acid)	Hydro-EVE Acid	Hydro-EVE Acid	773804-62-9	not 3M	Y (Eurofins 537.1[mod])	N
38	Perfluoro-4-isopropoxybutanoic acid (PFECA-G)	PFECA-G	PFECA G	801212-59-9	not 3M	Y (Eurofins 537.1[mod])	N
39	3-(Perfluoroheptyl)propanoic acid (7:3 FTCA)	7:3 FTCA	7:3 FTCA	812-70-4	not 3M	Y (Eurofins 537.1[mod])	N
40	2-(Perfluorodecyl)ethanol (10:2 FTOH)	10:2 FTOH	10:2 FTOH	865-86-1	not 3M	Y (Eurofins 537.1[mod])	N

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	**Analyte Description**	**Acronym**	**3M Abbreviation for Reporting**	**CAS Number**	**3M Reason to Remove**	**Commercial Lab Method Available**	**3M Method Available**
41	2H,2H,3H,3HPerfluorooctanoic acid (5:3 FTCA)	5:3 FTCA	5:3 FTCA	914637-49-3	not 3M	Y (Eurofins 537.1[mod])	N
42	2- (1,1,2,2,3,3,4,4,5,5,6,6,6 - Tridecafluorohexanesulfonamido)acetic acid (FHxSAA)	FHxSAA	FHSAA	1003193-99-4	from NTA, level 2, no ref std or method	N	N
43	Sodium perfluorododecane sulfonate (L-PFDoS)	L-PFDoS	PFDoS	1260224-54-1	DUPLICATE-remove	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
44	6:2 Fluorotelomer sulfonamido-N,N-dimethyl amine (6:2 FTA)	6:2 FTA	6:2 FTA	1383438-86-5	not 3M	N	N
45	2,2,3,3,5,5,6,6- Octafluoro-4-[1,2,2- trifluoro-2-(2,2,2-trifluoroethoxy)ethyl]morpholine (PFAS compound)	PFAS compound		1600-71-1	not 3M	N	N
46	Sodium perfluorodecane sulfonate (PFDS-Na / L-PFDS)	PFDS-Na / L-PFDS	PFDS	2806-15-7	DUPLICATE-remove	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
47	[3-(Heptadecafluorooctylsulfonylamino)propyl]-di methylamine N-oxide (AOF)	AOF	PFOSA-NO	30295-51-3		N	Y (ETS-8-044)
48	Tributyl(2-methoxypropyl)phosphonium methyl((nonafluorobutyl)sulfonyl)azanide (TBBP:MeFBSA (1:1))	TBBP:MeFBSA	TBBP or TBMOPP	332350-90-0	The TBBP:MeFBSA salt complex dissociates in water to TBBP and MeFBSA, Should only list TBBP. The MeFBSA analyte is already on this list separately. However, no method currently exists for TBBP so remove from list	N	N
49	Lithium trifluoromethanesulfonate (Li triflate / TFMS lithium salt)	LiTFMS	TFMS	33454-82-9	DUPLICATE-remove	N	Y (ETS-8-044)
50	Fluoromalonic acid (2- FPDA)	2- FPDA	2-FPDA	473-87-0	no method	N	N
51	Potassium perfluoro(perfluoroethyl)cyclohexanesulfonate (PFecHS-K)	PFecHS-K	PFECHS	67584-42-3	DUPLICATE-remove	N	Y (ETS-8-044)
52	3,5-Bis(heptafluoropropyl)-1H-1,2,4-triazole (PFAS compound)	PFAS compound		709-62-6	not 3M	N	N
53	3-(Dimethyl(3-(((tridecafluorohexyl)sulfonyl)amino)propyl)azaniumyl)-2-hydroxypropane-1- sulfonate (PHSA-OH1)	PHSA-OH1	PHSA-OH1	73772-32-4		N	Y (ETS-8-044)
54	Sodium 1,1,2,2- tetrafluoro-2-(1,2,2,2-tetrafluoroethoxy)ethane-1-sulfonate (NVHOS)	NVHOS	NVHOS	801209-99-4	not 3M	Y (Eurofins 537.1[mod])	N
55	2-[N-(Ethyl)perfluorooctanesulfonamido]acetic acid (N-EtFOSAA / N-EtFOSAA / EtFOSAA)	N-EtFOSAA / N-EtFOSAA / EtFOSAA	N-EtFOSAA	2991-50-6		Y (Eurofins 537.1[mod])	N
56	2,3,3,3- Tetrafluoropropanoic acid (2333-TFPA)	2333-TFPA	2333-TFPA	359-49-9		N	Y (ETS-8-044)
57	3- (Perfluorohexanesulfonamido)-N,N,N-trimethylpropan-1-aminium (N-TAmPFHxSA)	N-TAmPFHxSA	N-TAmP-FHxSA	38850-51-0	from NTA, level 3, no ref standard	N	N
58	C10H3F18NO2 (PFAS compound)				from NTA, level 3, no ref standard	N	N

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
59	C13H3F18N3O4 (PFAS compound)				from NTA, level 3, no ref standard	N	N
60	C15H21F13N2O2S (PFAS compound)				from NTA, level 3, no ref standard	N	N
61	Methyl 2-[[bis(trifluoromethyl)amino]-difluoromethyl]-2,3,3,3-tetrafluoropropanoate (PFAS compound)	PFAS compound			no ref standard	N	N
62	4,8-Dioxa-3Hperfluorononanoic acid (ADONA)	ADONA	ADONA	919005-14-4		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
63	N-(Ethyl)perfluorooctanesulfonamide (EtFOSA / N-EtFOSA)	EtFOSA / N-EtFOSA	EtFOSA	4151-50-2		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
64	N-(Ethyl)-N-(2-hydroxyethyl)perfluorooctanesulfonamide (N-EtFOSE)	N-EtFOSE	EtFOSE	1691-99-2		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
65	Perfluorobutanesulfonamide (FBSA)	FBSA	FBSA	30334-69-1		N	Y (ETS-8-044)
66	Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA / GenX)	HFPO-DA / GenX	HFPO-DA	13252-13-6		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
67	Lithium bis[(trifluoromethyl)sulfonyl]azanide (HQ-115 / TFSI-LI)	TFSI	TFSI	90076-65-6		N	Y (ETS-8-044)
68	N-(methyl)perfluoro-1-octanesulfonamide (MeFOSA / N-MeFOSA)	MeFOSA / N-MeFOSA	MeFOSA	31506-32-8		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
69	2-[N-(methyl)perfluoro-1-octanesulfonamido]-ethanol (N-MeFOSE)	N-MeFOSE	MeFOSE	24448-09-7		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
70	Perfluorobutanoic acid (PFBA)	PFBA	PFBA	375-22-4		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
71	Perfluorobutanesulfonic acid (PFBS)	PFBS	PFBS	375-73-5		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
72	Perfluorobutane-1-sulfinic acid (PFBSi)	PFBSi	PFBSi	34642-43-8		N	Y (ETS-8-044)
73	Perfluorodecanoic acid (PFDA)	PFDA	PFDA	335-76-2		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
74	Perfluorododecanoic acid (PFDoA)	PFDoA	PFDoA	307-55-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
75	Perfluorododecanesulfonic acid (PFDoS)	PFDoS	PFDoS	79780-39-5		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
76	Perfluorodecanesulfonic acid (PFDS)	PFDS	PFDS	335-77-3		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
77	2,2,3,3-Tetrafluoro-3-methoxypropanoic acid (MTP)	MTP	PFMPA	377-73-1	DUPLICATE-remove	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
78	Perfluoro-3-methoxypropanoic acid (PFMPA)	PFMPA	PFMPA	377-73-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
79	Perfluoro(4-methoxybutanoic acid) (PFECA-A / PFMBA)	PFECA-A / PFMBA	PFMBA	863090-89-5		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
80	Perfluoroheptanoic acid (PFHpA)	PFHpA	PFHpA	375-85-9		Y (Eurofins 537.1[mod])	Y (ETS-8-044)

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)

No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
81	Perfluoroheptanesulfonic acid (PFHpS)	PFHpS	PFHpS	375-92-8		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
82	Perfluorohexanoic acid (PFHxA)	PFHxA	PFHxA	307-24-4		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
83	Perfluorohexadecanoic acid (PFHxDA)	PFHxDA	PFHxDA	67905-19-5		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
84	Perfluorohexanesulfonic acid (PFH1S / PFHS / PFHxS)	PFH1S / PFHS / PFHxS	PFHxS	355-46-4		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
85	Perfluorononanoic acid (PFNA)	PFNA	PFNA	375-95-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
86	Perfluorononanesulfonic acid (PFNS)	PFNS	PFNS	68259-12-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
87	Sodium perfluorononanesulfonate (PFNS / PFNS-NA / LPFNS)	PFNS / PFNS-NA / LPFNS	PFNS	68259-12-1	DUPLICATE-remove	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
88	Perfluorooctanoic acid (PFOA)	PFOA	PFOA	335-67-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
89	Perfluorooctanesulfonic acid (PFOS)	PFOS	PFOS	1763-23-1		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
90	Perfluorooctanesulfonamide (PFOSA / FOSA)	PFOSA / FOSA	FOSA	754-91-6		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
91	Perfluoropropanoic acid (PFPA / PFPrA)	PFPA / PFPrA	PFPA	422-64-0		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
92	Perfluoropentanoic acid (PFPeA)	PFPeA	PFPeA	2706-90-3		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
93	Perfluoropentanesulfonic acid (PFPeS)	PFPeS	PFPeS	2706-91-4		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
94	Perfluoropropanesulfonic acid (PFPrS)	PFPrS	PFPS	423-41-6		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
95	Perfluorotetradecanoic acid (PFTeDA / PFTeA / PFTA)	PFTeDA / PFTeA / PFTA	PFTeA	376-06-7		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
96	Perfluorotridecanoic acid (PFTrA / PFTrDA)	PFTrA / PFTrDA	PFTrA	72629-94-8		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
97	Perfluoroundecanoic acid (PFUnA)	PFUnA	PFUnA	2058-94-8		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
98	2,3,3,3-Tetrafluoro-2-(trifluoromethyl)propanamide (PIBA)	PIBA	PIBA	662-20-4		N	Y (ETS-8-044)
99	Trifluoromethanesulfonic acid (TFMS / PFMeS)	TFMS / PFMeS	TFMS	1493-13-6		N	Y (ETS-8-044)
100	2-[N-(Methyl)perfluorooctanesulfonamido]acetic acid (N-MeFOSAA / N-MeFOSAA / MeFOSAA)	N-MeFOSAA / N-MeFOSAA / MeFOSAA	N-MeFOSAA	2355-31-9		Y (Eurofins 537.1[mod])	Y (ETS-8-044)
101	Potassium 2,2,3,3-tetrafluoropropanoate (2233-TFPA)	2233-TFPA	2233-TFPA	756-09-2 8		N	Y (ETS-8-044)
102	4H-Perfluorobutanoic acid (4H-PFBA)	4H-PFBA	4H-PFBA	679-12-9		N	Y (ETS-8-044)

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
103	Phosphonium, triphenyl(phenylmethyl) -, salt with 1,1,2,2,3,3,4,4,4- nonafluoro-N-methyl-1-butanesulfonamide (1:1) (C4 Methyl amide phosphonium curatives / TPBP:MeFBSA)	TPBP:MeFBSA	TPBP	332350-93-3	The TPBP:MeFBSA salt complex dissociates in water to TPBP and MeFBSA, Should only list TPBP. The MeFBSA analyte is already on this list separately	N	Y (ETS-8-044)
104	Potassium N,N-bis(perfluorobutanesulfonyl)imide (DBI)	DBI	DBI	39847-39-7		N	Y (ETS-8-044)
105	Perfluoro-1,4-diiodobutane (DIOFB)	DIOFB	DIOFB	375-50-8	unstable, reactive in water, documented stability of 3.8 hrs. at room temp.	N	Y (ETS-8-182 Purge & Trap)
106	Methane, bis[(trifluoromethyl)sulfonyl]- (MEDSULF)	MEDSULF	MEDSULF	428-76-2		N	Y (ETS-8-044)
107	(Perfluorobutyl) sulfonamido acetic acid (FBSAA)	FBSAA	FBSAA	347872-22-4		N	Y (ETS-8-044)
108	2,2'-(((Nonafluorobutyl)sulfonyl)imino)diacetic acid (FBSEE diacid)	FBSEE diacid	FBSEE-DA	347872-22-4		N	Y (ETS-8-044)
109	Perfluorobutane-1-sulfonamidoethanol (FBSE)	FBSE	FBSE	34454-99-4		N	Y (ETS-8-044)
110	N,N-Bis(2- hydroxyethyl)perfluorobutanesulfonamide (FBSEE / FBSEE Diol)	FBSEE / FBSEE Diol	FBSEE Diol	34455-00-0		N	Y (ETS-8-044)
111	Hexafluoropropene (HFP)	HFP	HFP	116-15-4	Kh(dim) = 2.75e-2; Not expected in water, as per EPA OPPTS 835.6100: If Kh dimensionless >10^-3 then considered volatile from water surface	N	Y (ETS-8-182 Purge & Trap)
112	N-(Methyl)-nonafluorobutanesulfonamide (MeFBSA)	MeFBSA	MeFBSA	68298-12-4		N	Y (ETS-8-044)
113	N-(Methyl)-N-[(perfluorobutyl)sulfonyl]glycine (MeFBSAA)	MeFBSAA	MeFBSAA	159381-10-9		N	Y (ETS-8-044)
114	2-(N-(Perfluorobutylsulfonyl)-N-methylamino)ethanol (MeFBSE)	MeFBSE	MeFBSE	34454-97-2		N	Y (ETS-8-044)
115	2-(N-Methylperfluorobutylsulfonamido)ethyl acrylate (MeFBSEA)	MeFBSEA	MeFBSEA	67584-55-8	No method; currently analyze for major biodegradation products PFBS, FBSA, FBSE	N	N
116	Perfluoro-4- ethenyloxybutane-1-sulfonyl fluoride (PFSA monomer)	PFSA monomer	MV4S	88190-28-7	MV4S is highly volatile and unstable, with a 2-day stability in water; Substance hydrolyzes readily in water to form a sulfonic acid (MV4S-SA) and ultimately a diacid (MV4S-DA)) and is analyzed as those two products in water.	N	Y (ETS-8-182 Purge & Trap)
117	Bisphenol AF (BPAF)		BPAF	42355-31-9		N	Y (ETS-8-044)

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)							
No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
118	Perfluorobutane-N-(3- (dimethylamino)propyl)- 1-sulfonamide sulfonamido amine (PBSA)	PBSA	PBSA	68555-77-1		N	Y (ETS-8-044)
119	3-((3-((N-(2- Carboxyethyl)- perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate (PBSA-DC)	PBSA-DC	PBSA-DC	225460-13-7		N	Y (ETS-8-044)
120	3-((3-((2-Hydroxyethyl)(dimethyl)azaniumyl)propyl)((perfluorobutyl)sulfonyl)amino)propane-1-sulfonate (PBSA-S1)	PBSA-S1	PBSA-S1	2089108-94-9		N	Y (ETS-8-044)
121	Perfluorobutanesulfonyl fluoride (PBSF)	PBSF	PBSF	375-72-4	Kh(dim) = 8.23e-1; Not expected in water, as per EPA OPPTS 835.6100: If Kh dimensionless >10^-3 then considered volatile from water surface	N	Y (ETS-8-182 Purge & Trap)
122	N- (Perfluorobutanesulfonyl)-N-(3-dimethylaminopropyl)- 3-aminopropanoic acid (PBSA-C1)	PBSA-C1	PBSA-C1	172616-04-5		N	Y (ETS-8-044)
123	Potassium perfluoro-4-ethylcyclohexanesulfonate (PECHS / PFECHS)	PECHS / PFECHS	PFECHS	335-24-0		N	Y (ETS-8-044)
124	Perfluoroethanesulfonic acid (PFES / PFEtS)	PFES / PFEtS	PFES	2837-92-5		N	Y (ETS-8-044)
125	Potassium pentafluoroethane-1- sulfonate (K-PFES)	K-PFES	PFES	2837-92-5	DUPLICATE-remove	N	Y (ETS-8-044)
126	Perfluorohexanesulfonamide (PFHxSA)	PFHxSA	PFHxSA	41997-13-1		N	Y (ETS-8-044)
127	N-(3-(Dimethylamino)propyl) perfluorohexane sulfonamide (PHSA)	PHSA	PHSA	50598-28-2		N	Y (ETS-8-044)
128	N-(Perfluorohexanesulfonyl)-N-(3-dimethylaminopropyl)- 3-aminopropanoic acid (PHSA-C1)	PHSA-C1	PHSA-C1	141607-32-1		N	Y (ETS-8-044)
129	3-(Dimethyl(3-(((tridecafluorohexyl)sulfonyl)amino)propyl)azaniumyl)propanoate (PHSA-C2)	PHSA-C2	PHSA-C2	81190-41-2		N	Y (ETS-8-044)
130	3-((3-((2- Carboxyethyl)((tridecafluorohexyl)sulfonyl)-amino)propyl)(dimethyl)azaniumyl)propanoate (PHSA-DC)	PHSA-DC	PHSA-DC	756771-34-3		N	Y (ETS-8-044)
131	N-(2-Hydroxyethyl)-N,Ndimethyl-3-(((tridecafluorohexyl)sulfonyl)amino)propan-1-aminium (PHSA-E1)	PHSA-E1	PHSA-E1	736877-37-5		N	Y (ETS-8-044)
132	3-(3-[(2- Hydroxyethyl)(dimethyl) azaniumyl]propyl[(perfluorohexyl)sulfonyl]amino)-1-propanesulfonate (PHSA-S1)	PHSA-S1	PHSA-S1	38850-58-7		N	Y (ETS-8-044)
133	3-[[3-(Dimethylamino)propyl][(1,1,2,2,3,3,4,4,5,5,6,6, 6-tridecafluorohexyl)-sulfonyl]amino]-1-propane sulfonic acid (PHSA-S3)	PHSA-S3	PHSA-S3	38850-60-1		N	Y (ETS-8-044)

Table 1. Original PFAS Analyte List from MPCA (with 3M Reasons to Remove)

No.	Analyte Description	Acronym	3M Abbreviation for Reporting	CAS Number	3M Reason to Remove	Commercial Lab Method Available	3M Method Available
134	Trifluoro(trifluoromethoxy)ethylene (PMVE)	PMVE	PMVE	1187-93-5	Kh(dim) = 13 Not expected in water, as per EPA OPPTS 835.6100: If Kh dimensionless >10^-3 then considered volatile from water surface	N	Y (ETS-8-182 Purge & Trap)
135	Trifluoroacetic acid (TFA)	TFA	TFA	76-05-1		N	Y (ETS-8-044)
136	Tetrafluoroethylene (TFE)	TFE	TFE	116-14-3	Kh(dim) = 7.32e-3; Not expected in water, as per EPA OPPTS 835.6100: If Kh dimensionless >10^-3 then considered volatile from water surface	N	Y (ETS-8-182 Purge & Trap)
137	Vinylidene fluoride (VDF / VF2)	VDF / VF2	VDF	75-38-7	Kh(dim) = 2.07e-1; Not expected in water, as per EPA OPPTS 835.6100: If Kh dimensionless >10^-3 then considered volatile from water surface	N	Y (ETS-8-182 Purge & Trap)

Table 2. 3M-Recommended PFAS Analyte List for CG NPDES Permit

No.	Analyte Description	Acronym	CAS Number	Commercial Lab Method Available	3M Method Available
1	Perfluorooctadecanoic acid (PFODA)	PFODA	16517-11-6	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
2	Perfluoro-2-ethoxypropanoic acid (PEPA)	PEPA	267239-61-2	Y (Eurofins 537.1[mod])	N
3	3-(Dimethyl(3-(((tridecafluorohexyl)sulfonyl)amino)propyl)azaniumyl)-2-hydroxypropane-1- sulfonate (PHSA-OH1)	PHSA-OH1	73772-32-4	N	Y (ETS-8-044)
4	2-[N-(Ethyl)perfluorooctanesulfonamido]acetic acid (N-EtFOSAA / N-EtFOSAA / EtFOSAA)	N-EtFOSAA / N-EtFOSAA / EtFOSAA	2991-50-6	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
5	2,3,3,3- Tetrafluoropropanoic acid (2333-TFPA)	2333-TFPA	359-49-9	N	Y (ETS-8-044)
6	N-(Ethyl)perfluorooctanesulfonamide (EtFOSA / N-EtFOSA)	EtFOSA / N-EtFOSA	4151-50-2	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
7	N-(Ethyl)-N-(2-hydroxyethyl)perfluorooctanesulfonamide (N-EtFOSE)	N-EtFOSE	1691-99-2	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
8	Perfluorobutanesulfonamide (FBSA)	FBSA	30334-69-1	N	Y (ETS-8-044)
9	Perfluoro-2-methyl-3-oxahexanoic acid (HFPO-DA / GenX)	HFPO-DA / GenX	13252-13-6	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
10	Lithium bis[(trifluoromethyl)sulfonyl]azanide (HQ-115 / TFSI-LI)	TFSI	90076-65-6	N	Y (ETS-8-044)
11	N-(methyl)perfluoro-1-octanesulfonamide (MeFOSA / N-MeFOSA)	MeFOSA / N-MeFOSA	31506-32-8	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
12	2-[N-(methyl)perfluoro-1-octanesulfonamido]-ethanol (N-MeFOSE)	N-MeFOSE	24448-09-7	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
13	Perfluorobutanoic acid (PFBA)	PFBA	375-22-4	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
14	Perfluorobutanesulfonic acid (PFBS)	PFBS	375-73-5	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
15	Perfluorobutane-1-sulfinic acid (PFBSi)	PFBSi	34642-43-8	N	Y (ETS-8-044)
16	Perfluorodecanoic acid (PFDA)	PFDA	335-76-2	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
17	Perfluorododecanoic acid (PFDoA)	PFDoA	307-55-1	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
18	Perfluoro-3-methoxypropanoic acid (PFMPA)	PFMPA	377-73-1	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
19	Perfluoro(4-methoxybutanoic acid) (PFECA-A / PFMBA)	PFECA-A / PFMBA	863090-89-5	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
20	Perfluoroheptanoic acid (PFHpA)	PFHpA	375-85-9	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
21	Perfluoroheptanesulfonic acid (PFHpS)	PFHpS	375-92-8	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
22	Perfluorohexanoic acid (PFHxA)	PFHxA	307-24-4	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
23	Perfluorohexadecanoic acid (PFHxDA)	PFHxDA	67905-19-5	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
24	Perfluorohexanesulfonic acid (PFH1S / PFHS / PFHxS)	PFH1S / PFHS / PFHxS	355-46-4	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
25	Perfluorononanoic acid (PFNA)	PFNA	375-95-1	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
24	Perfluorooctanoic acid (PFOA)	PFOA	335-67-1	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
27	Perfluorooctanesulfonic acid (PFOS)	PFOS	1763-23-1	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
28	Perfluorooctanesulfonamide (PFOSA / FOSA)	PFOSA / FOSA	754-91-6	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
29	Perfluoropropanoic acid (PFPA / PFPrA)	PFPA / PFPrA	422-64-0	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
30	Perfluoropentanoic acid (PFPeA)	PFPeA	2706-90-3	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
31	Perfluoropentanesulfonic acid (PFPeS)	PFPeS	2706-91-4	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
32	Perfluoropropanesulfonic acid (PFPrS)	PFPrS	423-41-6	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
33	Perfluorotetradecanoic acid (PFTeDA / PFTeA / PFTA)	PFTeDA / PFTeA / PFTA	376-06-7	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
34	Perfluorotridecanoic acid (PFTrA / PFTrDA)	PFTrA / PFTrDA	72629-94-8	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
35	Perfluoroundecanoic acid (PFUnA)	PFUnA	2058-94-8	Y (Eurofins 537.1[mod])	Y (ETS-8-044)
36	2,3,3,3-Tetrafluoro-2-(trifluoromethyl)propanamide (PIBA)	PIBA	662-20-4	N	Y (ETS-8-044)

Table 2. 3M-Recommended PFAS Analyte List for CG NPDES Permit					
No.	**Analyte Description**	**Acronym**	**CAS Number**	**Commercial Lab Method Available**	**3M Method Available**
37	Trifluoromethanesulfonic acid (TFMS / PFMeS)	TFMS / PFMeS	1493-13-6	N	Y (ETS-8-044)
38	Potassium 2,2,3,3-tetrafluoropropanoate (2233-TFPA)	2233-TFPA	756-09-2 8	N	Y (ETS-8-044)
39	4H-Perfluorobutanoic acid (4H-PFBA)	4H-PFBA	679-12-9	N	Y (ETS-8-044)
40	Phosphonium, triphenyl(phenylmethyl) -, salt with 1,1,2,2,3,3,4,4,4- nonafluoro-N-methyl-1-butanesulfonamide (1:1) (C4 Methyl amide phosphonium curatives / TPBP:MeFBSA)	TPBP:MeFBSA	332350-93-3	N	Y (ETS-8-044)
41	Potassium N,N-bis(perfluorobutanesulfonyl)imide (DBI)	DBI	39847-39-7	N	Y (ETS-8-044)
42	Methane, bis[(trifluoromethyl)sulfonyl]- (MEDSULF)	MEDSULF	428-76-2	N	Y (ETS-8-044)
43	(Perfluorobutyl) sulfonamido acetic acid (FBSAA)	FBSAA	347872-22-4	N	Y (ETS-8-044)
44	2,2'-(((Nonafluorobutyl)sulfonyl)imino)diacetic acid (FBSEE diacid)	FBSEE diacid	347872-22-4	N	Y (ETS-8-044)
45	Perfluorobutane-1- sulfonamidoethanol (FBSE)	FBSE	34454-99-4	N	Y (ETS-8-044)
46	N,N-Bis(2- hydroxyethyl)perfluorobutanesulfonamide (FBSEE / FBSEE Diol)	FBSEE / FBSEE Diol	34455-00-0	N	Y (ETS-8-044)
47	N-(Methyl)-nonafluorobutanesulfonamide (MeFBSA)	MeFBSA	68298-12-4	N	Y (ETS-8-044)
48	N-(Methyl)-N-[(perfluorobutyl)sulfonyl]glycine (MeFBSAA)	MeFBSAA	159381-10-9	N	Y (ETS-8-044)
49	2-(N-(Perfluorobutylsulfonyl)- N-methylamino)ethanol (MeFBSE)	MeFBSE	34454-97-2	N	Y (ETS-8-044)
50	2,2,3,4,4-Hexafluoro-4-sulfobuanoic acid	MV4S-SA	83071-25-4	N	Y (ETS-8-044)
51	1,2,3,3,4,4,5,5-Octafluoro-4-((trifluoroethenyl)oxy)butane-1-sulfonic acid	MV4S-DA	913556-89-5	N	Y (ETS-8-044)
52	Perfluorobutane-N-(3-(dimethylamino)propyl)-1-sulfonamide sulfonamido amine (PBSA)	PBSA	68555-77-1	N	Y (ETS-8-044)
53	3-((3-((N-(2- Carboxyethyl)-perfluorobutyl)sulfonamido)propyl)-dimethylammonio)propanoate (PBSA-DC)	PBSA-DC	225460-13-7	N	Y (ETS-8-044)
54	3-((3-((2- Hydroxyethyl)(dimethyl) azaniumyl)propyl)((perfluorobutyl)sulfonyl)amin o)propane-1-sulfonate (PBSA-S1)	PBSA-S1	2089108-94-9	N	Y (ETS-8-044)
55	N-(Perfluorobutanesulfonyl)-N-(3-dimethylaminopropyl)- 3-aminopropanoic acid (PBSA-C1)	PBSA-C1	172616-04-5	N	Y (ETS-8-044)
56	Potassium perfluoro-4-ethylcyclohexanesulfonate (PECHS / PFECHS)	PECHS / PFECHS	335-24-0	N	Y (ETS-8-044)
57	Perfluoroethanesulfonic acid (PFES / PFEtS)	PFES / PFEtS	2837-92-5	N	Y (ETS-8-044)
58	Perfluorohexanesulfonamide (PFHxSA)	PFHxSA	41997-13-1	N	Y (ETS-8-044)
59	N-(3- (Dimethylamino)propyl) perfluorohexane sulfonamide (PHSA)	PHSA	50598-28-2	N	Y (ETS-8-044)
60	N-(Perfluorohexanesulfonyl)-N-(3- dimethylaminopropyl)- 3-aminopropanoic acid (PHSA-C1)	PHSA-C1	141607-32-1	N	Y (ETS-8-044)
61	3-(Dimethyl(3-(((tridecafluorohexyl)sulfonyl)amino)propyl)azaniumyl)propanoate (PHSA-C2)	PHSA-C2	81190-41-2	N	Y (ETS-8-044)
62	N-(2-Hydroxyethyl)-N,Ndimethyl-3-(((tridecafluorohexyl)sulfonyl)amino)propan-1-aminium (PHSA-E1)	PHSA-E1	736877-37-5	N	Y (ETS-8-044)

Table 2. 3M-Recommended PFAS Analyte List for CG NPDES Permit

No.	Analyte Description	Acronym	CAS Number	Commercial Lab Method Available	3M Method Available
63	3-(3-[(2-Hydroxyethyl)(dimethyl)azaniumyl]propyl[(perfluorohexyl)sulfonyl]amino)-1-propanesulfonate (PHSA-S1)	PHSA-S1	38850-58-7	N	Y (ETS-8-044)
64	3-[[3-(Dimethylamino)propyl] [(1,1,2,2,3,3,4,4,5,5,6,6, 6-tridecafluorohexyl)-sulfonyl]amino]-1-propane sulfonic acid (PHSA-S3)	PHSA-S3	38850-60-1	N	Y (ETS-8-044)
65	Trifluoroacetic acid (TFA)	TFA	76-05-1	N	Y (ETS-8-044)