Cape Fear
Public Utility Authority
Stewardship. Sustainability. Service.

November 28, 2018

House Select Committee on North Carolina River Quality
Representative Ted Davis, Chair
300 North Salisbury Street, Room 417B
Raleigh, NC 27603

Senate Select Committee on North Carolina River Water Quality
Senator Trudy Wade, Chair
300 North Salisbury Street, Room 525
Raleigh, NC 27603

Environmental Review Commission
Senator Trudy Wade, Chair
300 North Salisbury Street, Room 525
Raleigh, NC 27603

NCLG Fiscal Research Division
Mark Trogdon, Director
300 North Salisbury Street, Suite 619
Raleigh, NC 27603

Re: Session Law 2018-5, Section 13.1.(e) Interim Report on activities related to grant-in-aid to Cape Fear Public Utilities Authority (CFPUA) in the amount of $450,000 to perform large scale pilot testing on Granular Activated Carbon (GAC) and Ion Exchange (IX) media for per- and poly-fluoroalkyl substances (PFAS)

Dear Sir or Madam,

Cape Fear Public Utility Authority (CFPUA) is pleased to submit this Interim Report as required by the Grant-In-Aid Funding under Session Law 2018-5, Section 13.1.(e).

CFPUA submitted Attachment A, Scope of Work and Annual Budget for the subject project to the NCDEQ Financial Services Division and executed the following actions and contracts as described in Attachment A:

SCOPE

(1) Perform nontargeted sampling of finished drinking water from the Authority's Sweeney Water Treatment Plant and in its Aquifer Storage and Recovery Well (ASR) to identify levels of per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), that may be included in the water. CFPUA will sample both the finished drinking water from the distribution system treated by the Authority's

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Sweeney Water Treatment Plant and the Aquifer Storage and Recovery Well (ASR), both at the Westbrook Avenue site.

(2) Contract with HDR Engineering, Inc. of the Carolinas (Engineer) to assist CFPUA with full-scale piloting of two pilot trains at the ASR Well. Specific tasks include assisting with the procurement of the pilot trains, an evaluation of water quality and full-scale feasibility of implementation at the ASR site. Additionally, the Engineer will generate Interim and Final Reports that will be submitted to the House and Senate Select Committees on North Carolina River Quality, the Fiscal Research Division, and the Environmental Regulatory Commission.

(3) Contract with a Water and Waste Services, Incorporated (General Contractor) for the installation, demobilization and rental of the two pilot systems. Shop drawing preparation, site preparation, temporary piping are also provided by the General Contractor.

(4) Contract with CATLIN Engineers and Scientists (CATLIN) to conduct field sampling under the direction of CFPUA of any wells or water sources associated with the project and prepare/ship the samples in a timely manner to the appropriate laboratory. CFPUA will pay the laboratory directly for all analytical sampling costs.

(5) Contract with University of North Carolina at Wilmington (UNCW) to identify and quantify unregulated compounds and chemicals from samples collected from the ASR well. Analyses will be conducted at UNCW's Marine and Atmospheric Chemistry Research Laboratory (MACRL).

(6) CFPUA will pay GEL Labs for the analysis of PFAS, including GenX. Samples will be collected and shipped by CATLIN (see item 4).

BUDGET

As indicated on Attachment A, services and contract expenses are budgeted by CFPUA as $483,641 with a grant-in-aid total of $450,000. The following table breaks out this budget in more detail:

CONTRACTED SERVICES	FIRM	ESTIMATED COST
Treatment Engineering Consultant	HDR	$97,000
Equipment Lease, Installation and Treatment Media	W&WS	$232,000
Field Sampling	Catlin	$55,000
Perfluorinated Compound Laboratory Analysis	GEL Labs	$65,000
Advanced Perfluorinated Compound Chemistry	UNCW	$34,641
TOTAL COST RELATED TO PFC TREATMENT TEST		$483,641

Field Sampling and Laboratory Analysis contracts are based on time and materials, not to exceed the stated amount. All other contracts are firm fixed price.

SCHEDULE

The project is on schedule with the General Contractor working and receiving deliveries on site.

Test Plan Phase	Objectives	Schedule											
		2018						2019					
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Groundwater and Finished Drinking Water Sampling	Perform nontargeted sampling to establish baseline PFAS levels.	✓											
Test Plan Development	Includes treatment objectives, staffing, lab methods, and data analysis.		✓	✓									
Design Pilot Plant	Design a reliable and efficient pilot plant and site area.		✓	✓	✓								
Pilot Procurement and Installation	Bid and construct pilot plant.				✓	✓							
Interim Report	Report to Stakeholders Identified in Session Law 2018-5, Section 13.1.(e).					✓							
Pilot Testing	Conduct Pilot Test of Granular Activated Carbon and Ion Exchange on PFAS.												
Pilot Shutdown and Final Report	Report to Stakeholders Identified in Session Law 2018-5, Section 13.1.(e).												

PILOT TEST PLAN

HDR Engineering developed a draft GAC and IX Groundwater Treatment Pilot Test Plan and submitted it to the Department of Environmental Quality Division of Water Infrastructure for review and comment. It was agreed that since the well has a capacity of 500 gallons per minute that two (1 GAC, 1 IX) 250 gallon per minute vessels operated simultaneously with the same feed water would provide the optimal pilot test results. The final Pilot Test Plan is Attachment B to this Interim Report.

CFPUA conducted nontargeted baseline sampling in accordance the grant-in-aid requirements on both groundwater and finished drinking water in July of 2018. Subsequent to the testing of finished drinking water, CFPUA replaced shallow bed filter media at Sweeney WTP with GAC and routinely samples and monitors there. That data and other data collected on finished water at the plant will be included in the final report in the interest of focusing the pilot test on groundwater, where the higher concentration of combined PFAS are available for treatment.

BASELINE NONTARGETED SAMPLING RESULTS

On July 18, 2018 when the groundwater in the aquifer storage and recovery well was sampled, the total of all PFAS using the best methods available totaled **1,010.86 ppt**. At that same time, the total PFAS in CFPUA finished water sampled from the distribution system at the Westbrook Elevated Storage Tank was **752.98 ppt**. The following table provides the results from GEL Laboratories for the PFAS compounds that were detected in the groundwater and finished water on that day.

Analyte	Finished Water Westbrook Tank (ppt)	Groundwater ASR-1 (ppt)
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA - GenX)	35.7	37.7
Perfluorobutanesulfonate (PFBS)	7.82	ND
Perfluorodecanoic acid (PFDA)	3.30	ND
Perfluoroheptanoic acid (PFHpA)	21.3	2.22
Perfluorohexanesulfonate (PFHxS)	11.5	ND
Perfluorohexanoic acid (PFHxA)	34.9	2.90
Perfluorononanoic acid (PFNA)	3.03	ND
Perfluorooctanesulfonate (PFOS)	23.9	3.92
Perfluorooctanoic acid (PFOA)	15.2	2.58
Perfluoropentanesulfonate (PFPeS)	2.53	ND
Perfluorobutyric acid (PFBA)	17.2	ND
Perfluoropentanoic acid (PFPeA)	40.4	6.06
Nafion Byproduct 1*	ND	ND
Nafion Byproduct 2*	19.0	6.15
Perfluoro(3,5,7,9-tetraoxadecanoic) acid (PFO4DA)*	92.9	30.7
Perfluoro(3,5-dioxahexanoic) acid (PFO2HxA)*	106	365
Perfluoro-2-methoxyacetic acid (PFMOAA)*	137	404
Perfluoro-3-methoxypropanoic acid (PFMOPrA)*	16.1	8.63
Perfluoro-4-methoxybutanic acid (PFMOBA)*	12.2	ND
Perfluoro(3,5,7-trioxaoctanoic) acid (PFO3OA)*	153	141
Total PFAS (ppt)	**752.98**	**1,010.86**

*Compounds do not have certified standards

Note: < reporting limit = ND

CONCLUSION

The baseline nontargeted sampling results indicate significant concentrations of PFAS in groundwater at CFPUA's ASR well from contamination discharged by others into the surface water source of CFPUA's water distribution system.

We are grateful for the funds to conduct this important pilot study for research contributing to the body of knowledge available to all citizens of North Carolina to be more protective of public health from exposure to PFAS. As a water provider exposed to PFAS from upstream discharges in the Lower Cape Fear River, we see this project as an opportunity to:

- provide safer drinking water to our customers,
- Clean the aquifer for the community, and
- help others through our research.

A final report of the testing will be submitted by June 1, 2019. Please contact me for any additional information related to this pilot project.

Sincerely,

James R. Flechtner, P.E.
Executive Director

Attachment

cc: Carel Vandermeyden, P.E., Director of Engineering
Gary McSmith, P.E., Assistant Director of Engineering

Attachment A
Scope of Work and Annual Budget

Before it will be possible to finalize this award and make any disbursement, you are required to provide to the Agency a description for how the organization will spend the amount of funding allocated for the specific purpose as stated in the grant contract. This will include a scope of work, information related to any potential subgrants and an annual budget for the grant funds. Please attach additional sheets as necessary.

1. Organization:	
Organization Name:	Cape Fear Public Utility Authority
Tax Identification #:	26-2171251
Organization Fiscal Year End: (mmddyyyy)	06302019

2. Scope of Work:

Recipient shall detail below how the organization will spend the amount of funding allocated for the specific purpose as stated in the grant contract. The description should include services to be provided, objectives to be achieved, and expected results. The description should also include anticipated timing of those services, objectives and expected results.

CFPUA plans to spend the grant funds in accordance with Session Law 2018-5, Section 13.1(e) as follows:

(1) Perform nontargeted sampling of finished drinking water from the Authority's Sweeney Water Treatment Plant and in its Aquifer Storage and Recovery Well (ASR) to identify levels of per- and poly-fluoroalkyl substances (PFAS), including the chemical known as "GenX" (CAS registry number 62037-80-3 or 13252-13-6), that may be included in the water. CFPUA will sample both the finished drinking water from the distribution system treated by the Authority's Sweeney Water Treatment Plant and the Aquifer Storage and Recovery Well (ASR), both at the Westbrook Avenue site.

(2) Contract with HDR Engineering, Inc. of the Carolinas (Engineer) to assist CFPUA with full-scale piloting of two pilot trains at the ASR Well. Specific tasks include assisting with the procurement of the pilot trains, an evaluation of water quality and full-scale feasibility of implementation at the ASR site. Additionally, the Engineer will generate Interim and Final Reports that will be submitted to the House and Senate Select Committees on North Carolina River Quality, the Fiscal Research Division, and the Environmental Regulatory Commission.

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(4) Contract with CATLIN Engineers and Scientists (CATLIN) to conduct field sampling under the direction of CFPUA of any wells or water sources associated with the project, and prepare/ship the samples in a timely manner to the appropriate laboratory. CFPUA will pay the laboratory directly for all analytical sampling costs.

(5) Contract with University of North Carolina at Wilmington (UNCW) to identify and quantify unregulated compounds and chemicals from samples collected from the ASR well. Analyses will be conducted at UNCW's Marine and Atmospheric Chemistry Research Laboratory (MACRL).

(6) CFPUA will pay GEL Labs for the analysis of PFAS, including GenX. Samples will be collected and shipped by CATLIN (see item 4).

3. Subgrants:

a. Does the Recipient anticipate that it will subgrant or pass down any funds to another organization?		Yes	X	No

If yes, answer the following:

b. Name of Subrecipient	c. Program Name	d. Amount to Subrecipient

Below are general expenditure descriptions that can serve as a ***guide*** for preparing the organization's annual budget related to the grant award. Please add or delete expenditure captions for clarity if needed. The annual budget must be signed by an authorizing official.

The following annual budget is for the time period beginning 07/01/2018 and ending 06/30/2019

EXPENDITURE DESCRIPTION		**AMOUNT**
Employee Expenses (e.g. program related staffing).	$	
Services and Contract Expenses (e.g. utilities, telephone, data, lease related expenses)	$	$483,641
Goods (e.g. supplies and equipment) **Expenses**	$	
Administration Expenses (e.g. overhead & project management)	$	
Other Expenses (e.g. related charges not assigned above and described by recipient)	$	
Total Beginning Balance of the Project Fund	$	$450,000

With regard to the information contained herein, I certify that the annual budget has been approved by the Recipient's Chief Fiscal Officer, CEO or Board Chair.

[signature]
Signature

10/22/18
Date

John B. McLean
Printed Name

Chief Financial Officer
Title

GAC and IX Groundwater Treatment Pilot Test Plan

Cape Fear Public Utility Authority

Wilmington, NC

November 28, 2018

Table of Contents

Test Plan

Introduction

The Cape Fear Public Utility Authority (Authority) operates an Aquifer Storage and Recovery (ASR) system to supplement their potable water supply through the storage of treated water from the Sweeney Water Treatment Plant (WTP) in the PeeDee Aquifer. The purpose of the Westbrook ASR system is to provide water that can later be withdrawn during peak demand times. The ASR system has a capacity of 1 million gallons per day (mgd). Due to per- and poly-fluoroalkyl substance (PFAS) contamination in the Cape Fear River, Sweeney WTP finished water injected into the ASR system can be contaminated with these compounds that are at concentrations greater than the current EPA and NC health advisories that exist for three of these compounds: perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA) and GenX. As a result, the ASR system is not currently in operation and 50,000,000 gallons of groundwater have been withdrawn from the aquifer and disposed. Results of baseline PFAS testing from the ASR well conducted in July 2018 are presented in Appendix A.

As a result, the Division of Water Infrastructure (DWI) of the Department of Environmental Quality (DEQ) has granted the Authority funds, per North Carolina Session Law 2018-5, to perform non-targeted sampling of finished water in its ASR system. Additionally, funds have been provided to determine the relative effectiveness of granular activated carbon (GAC) and ion exchange (IX). To accomplish this task, main pilot trains and mini pilot columns will be evaluated over a three month period according to Table 1.

Table 1. Testing Scenarios

Test Scenarios	Purpose
GAC and IX Main Pilot Trains in Parallel	To evaluate GAC and IX simulating large-scale groundwater treatment.
GAC and IX Mini Pilot Columns in Parallel	To evaluate PFAS breakthrough in GAC and IX processes. Mini pilot columns will be scaled-down versions of the pilot trains.
GAC-IX Mini Pilot Columns in Series	To determine the PFAS removal capabilities of a GAC-IX lead-lag configuration.

This test plan outlines the general testing conditions, equipment procurement and setup, and test monitoring for two main pilot trains and four mini pilot columns located at the Westbrook ASR well. The objective of this investigation will be to evaluate the treatment efficacy of two treatment technologies (GAC and IX), the benefits of GAC and IX processes on water quality, demonstrate the feasibility of implementation, and reduce process and cost risks based on real-time operations.

General Testing Conditions

Per North Carolina Session Law 2018-5, this project, including a final report, must be completed by June 1, 2019. Pilot operation and PFAS sample collection must be completed by the end of March due to the lengthy turnaround time of PFAS results.

It is estimated that the main pilot trains and mini pilot columns will begin operation on December 30, 2018. Main pilot trains will continue operating until March 31, 2019, although the operation of mini pilot columns may be halted prior to this time, depending on when PFAS breakthrough is observed. The GAC and IX main pilot trains will be operated in parallel for the entire duration of the project. Over the duration of the project, it is anticipated that the main pilot trains will operate at three different flow rates to evaluate PFAS removal at different empty bed contact times (EBCT). Mini pilot columns will be in operation at a constant flow rate until PFAS breakthrough is achieved. The main pilot columns will have a sample ports at different depths media depths to evaluate removal and breakthrough along the media depth.

Routine field water quality analyses will be conducted by The Authority, and PFAS, compounds of emerging concern (CECs) and other non-routine (e.g. disinfection by-products, metals, etc.) samples will be collected by Catlin Engineers and Scientists (Catlin). GEL Laboratories (GEL) will conduct the PFAS analyses, and Eurofins Eaton Analytical (Eurofins) will conduct the CEC and non-routine compound analyses. A summary of parameters and sampling frequencies is presented in the Test Monitoring Section of this Test Plan. A complete list of PFAS, CECs, and non-routine compounds is presented in Appendix B.

Equipment Procurement and Setup

In accordance with General Assembly of North Carolina Session 2017, Session Law 2018-5, Senate Bill 99, the Authority is to test the effectiveness of ion exchange and activated carbon technologies for treatment of PFAS, including GenX. The Senate bill established the following: (i) install temporary ion exchange and carbon treatment systems suitable to treat 500 gallons per minute (gpm) flow as a minimum capacity; (ii) after installation of the temporary treatment systems, test the water treated weekly, before and after treatment by ion exchange and activated carbon, over a period of six weeks at increasing flow rates to determine the relative effectiveness of the two technologies at reducing PFAS, including GenX, and (iii) after determination of the most successful treatment technology at a high flow of 500 gpm, continue sampling water treated by the technology at two week intervals thereafter.

This study will be performed by operating one GAC main pilot train and one IX main pilot train in parallel to compare the two alternatives for PFAS removal. Both main pilot trains will be supplied by the same contractor, Water and Waste Systems Construction, Inc., who was selected based on the lowest responsible bid. The contractor's equipment vendor, Calgon, Inc., will provide on-site service during start-up of the main pilot trains and mini pilot columns.

The existing ASR pump has an approximate capacity of 700 gpm. Therefore it is not possible to operate both pilots at 500 gpm. There is also concern that it will not be possible to determine the most successful technology after a period of six weeks as breakthrough is not likely to occur for many of the constituents and each technology may perform differently with respect to specific contaminants. Therefore, it is recommended that both main pilot trains operate under the same conditions at all times, up to a flow rate of 250 gallons per minute (gpm) per train. It is not expected that backwashing will need to be performed during testing due to the relatively short time frame, and treated pilot effluent will be discharged to the sanitary sewer. Mini pilot columns will be used as a small scale pilot to simulate full-scale operations and test PFAS breakthrough at a constant flow rate.

Given the relatively short study timeframe, it is possible that the main pilot trains will not see complete breakthrough of specific PFAS compounds prior to the completion of this study. Sample ports at 25%, 50%, 75% and 100% media bed depths are proposed on both the GAC and IX main pilot trains to determine breakthrough patterns within the vessels. Additionally, GAC and IX mini pilot columns will be evaluated to ensure complete breakthrough is observed and results will be scaled up appropriately to estimate full-scale PFAS breakthrough. These mini pilot columns will be supplied by the same vendor who is providing the main pilot trains The mini pilot columns will be 4-inches in diameter. A schematic of mini pilot columns is depicted in Figure 1. Three mini pilot column configurations will be tested: one GAC column (column 1, shown in blue), one IX column (column 2, shown in green), and one lead-lag (GAC-IX) column configuration (columns 3 and 4, shown in yellow). Mini pilot columns will be located inside of the existing water tower at the Westbrook ASR well site, and mini pilot column influent will come from the same common pipeline that is used to supply the two main pilot trains.

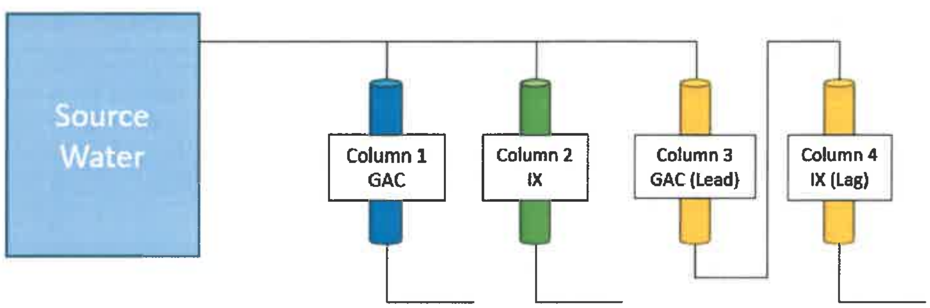

Figure 1. Mini Pilot Column Configuration

Main pilot train flow rates will be periodically increased throughout the duration of this study to evaluate the removal of PFAS at multiple EBCTs since research has shown that increased EBCTs often result in increased constituent removal. It is estimated that main pilot train GAC media capacity will be 300 ft^3 and IX resin capacity will be 100 ft^3 based on information obtained the GAC and IX vendor. Previous research has recommended GAC EBCTs ranging from 10 minutes to 20 minutes and IX EBCTs ranging from 2 minutes to 4 minutes for PFAS removal. Flow rates and EBCTs in the main pilot trains will be evaluated sequentially as shown in Table 2. As shown in Table 2 and Table 4, it is anticipated that main pilot train flow rate will start at 130 gpm for the first two weeks, then be increased to 175 gpm for an additional two weeks. A final increase in flow rate to 250 gpm per main pilot train will occur during week 5, which will remain constant for the remainder of this investigation (through week 13), for a total operation time of 9 weeks at 250 gpm. Changes in flow rate will be modified as deemed necessary based on results. Although it is not expected that breakthrough will be observed at the 100% bed depth during the first few weeks at the lower feed rate, breakthrough will be tracked through the bed, and results obtained from intermediate sampling ports will be used to compare the impact of EBCTs on PFAS removal.

GAC and IX mini pilot columns will consistently operate at EBCTs of 10 minutes and 2 minutes, respectively. Four-inch diameter mini pilot columns previously used for the Sweeney WTP pilot will be relocated to the ASR site.

Table 2. GAC and IX EBCTs to be evaluated for Main Pilot Train Demonstration

Flow Rate (gpm)[a]	GAC EBCT (min)	IX EBCT (min)	No. Weeks[a]
130	20	4	2
175	15	3	2
250	10	2	9

[a]Subject to change based on preliminary results.

Test Monitoring

Routine water quality monitoring will be performed on samples collected from a common influent sample port in addition to GAC and IX main pilot train effluent sample ports and mini pilot columns. Collected hydraulic and water quality data will be input into project data monitoring templates by the Project Team on a weekly basis. Field parameters routinely collected will be provided to HDR by the Authority weekly. Results from samples analyzed by an external lab will be provided as soon as they are available. Table 3 presents a list monitoring parameters, monitoring frequency, and the entity/lab responsible for sample collection and analysis. Many parameters in Table 3 are already monitored in the Authority's ASR system, including flow rate, water level/pressure, cumulative volume, pH, temperature, dissolved oxygen, and redox potential.

PFAS samples will be collected once per week, and a suite of 41 PFAS will be tested. Individual PFAS analyzed in this study are presented in Appendix B. Daily monitoring of total organic carbon (TOC) and TOC's surrogate, UV absorbance at 254 nm (UV254), can provide invaluable information regarding breakthrough of the main pilot trains. For example, if TOC is monitored daily in mini pilot columns and breakthrough is observed after a given period of time, this information can be used to predict when TOC and PFAS breakthrough will occur in the main pilot trains. The pattern of TOC breakthrough relative to PFAS breakthrough in the mini pilot columns can be applied to the main pilot trains to help predict when PFAS breakthrough can be expected. This would allow PFAS sampling to be conducted at the appropriate media depths after the appropriate run time.

Table 3. Sampling Plan – Main Pilot Trains

Parameter	Frequency[a]	Entity/Lab
Flow Rate	Continuous/Daily[b]	Authority
Water Level/Pressure	Continuous/Daily[b]	Authority
Cumulative Volume	Continuous/Daily[b]	Authority
pH	Daily	Authority
Temperature	Daily	Authority
Dissolved Oxygen	Daily	Authority
Conductivity	Daily	Authority
Total Organic Carbon	3 x Week	Authority/Eurofins
UV254	3 x Week	Authority/Eurofins
Redox Potential	1 x Week	Authority
Turbidity	1 x Week	Authority
Alkalinity	1 x Week	Authority/Eurofins
Hardness	1 x Week	Authority/Eurofins
Total Dissolved Solids	1 x Week	Authority/Eurofins
Iron	1 x Week	Authority/Eurofins
Manganese	1 x Week	Authority/Eurofins
PFAS[c]	1 x Week	Catlin/GEL
CECs and non-routine compounds[c]	Weeks 1, 7 and 13[d]	Catlin/Eurofins

[a]Parameters evaluated daily should be monitored around the same time each day. Parameters evaluated weekly should be evaluated on the same day each week. The date and time of initial pilot startup and all sample collection shall be recorded along with any interference with treatment process due to shutdowns, significant increase or drop in flow rate, etc. [b]Continuously monitored parameters will be manually checked daily using the appropriate gauges/meters to ensure the instrumentation is operating correctly. [c]A complete list of PFAS, CECs, and non-routine compounds is presented in Appendix B. [d]Subject to change based on Week 1 results and cost considerations (see next section).

Analytical Cost Considerations and Sampling Schedule

The current budget for PFAS testing at an external laboratory is $65,000, and the cost to test one PFAS sample (including the entire suite of 41 PFAS) is $450.50. This allows 144 PFAS samples to be collected throughout this study. Samples will be collected at the following sample ports, although collection at each sample port will not occur during each sampling event:

1. Influent
2. GAC main pilot train effluent – 25% bed depth
3. GAC main pilot train effluent – 50% bed depth
4. GAC main pilot train effluent – 75% bed depth
5. GAC main pilot train effluent – 100% bed depth
6. IX main pilot train effluent – 25% bed depth
7. IX main pilot train effluent – 50% bed depth
8. IX main pilot train effluent – 75% bed depth
9. IX main pilot train effluent – 100% bed depth
10. GAC mini pilot column 1 effluent
11. IX mini pilot column 2 effluent
12. GAC mini pilot column 3 effluent (column 4 influent)
13. IX mini pilot column 4 effluent

Available PFAS sampling funds cannot cover sample collection from each location over the course of this study, and sampling each port throughout the entire duration of the study is not necessary. PFAS breakthrough in mini pilot columns is expected to occur early on in the study; therefore, collecting samples from mini pilot columns may not be necessary for the entire duration of the project. Table 4 presents the proposed PFAS sample collection schedule. This schedule results in 135 samples collected from various points throughout the main pilot trains and mini pilot columns, allowing 9 additional samples to be collected from locations or at frequencies that have yet to be determined. Sample collection locations and frequencies in the main pilot trains are subject to change based on breakthrough patterns observed in the mini pilot columns. If additional samples are needed elsewhere (e.g. if it is decided that the 75% bed depth should be sampled numerous times from both main pilot trains, exceeding the 9 allotted additional samples), sampling the lead column in the GAC-IX lead-lag configuration (column 3) will be reduced, as results should be the same as those observed in column 1. As previously mentioned, flow rates/EBCTs are subject to change based on preliminary PFAS results.

There are over 150 non-regulated CECs and non-routine compounds that could be sampled during this project, and testing the entire suite of parameters costs around $4,200 per sample; therefore, it is most cost-effective to only sample for compounds that are of concern or of potential concern at the ASR well. There is initially $50,000 available for CEC testing. It is recommended that the complete suite of compounds be tested in the influent and GAC and IX main pilot train effluents during Week 1 of this study to provide baseline data and eliminate compounds that do not need further investigation. After the Week 1 screening, $37,400 of funds would remain, allowing at least three additional sampling events, depending on the number of compounds analyzed in the future. Parameters that are detected in this screening study can then be monitored in Weeks 7 and 13 at various bed depths throughout the main pilot trains and mini pilot columns.

Sampling for TOC and UV254 will occur three times per week for the duration of this project from seven sample ports: influent, GAC main pilot train effluent, IX main pilot train effluent, and the four mini pilot columns. This results in 273 total TOC and UV254 samples for this project, resulting in a total estimated cost of $23,205 for external laboratory analyses. Additional parameters, including alkalinity, hardness, total dissolved solids, iron, and manganese will be collected once per week from the same seven sample ports and shipped to Eurofins for analyses. It is estimated that sampling for these parameters will result in a total cost $23,205 for this project. Data will be evaluated on an ongoing basis to determine if the frequency of analysis should be changed during the course of the study. Additional parameters, including alkalinity, hardness, total dissolved solids, iron, and manganese will be collected once per week from the same seven sample ports and shipped to Eurofins for analyses.

Table 4. Proposed PFAS Sampling Schedule

Sample Location	***Week***												
	12/30/18 -1/5/19	1/6/19-1/12/19	1/13/19-1/19/19	1/20/19-1/26/19	1/27/19-2/2/19	2/3/19-2/9/19	2/10/19-2/16/19	2/17/19-2/23/19	2/24/19-3/2/19	3/3/19-3/9/19	3/10/19-3/16/19	3/17/19-3/23/19	3/24/19-3/30/19
	1	2	3	4	5	6	7	8	9	10	11	12	13
	Main Pilot Train Flow Rate (gpm per train)												
	130	130	175	175	250	250	250	250	250	250	250	250	250
	Main Pilot Train GAC/IX EBCT (minutes)												
	20/4	20/4	15/3	15/3	10/2	10/2	10/2	10/2	10/2	10/2	10/2	10/2	10/2
Influent	x	x	x	x	x	x	x	x	x	x	x	x	x
GAC Main Pilot Train Effluent – 25%	x	x	x	x	x	x	x	x	x	x	x	x	x
IX Main Pilot Train Effluent – 25%	x	x	x	x	x	x	x	x	x	x	x	x	x
GAC Main Pilot Train Effluent – 50%	x	x	x	x	x	x	x	x	x	x	x	x	x
IX Main Pilot Train Effluent – 50%	x	x	x	x	x	x	x	x	x	x	x	x	x
GAC Main Pilot Train Effluent – 75%	*As Needed*												
IX Main Pilot Train Effluent – 75%	*As Needed*												
GAC Main Pilot Train Effluent – 100%	x	x	x	x	x	x	x	x	x	x	x	x	x
IX Main Pilot Train Effluent – 100%	x	x	x	x	x	x	x	x	x	x	x	x	x
GAC Mini Pilot Column Effluent (col. 1)	x	x	x	x	x	x	x	x	x	x	x		
IX Mini Pilot Column Effluent (col. 2)	x	x	x	x	x	x	x	x	x	x	x		
GAC Mini Pilot Column Effluent (col. 3)	x	x	x	x	x	x	x	x	x	x	x		
IX Mini Pilot Column Effluent (col. 4)	x	x	x	x	x	x	x	x	x	x	x		

*It is assumed that mini pilot columns will reach breakthrough in less than 10 weeks; therefore sampling for the entire duration of the project may not be necessary. The mini pilot columns will be operated at constant flow rate (250 gpm) throughout the duration of the study at EBCTs of 20 and 4 minutes for GAC or IX, respectively. The 75% bed depth will be sampled as needed based on preliminary results. Flow rates/EBCTs are subject to change based on preliminary results.

A

Appendix A – Baseline PFAS Results from the Westbrook ASR Well

Appendix A – Baseline PFAS Results from the Westbrook ASR Well

Table A-1 presents PFAS results from a baseline study using samples collected from the ASR well in July 2018. In this analysis, 12 out of 41 PFAS were above reporting limits. The highest PFAS concentration was 404 ng/L for perfluoro-2-methoxyacetic acid (PFMOAA).

Table A-1. Baseline PFAS Results from the Westbrook ASR Well

Analyte	Concentration (ng/L)
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate (F-53B Minor)	ND
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid (PFPrOPrA, GenX)	37.7
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (N-EtFOSE)	ND
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (N-MeFOSE)	ND
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	ND
Fluorotelomer sulfonate 10:2 (10:2 FTS)	ND
Fluorotelomer sulfonate 6:2 (6:2 FTS)	ND
Fluorotelomer sulfonate 8:2 (8:2 FTS)	ND
N-ethylperfluoro-1-octanesulfonamide (N-EtFOSA)	ND
N-ethylperfluoro-1-octanesulfonamidoacetic acid (N-EtFOSAA)	ND
N-methylperfluoro-1-octanesulfonamide (N-MeFOSA)	ND
N-methylperfluoro-1-octanesulfonamidoacetic acid (N-MeFOSAA)	ND
Perfluorobutanesulfonate (PFBS)	ND
Perfluorodecanesulfonate (PFDS)	ND
Perfluorodecanoic acid (PFDA)	ND
Perfluorododecanoic acid (PFDoA)	ND
Perfluoroheptanesulfonate (PFHpS)	ND
Perfluoroheptanoic acid (PFHpA)	2.22
Perfluorohexanesulfonate (PFHxS)	ND
Perfluorohexanoic acid (PFHxA)	2.90
Perfluorononanesulfonate (PFNS)	ND
Perfluorononanoic acid (PFNA)	ND
Perfluorooctanesulfonamide (PFOSA)	ND
Perfluorooctanesulfonate (PFOS)	3.92
Perfluorooctanoic acid (PFOA)	2.58
Perfluoropentanesulfonate (PFPeS)	ND
Perfluorotetradecanoic acid (PFTeDA)	ND
Perfluorotridecanoic acid (PFTrDA)	ND
Perfluoroundecanoic acid (PFUdA)	ND
Sodium dodecafluoro-3H-4,8-dioxanonanoate (ADONA)	ND
Fluorotelomer sulfonate 4:2 (4:2 FTS)	ND
Perfluorobutyric acid (PFBA)	ND
Perfluoropentanoic acid (PFPeA)	6.06
Nafion Byproduct 1*	ND
Nafion Byproduct 2*	6.15
Perfluoro(3,5,7,9-tetraoxadecanoic) acid (PFO4DA)*	30.7
Perfluoro(3,5-dioxahexanoic) acid (PFO2HxA)*	365

Analyte	**Concentration (ng/L)**
Perfluoro-2-methoxyacetic acid (PFMOAA)*	404
Perfluoro-3-methoxypropanoic acid (PFMOPrA)*	8.63
Perfluoro-4-methoxybutanic acid (PFMOBA)*	ND
Perfluoro(3,5,7-trioxaoctanoic) acid (PFO3OA)*	141

ND = not detected.

B

PFAS and CECs Analyzed

Appendix B – PFAS and CECs

PFAS that will be analyzed are presented in Table B-1. PFAS samples will be collected by Catlin and analyzed by GEL using EPA Method 537. Compounds in bold were detected in the baseline study previously presented in Appendix A.

Table B-1. PFAS Analyzed

PFAS	Abbreviation
11-chloroeicosafluoro-3-oxaundecane-1-sulfonate	F-53B Minor
2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)-propanoic acid	**PFPrOPrA, GenX**
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol	N-EtFOSE
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol	N-MeFOSE
9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	No abbreviation
Fluorotelomer sulfonate 10:2	10:2 FTS
Fluorotelomer sulfonate 4:2	4:2 FTS
Fluorotelomer sulfonate 6:2	6:2 FTS
Fluorotelomer sulfonate 8:2	8:2 FTS
N-ethylperfluoro-1-octanesulfonamide	N-EtFOSA
N-ethylperfluoro-1-octanesulfonamidoacetic acid	N-EtFOSAA
N-methylperfluoro-1-octanesulfonamide	N-MeFOSA
N-methylperfluoro-1-octanesulfonamidoacetic acid	N-MeFOSAA
Nafion Byproduct 1[a]	No abbreviation
Nafion Byproduct 2[a]	**No abbreviation**
Perfluoro(3,5,7,9-tetraoxadecanoic) acid[a]	**PFO4DA**
Perfluoro(3,5,7-trioxaoctanoic) acid[a]	**PFO3OA**
Perfluoro(3,5-dioxahexanoic) acid[a]	**PFO2HxA**
Perfluoro-2-methoxyacetic acid[a]	**PFMOAA**
Perfluoro-3-methoxypropanoic acid[a]	**PFMOPrA**
Perfluoro-4-methoxybutanic acid[a]	PFMOBA
Perfluorobutanesulfonate	PFBS
Perfluorobutyric acid	PFBA
Perfluorodecanesulfonate	PFDS
Perfluorodecanoic acid	PFDA
Perfluorododecanoic acid	PFDoA
Perfluoroheptanesulfonate	PFHpS
Perfluoroheptanoic acid	**PFHpA**
Perfluorohexanesulfonate	PFHxS
Perfluorohexanoic acid	**PFHxA**
Perfluorononanesulfonate	PFNS
Perfluorononanoic acid	PFNA
Perfluorooctanesulfonamide	PFOSA
Perfluorooctanesulfonate	**PFOS**
Perfluorooctanoic acid	**PFOA**
Perfluoropentanesulfonate	PFPeS
Perfluoropentanoic acid	**PFPeA**
Perfluorotetradecanoic acid	PFTeDA
Perfluorotridecanoic acid	PFTrDA
Perfluoroundecanoic acid	PFUdA
Sodium dodecafluoro-3H-4,8-dioxanonanoate	ADONA

[a]Compounds do not have certified standards.

Table B-2 presents CECs and non-routine water quality parameters that will be analyzed in an initial screening of the ASR system. Non-routine parameters include constituents that are not frequently tested in water treatment, but are not necessarily CECs (e.g. chlorite, chlorate, disinfection by-products, metals, etc.). These compounds will be collected by Catlin and analyzed by Eurofins using liquid chromatography with tandem mass spectrometry (LC/MS/MS). Compounds in bold were detected in samples collected in 2012 and/or 2013.

Table B-2. CECs and Non-Routine Compounds Analyzed

Group Name	**Individual Compounds**
1,4-Dioxane	1,4-Dioxane
Bromide, Chlorate, Chlorite	**Bromide**, Chlorate, Chlorite
Carbamates	1-Naphthol Aldicarb Aldicarb sulfoxide Carbofuran Oxamyl 3-Hydroxycarbofuran Aldicarb sulfone Cararyl Methomyl
Chlorinated Acids	Dinoseb 2,4-D Pecloram Pentachlorophenol **Dalapon** 2,4,5-TP (Silvex)
Total Cyanide	Total Cyanide
Diquat	Diquat
EDB/DBCP	1,2-Dibromoethane 1,2-Dibromo-3-chloropropane
EDCs, PPCPs, Hormones	1,7-Dimethylxanthine 17alpha-Ethynyl estradiol 17beta-Estradiol 2,4-D 4-Androstene 4-Nonylphenol 4-tert-Octylphenol Acesulfame-K Acetaminophen Albuterol Amoxicillin Antipyrine Atenolol Atrazine Azithromycin Bendroflumethiazide Bezafibrate Bisphenol A

Group Name	Individual Compounds
	Bromacil Butalbital Butylparaben Caffeine Carbadox Carbamazepine Carisoprodol Chloramphenicol Chloridazon Chlorotoluron Cimedtidine Clofibric acid Cotinine Cyanazine DEET Dehydronifedipine Desethylatrazine Desisopropylatrazine Diaminochlorotriazine Diazepam Diclofenac Dilantin Diltiazem Diruon Erythromycin Estriol Estrone Ethylparaben Flumequine Fluoxetine (Prozac) Gemfibrozil Ibuprofen Iohexal Iopromide Isobutylparaben Isoproturon Ketoprofen Ketorolac Lidocaine Lincomycin Linuron Lopressor Meclofenamic acid Meprobamate Metazochlor Methylparaben Metolachlor Naproxen Nifedipine

Group Name	Individual Compounds
	Norethisterone Oxolinic acid Pentoxifylline Primidone Progesterone Propazine Propylparaben Quinoline Salicylic Acid Simazine Sucralose Sulfachloropyridazine Sulfadiazine Sulfadimethoxine Sulfamerazine Sulfamethazine Sulfamethizole Sulfamethoxazole Sulfathiazole Sulfometruon Methyl Testosterone Theobromine Theophylline Thiabendazole Triclocarban Triclosan Trimethoprim Tris(1,3-dichloro-2-propyl) phosphate Tris(2-carboxyethyl)phosphine hydrochloride Warfarin
Endothall	Endothall
Fluoride, Chloride, Nitrate, Sulfate	Fluoride, Chloride, Nitrate, Sulfate
Glyphosate	Glyphosate
Gross Alpha & Beta	**Gross Alpha** Gross Beta
Haloacetic Acids	**Dibromoacetic Acid** **Dichloroacetic Acid** **Monobromoacetic Acid** **Monochloracetic Acid** **Trichloroacetic Acid**
Metals – ICP AES	**Sodium** **Total Silica** **Potassium** **Magnesium** **Calcium**
Metals – ICP MS	Aluminum Antimony **Arsenic** Barium

Group Name	Individual Compounds
	Beryllium Boron Cadmium Chromium Cobalt Copper Lead Lithium **Manganese** Molybdenum Nickel Selenium Silver Strontium Thallium Thorium Tin Titanium Uranium Vanadium Zinc
Mercury	Mercury
Nitrogen, Ammonia	Nitrogen, Ammonia
Perchlorate	Perchlorate
Phase II & V	Di(2-ethylhexyl)adipate Hexachlorobenzene Heptachlor epoxide Endrin Di(2-ethylhexyl)phthalate Alachlor Hexachlorocyclopentadiene Simazine Gamma-BHC (Lindane) Atrazine Heptachlor Methoxychlor Benzo(a)pyrene
Phase II & V PCB/Toxaphene/Chlordane	Aroclor 1016 Aroclor 1221 Aroclor 1232 Aroclor 1242 Aroclor 1248 Aroclor 1254 Aroclor 1260 Chlordane Toxaphene
Radium-226	**Radium-226**
Radium-228	**Radium-228**
RC Uranium	RC Uranium

Group Name	Individual Compounds
Trihalomethanes	Bromodichloromethane Bromoform **Chloroform** Dibromochloromethane
LTB/VOCs	Tetrachloroethylene Toluene Trichloroetylene Vinyl Chloride Trans-1,2-Dichloroethylene Carbon Tetrachloride Chlorobenzene Benzene 1,1-Dichloroethylene **Dichloromethane** 1,4-Dichlorobenzene 1,3+1,4-Xylene Cis-1,2-Dichloroethylene Ethylbenzene 1,2-Xylene 1,2-Dichloropropane 1,1,2-Trichloroethane 1,2-Dichloroethane Epichlorohydrin 1,2-Dichlorobenzene 1,1,1-Trichloroethane
VOCs	Cis-1,2-Dichloroethylene Trans-1,2-Dichloroethylene Carbon Tetrachloride 1,4-Dichlorobenzene 1,2,4-Trichlorobenzene 1,1,2-Trichloroethane 1,2-Xylene Ethylbenzene Styrene Tetrachloroethylene Toluene Trichloroethylene Vinyl Chloride Benzene Chlorobenzene 1,2-Dichloroethane Epichlorohydrin 1,3+1,4-Xylene 1,2-Dichloropropane Dichloromethane 1,2-Dichlorobenzene 1,1,1-Trichloroethane 1,1-Dichloroethylene