FINAL

PROGRESS UPDATE

Emerging Contaminants Treatment Strategy Pilot Study

B&V PROJECT NO. 196369

PREPARED FOR

Cape Fear Public Utility Authority

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BLACK & VEATCH

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1.0 Purpose

This document presents the status of ongoing bench- and pilot-scale testing to evaluate the performance of several proposed treatment technologies in their removal of perfluoroalkyl substances (PFASs), including perfluoro-2-propoxypropanoic acid (commonly known as GenX).

2.0 Introduction

PFASs have been detected in the Cape Fear River, which is the source of raw water for the Sweeney Water Treatment Plant (WTP). The Sweeney WTP provides drinking water to Cape Fear Public Utility Authority (CFPUA) customers in the City of Wilmington and New Hanover County in North Carolina.

In response to the detection of GenX and other PFASs in the Cape Fear River and because of concern over potential health effects, CFPUA is proactively investigating the feasibility and effectiveness of PFAS removal technologies. CFPUA is one of the first utilities in the United States to pursue treatment to target removal of these compounds. Initial evaluations performed by Black & Veatch were provided in Technical Memoranda 1 and 2. As a result of those evaluations, bench- and pilot-scale testing of granular activated carbon (GAC) filter media and ion exchange (IX) resins was initiated. The details of the bench- and pilot- scale testing are presented herein.

3.0 Testing and Analysis

Granular activated carbon filter media and ion exchange resin were selected for bench- and pilot-scale testing. Reverse osmosis/nanofiltration was excluded because of much higher life-cycle cost and potential challenges related to disposal of the concentrate, but the technology will be considered if testing of GAC and IX fail to meet testing goals. The following sections provide information on the testing.

3.1 TESTING GOALS

The primary goal of the testing is to establish the adsorption characteristics for PFASs and other contaminants of emerging concern (CECs) on GAC media and IX resin. These characteristics will be used to refine the previous study-related evaluations and identify the most advantageous short- and longer-term treatment strategies for removal of PFASs and CECs at the Sweeney WTP. The data will help define a design basis for full-scale implementation of the selected technology. Ancillary benefits are also being identified as part of the study, such as reductions in total organic carbon (TOC), disinfection byproduct (DBP) formation, and inorganic compounds.

3.2 MEANS AND METHODS

Pilot testing is used to determine the adsorption characteristics of PFASs on GAC media and IX resins. Accelerated column testing was performed on two GAC media as one month of operating results can be used to estimate up to one year of performance. The same accelerated testing is not available for IX resins. Each test is discussed in the following sections.

During the initial screening process, commercially available GAC media and IX resins were surveyed to identify products that have the highest likelihood of achieving PFAS removal for testing. Testing of surveyed media and resins was then prioritized based on experience and suitability with PFAS removal.

3.2.1 Accelerated Column Test

The accelerated column test is designed to simulate year-long operation of a full-scale bed of GAC using a smaller bench-scale column that is operated for around a month. The test consists of scaling down commercial GAC by pulverizing it into smaller particles to achieve a proportionate adsorption capacity and placing it in a scaled-down column. Empty bed contact time (EBCT) for the accelerated column test is maintained equivalent to the full-scale design. A sample of water from the plant is pumped through the column for several weeks. Samples are collected for analytical testing to establish a breakthrough curve for the GAC media. A flow diagram of the ACT rig is shown in Figure 3-1 and an image of the test rig in Figure 3-2.

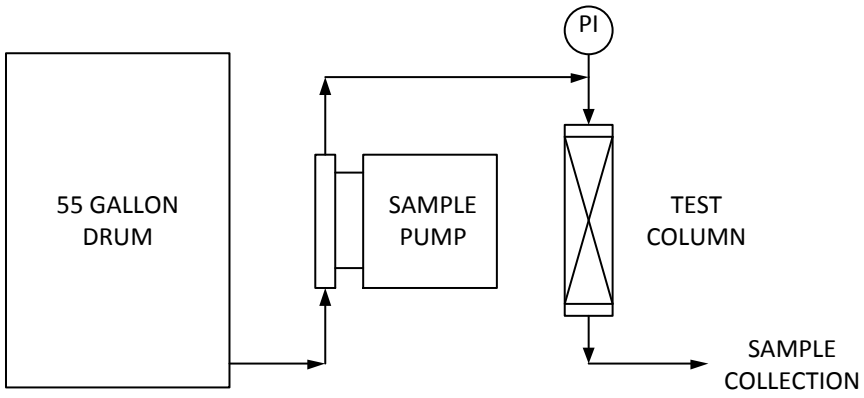

Figure 3-1 Accelerated Column Test Flow Diagram

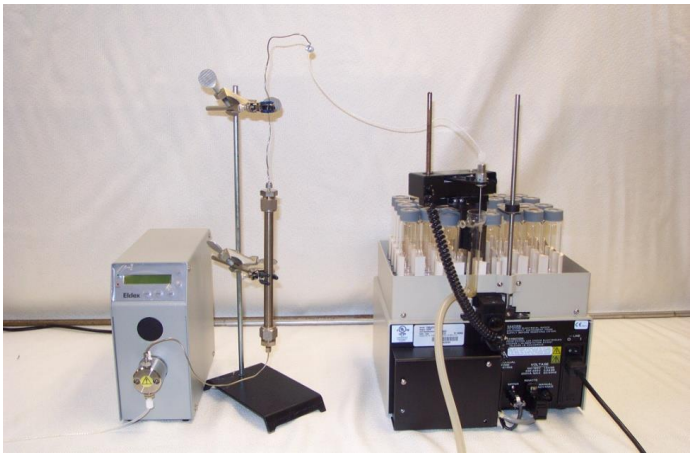

Figure 3-2 Accelerated Column Test Equipment

The ACT test for CFPUA was performed by Calgon Carbon Corporation, a supplier of granular activated carbon. Two 55 gallon drums of water drawn downstream from the existing filters at the Sweeney WTP were submitted for testing. Two ACTs were performed, one using Calgon's Filtasorb 400, and the other using Filtrasorb 600. Both GAC products were scaled down from mesh sizes of 12 by 40 for the test. Both tests were run simultaneously in parallel for 27 days to simulate one year of full-scale operation. Each test was run using an EBCT of 10 minutes.

3.2.2 Pilot Test

Pilot testing is used to evaluate performance of a design on a small scale in real-time prior to investment in full-scale implementation. The CFPUA pilot operates in parallel with the existing treatment scheme at the Sweeney WTP. The pilot consists of six test columns: four columns containing GAC media and two columns containing IX resin. A very small portion of the process flow in the WTP is diverted to each of the columns to assess placement within the overall process scheme and performance. A process flow diagram of the pilot is presented in Figure 3-3 and a picture of the GAC columns is illustrated in Figure 3-4.

Each column is equipped with valves and a flow meter to regulate flow through the column. Samples are collected at the inlet and outlet of the columns for analytical testing to measure adsorbent performance. Samples are collected at the following locations:

- Plant influent
- Existing filter influent
- Existing filter effluent
- Plant effluent prior to distribution
- Outlet of each test column

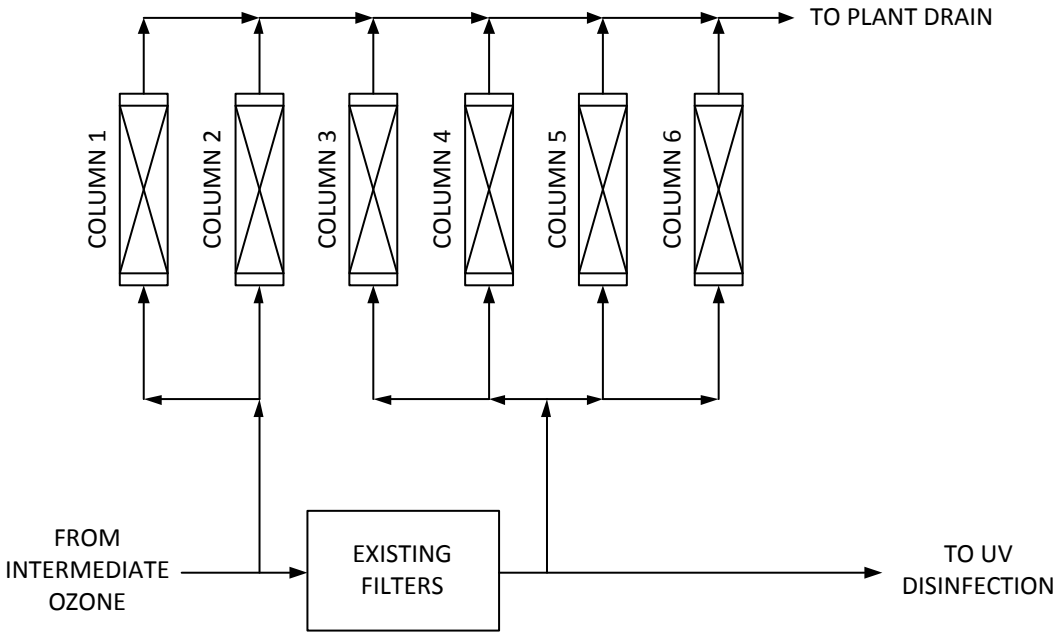

Figure 3-3 Pilot Test Flow Diagram

Figure 3-4 Pilot Test Skid

Operation of columns 1 through 4 began on August 2, 2017 and columns 5 and 6 (not shown) began operation on September 5, 2017. Each column containing GAC was run at an EBCT of 10 minutes. Each column containing IX resin was run at an EBCT of 1.5 minutes. The adsorbent selected for each test column is listed in Table 3-1. All test columns have operated continuously since their start.

Table 3-1 Adsorbents

Column	Type	Adsorbent	Supplier
Column 1	GAC	GAC 1 (Filtrasorb F400 12x40)	Calgon
Column 2	GAC	GAC 2 (Filtrasorb F300 12x30)	Calgon
Column 3	GAC	GAC 3 (Filtrasorb F400 12x40)	Calgon
Column 4	GAC	GAC 4 (AquaCarb 1230 CX)	Evoqua
Column 5	IX	IX 1 (DOWEX PSR-2)	Evoqua
Column 6	IX	IX 2 (CalRes 2304)	Calgon

3.3 GAC INTERIM RESULTS TO DATE

Granular activated carbon is used in the accelerated column testing and the pilot testing. Preliminary ACT results included a discrepancy in the dilution factors used and the laboratory is repeating the analysis. No ACT test results are available at this time.

Interim results of the ongoing pilot testing are presented in Table 3-2. All data is reported based on equivalent bed volumes of water treated.

Each GAC test column is exhibiting gradual breakthrough of TOC and PFASs, led by GenX. Columns 1 and 2, which are being tested using water from upstream of the existing filters, are showing slower breakthrough for all PFASs than columns 3 and 4, which are being tested using water from downstream of the existing filters. Testing data show higher values for each PFAS analyte in the water post filter than in the water pre filter. This may indicate that chromatographic peaking is occurring in the existing filters, where the existing media is desorbing PFASs to preferentially adsorb another compound leading to higher concentrations of PFASs in the post filter water.

Also included in Table 3-2 are other emerging contaminants that include Endocrine Disrupting Compounds (EDCs) and Pharmaceutical and Personal Care Products (PPCPs). The four GAC columns are highly effective for the removal of these compounds at this point whereas IX is ineffective for the removal of those compounds.

Table 3-2 Sampling Results as of October 3, 2017

Pilot Supply		**Intermediate Ozone**		**Biologically Active Filter Effluent**			
	Column Influent	**GAC-1**	**GAC-2**	**GAC-3**	**GAC-4**	**IX-1**	**IX-2**
Bed Volumes	---	8,800	9,200	8,800	9,100	27,400	27,400
PFASs							
	ng/L	**Percent Breakthrough**					
GenX	24 -42.2	68	90	100	113	0	0
PFHxA	18-41	50	63	74	80	0	0
PFHpA	11-28	36	44	62	62	0	0
PFOA	9.8-17	22	28	47	43	0	0
PFBS	4-6.4	3	26	45	58	0	0
PFHxS	5.4-11	0	9	28	27	0	0
PFOS	9.4-24	0	0	18	15	0	0
Endocrine Disrupting Compounds (EDCs)/Pharmaceutical and Personal Care Products (PPCPs) (Percent Breakthrough)							
	µg/L	**Percent Breakthrough**					
Sucralose	0.864-0.928	14	14	25	15	96	94
Tris(chloropropyl) phosphate	0.06-0.07	0	0	0	0	100	114
Cotinine	0.003	0	0	0	0	100	100
Acesulfame-K	0.02-0.04	0	0	0	0	0	0

3.4 IX INTERIM RESULTS TO DATE

Ion exchange is only undergoing pilot testing. Interim results of the ongoing pilot testing are presented in Table 3-2. Neither ion exchange test column has – to date – exhibited any breakthrough of PFASs through approximately 27,400 bed volumes treated. This indicates that both IX columns are adsorbing PFASs such that their levels in the treated water are not detectable.

4.0 Discussion

- The bench-scale and pilot testing is ongoing and scheduled to continue through the first quarter of 2018 until testing goals are achieved.
- PFAS are being observed in the pilot GAC media effluent.
    - Columns 3 and 4 are very near or above the influent concentration for GenX.
    - Other PFAS continue to be partially removed.
- Ion exchange adsorbents have yet to show any breakthrough of PFASs.
- GAC columns are more effectively removing EDCs and PPCPs than IX columns.
- Testing will evolve as data is received to refine short- and long-term treatment strategies. This includes the replacement of adsorbents that fail to perform.
    - GAC 1 – Continue piloting until regulatory review of alternative filter media configuration is complete. Also awaiting complete breakthrough of PFAS, EDCs, and PPCPs.
    - GAC 2 – Continue piloting until regulatory review of alternative filter media configuration is complete. Also awaiting complete breakthrough of PFAS, EDCs, and PPCPs.
    - GAC 3 – Continue piloting to observe complete breakthrough of PFAS in a post filtration location.
    - GAC 4 – Continue piloting to observe complete breakthrough of PFAS in a post filtration location. Maintain the opportunity to include an alternative supplier.
    - IX 1 – Continue piloting to observe breakthrough of PFAS.
    - IX 2 - Continue piloting to observe breakthrough of PFAS.
- Additional pilot columns are being considered for testing of other GAC and IX adsorbents.

5.0 Conclusions/Recommendations

The following conclusions and recommendations can be developed based on the interim testing results.

- PFAS are being detected in the pilot GAC media effluent after 1,600 bed volumes.
- EDCs and PPCPs are effectively removed by all GAC columns after 8,800 bed volumes.
- No PFAS have been observed in the IX column effluent after 27,400 bed volumes.
- EDCs and PPCPs are not effectively removed by either IX column.
- No cost evaluation has been completed comparing IX and GAC.

- No life-cycle costs have been developed comparing IX and GAC so it is premature to eliminate a technology at this time. Life-cycle cost development is occurring in parallel with the pilot study.