PARSONS

ENGINEERING REPORT
OLD OUTFALL 002 GAC PILOT STUDY RESULTS ADDENDUM
CHEMOURS FAYETTEVILLE PLANT
FAYETTEVILLE, NORTH CAROLINA

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APPENDICES

ACRONYMS

Acronym	Definition / Description
Chemours	The Chemours Company FC, LLC
CO	Consent Order
DWR	(NCDEQ) Division of Water Resources
EPA	Environmental Protection Agency
F400	(Calgon) Filtrasorb 400
GAC	Granular activated carbon
g/L	Gram(s) per liter
gpm	Gallon(s) per minute
HFPO-DA	Hexafluoropropylene oxide dimer acid
L/min	Liter(s) per minute
µg/L	Microgram(s) per liter
mg/L	Milligram(s) per liter
NCDEQ	North Carolina Department of Environmental Quality
NPDES	National Pollutant Discharge Elimination System
OOF2	Old Outfall 002
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFMOAA	Perfluoro-2-methoxyacetic acid
PMPA	Perfluoromethoxypropionic acid

1.0 INTRODUCTION

Parsons performed a pilot study to demonstrate the effectiveness of using GAC adsorption for removal of indicator PFAS compounds in Old Outfall 002 (OOF2) as required by paragraph 12.e of the February 25, 2019 Consent Order (CO) entered by The Chemours Company FC, LLC (Chemours) with the State of North Carolina and Cape Fear River Watch. The pilot study was conducted over a 3-month period from June through September 2019. Parsons prepared the Engineering Report - Old Outfall 002 GAC Pilot Study Results (September 2019) presenting and summarizing analytical data available at the time the study was completed. Parsons has prepared this addendum to present and summarize the remaining analytical data which has become available since issuance of the September 2019 Engineering Report.

2.0 BACKGROUND

The September 2019 Engineering Report provides the background, technical approach, and results available at the time of report issuance for the OOF2 pilot study required under Paragraph 12.e of the CO. The results available at the time the Engineering Report was issued included data collected from June 14 through August 27, 2019. This addendum supplements the September 2019 Engineering Report with remaining analytical data from August 27 through September 14, 2019, which covers the balance of samples collected during the 2nd test phase (Test #2) which compared Calgon Filtrasorb 400 (F400) GAC (Test 2A) and DSR-A (Test 2B), a regenerated GAC product also from Calgon. The remaining results for Test #2 are summarized below and presented in the following appendices:

- Appendix A – Conventional parameter figures.
- Appendix B – Comprehensive PFAS treatment results tables.
- Appendix C – Breakthrough curves for PFMOAA, HFPO-DA, and select additional parameters demonstrating progression of treatment through the GAC columns.

The figures in Appendix A and Appendix C are shown for the entirety of Test #2 but delineated to indicate additional data available since issuance of the September 2019 Engineering Report.

2.1 Sample Points

The sample points were identified as follows:

Sample Point #	Sample Point ID	Description
SP-1	INF	Untreated Stored Influent
SP-2	PRE-A	Pretreated/Filtered Batch ('A' Train)
SP-3	GAC 1A	Column 1 Effluent ('A' Train)
SP-4	GAC 2A	Column 2 Effluent ('A' Train)
SP-5	GAC 3A	Column 3 Effluent ('A' Train)
SP-6	GAC 4A	Column 4 Effluent ('A' Train)
SP-7	GAC B	Pretreated/Filtered Batch ('B' Train)
SP-8	GAC 1B	Column 1 Effluent ('B' Train)
SP-9	GAC 2B	Column 2 Effluent ('B' Train)
SP-10	GAC 3B	Column 3 Effluent ('B' Train)
SP-11	GAC 4B	Column 4 Effluent ('B' Train)

2.2 Conventional Parameters

The figures in Appendix A show the removal of Total Organic Carbon (TOC), Total Suspended Solids (TSS), total iron, and soluble iron during pretreatment/filtration and GAC adsorption.

2.3 PFMOAA

Pretreatment. Influent concentrations in Test #2 as analyzed by Chemours' on-site analytical laboratory were measured at an average of around 27 micrograms per liter (µg/L); pretreated and filtered flow concentrations were measured at an average of around 22 – 23 µg/L.

GAC Treatment and Breakthrough

Test 2A (F400 GAC). PFMOAA demonstrated generally similar breakthrough milestones in Test 2A as in Test #1 which also utilized F400 GAC. PFMOAA started to break through F400 in the 1st column (GAC 1A) at around 8,000 liters treated and the carbon appears to have approached saturation at approximately 18,500 L; PFMOAA did not break through Column #2 within this period, a result consistent with Test #1. As such, Test #2 demonstrated repeatability of testing procedures and performance.

Test 2B (DSR-A GAC). PFMOAA broke through DSR-A more rapidly than through F400; breakthrough was observed in all four columns, with effluent concentrations approaching influent levels observed in GAC 1B and GAC 2B even before any breakthrough was detected in the corresponding F400 GAC columns along the 'A' train.

As already discussed in the September 30, 2019 report, the results provided by Chemours' on-site analytical laboratory continued to reflect a low bias. The level of bias compared to analyses performed on field-duplicates by Chemours' contract independent analytical laboratory was consistent with previously-reported findings. The low bias did not affect breakthrough profiles, but a bias factor was applied to calculate utilization projections based on a comparison with split-sample duplicates analyzed by Chemours' contract independent analytical laboratory as described in the September 2019 Engineering Report. Commercial certified laboratory analyses were used for all GAC utilization projections based on isotherm studies.

Estimated GAC Utilization. The September 2019 Engineering Report presented a calculation of estimated GAC utilization based on Test #1 results. The calculation was based on complete exhaustion of the GAC in the first column (GAC 1A) plus the additional utilization of carbon in the second column (GAC 2A) attributed to the PFMOAA present in the effluent from GAC 1A during the same period.

This calculation has been revised for this Addendum as follows:

- Volume treated until saturation: 22,605 L (6,016 gal)
- Mass of carbon in first column (GAC 1A): 2.48 lb
- Total PFMOAA mass loading onto GAC 1A: 1,833 mg
- PFMOAA mass loading onto second column (GAC 2A): 633 mg (due to PFMOAA in GAC 1A effluent during same period)
- NET mass adsorbed onto first column (GAC 1A): 1,833 – 633 mg = 1,200 mg
- Mass loading ratio (x/m) = 1,200 mg/[(2.48 lb)*(453.6 g/lb)] = 1.07 mg per g GAC
- Design basis influent PFMOAA concentration: 85 µg/L
- GAC Usage Rate = (85 µg/L)*(1 mg/1000 µg)/(1.07 mg/g) = 0.079 g/L
- Carbon Utilization in first column (GAC 1A) @ 500 gpm:

  - (0.079 g/L)*(3.785 L/gal)*(500 gal/min)*(1440*365 min/yr)/(453.6 lb/g) = 173,200 lb/yr

- Carbon utilization in second column (GAC 2A) = (633 mg/1,200 mg)*(173,200 lb/yr) = 91,400 lb/yr
- Total GAC Utilization @ 500 gpm = 173,200 + 91,400 lb/yr = 264,600 lb/yr
- Total GAC Utilization @ 750 gpm = (750/500)*264,600 lb/yr = 396,900 lb/yr
- Total GAC Utilization @ 1,000 gpm = (1,000/500)*264,600 = 529,200 lb/yr

These results compare favorably with results from isotherm testing which projects utilization at 750 gpm of approximately 368,000 lb/year. It should be noted that the pilot system consistently demonstrated treatment of > 99% removal of PFMOAA in treated effluent and that the breakthrough information relates directly to how a GAC system would be operated and when GAC would be replenished.

2.4 HFPO-DA and Other Compounds

HFPO-DA. Appendix B provides updated breakthrough profiles for HFPO-DA as well as PFO2HxA, PFO3OA, PFO4DA, PEPA, and PMPA for Test #2. Breakthrough profiles with F400 GAC (Test 2A) were consistent with the profiles observed in Test #1 which also used F400 GAC, demonstrating test repeatability.

As with PFMOAA, the breakthrough profiles for other compounds demonstrated more rapid breakthrough with DSR-A GAC compared to F400 GAC. Although breakthrough rates were more rapid, the profiles demonstrate differing breakthrough rates between compounds. If the more rapid breakthrough had been due to short-circuiting (i.e., water flowing along unintended pathways such as fissures in the carbon beds or along the column walls due to blockages or insufficient column diameter), then the breakthrough rates would have been similar between compounds. Therefore, Parsons has concluded that the more rapid breakthrough in DSR-A was due primarily to differences in adsorption kinetics and capacity in DSR-A compared to F400 GAC.

Projected GAC utilization from Test #1 for PMPA, as presented in the September 2019 Engineering Report, was re-calculated as follows using the same bias factors as presented in the Engineering Report:

- Volume treated until saturation: 19,802 L (5,232 gal)
- Mass of carbon in first column (GAC 1A): 2.48 lb
- PMPA mass loading onto GAC 1A: 97.4 mg
- PMPA mass loading onto second column (GAC 2A): 32.9 mg (due to PMPA in GAC 1A effluent during same period)
- NET mass adsorbed onto GAC 1A = 97.4 – 32.9 mg = 64.5 mg
- Mass loading ratio (x/m) = 64.5 mg/[(2.48 lb)*(453.6 g/lb)] = 0.057 mg per g GAC
- Design basis influent PMPA concentration: 5.4 µg/L
- GAC Usage Rate = (5.4 µg/L)*(1 mg/1000 µg)/(0.057 mg/g) = 0.095 g/L
- Carbon Utilization in first column (GAC 1A) @ 500 gpm:
  - (0.095 g/L)*(3.785 L/gal)*(500 gal/min)*(1440*365 min/yr)/(453.6 lb/g) = 208,300 lb/yr

- PMPA mass loading onto second column (GAC 2A) = 32.9 mg (due to PMPA in GAC 1A effluent during same period)
- Carbon utilization in second column = (32.9 mg/64.5 mg)*(136,700 lb/yr) = 106,200 lb/yr
- Total GAC Utilization @ 500 gpm = 208,300 + 106,200 lb/yr = **314,500 lb/yr**
- Total GAC Utilization @ 750 gpm = (750/500)*314,500 lb/yr = **471,800 lb/yr**
- Total GAC Utilization @ 1,000 gpm = (1,000/500)*182,950 = **629,000 lb/yr**

As with PFMOAA, PMPA was consistently removed by > 99% in GAC-treated effluent prior to breakthrough. It should be noted that influent concentrations of PMPA are over an order of magnitude lower than influent rates of PFMOAA.

3.0 PILOT TREATMENT TEST CONCLUSIONS

The conclusions presented in the September 2019 Engineering Report did not change except for the following revisions on estimated GAC utilization.

- Estimated F400 GAC utilization based on PFMOAA treatment was 267,000 to 534,000 pounds/year for a flow rate of 500 to 1,000 gpm.
- Estimated F400 GAC utilization based on PMPA treatment was 315,000 to 629,000 pounds/year based on a flow rate of 500 to 1,000 gpm.

APPENDIX A
CONVENTIONAL PARAMETER FIGURES

APPENDIX B
COMPREHENSIVE PFAS TREATMENT RESULTS

APPENDIX C
BREAKTHROUGH CURVES FOR PFMOAA, HFPO-DA, AND SELECT PARAMETERS