Purolite

September 5, 2018

The Honorable John Shimkus, Chairman
The Honorable Paul Tonko, Ranking Member
Subcommittee on Environment
Energy and Commerce Committee
United States House of Representatives
Washington, DC 20515

Dear Chairman Shimkus and Ranking Member Tonko:

I write on behalf of Purolite Corporation ("Purolite"), in advance of the Subcommittee on Environment's hearing entitled "Perfluorinated Chemicals in the Environment: An Update on the Response to Contamination and Challenges Presented," to emphasize the serious health risks posed by the current shortage of ion exchange resin in the United States.

Purolite is one of only two U.S. producers of ion exchange resin, which is a compound made of polymers of styrene and functionalized with amines that is used to: purify drinking water; remove contaminants from waste water; supply nuclear power plants with adsorbents to remove radioactive nuclides in their waste stream; supply the sweetener, sugar, and food industries with products for chromatographic separation; and produce decolorization and purification chemicals that are used in various industries.[1] We employ approximately 300 people across the country, including 175 people at a production facility in Philadelphia and 50 people at our headquarters in Bala Cynwyd, Pennsylvania. Additionally, due to the increased demand for ion exchange resin in the United States – particularly after the recent water crisis in Flint, Michigan – we also import ion exchange resin from our manufacturing facilities located in China, Romania, and the United Kingdom.

Currently, there is an acute shortage of ion exchange resin globally as a result of recent plant closures in China, Germany, and Italy due to environmental restrictions. These plant closures have pushed global production to its maximum capabilities, causing six-month to one-year lead times and two recent price increases. We do not expect the supply situation to change in the near future because the plant closures are permanent and the limited number of remaining suppliers, including Purolite and DowDuPont Inc., cannot make up the shortfall with increased production. Moreover, new sources of supply are not expected to be available anytime soon, as it takes tens of millions of dollars and many years to permit and build a new factory and qualify its output. This is certainly true in the United States, where it takes over $150 million and 3-4 years, including the time it takes to obtain the required EPA approvals, to build a plant. Therefore, it is

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1 Further details regarding the basics of ion exchange are available on Purolite's website at https://www.purolite.com/about-us/what-is-ion-exchange.

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extremely unlikely that the United States will add any new production capacity over the next several years.

Further, the Office of the United States Trade Representative ("USTR") recently decided to exacerbate this problem by raising tariffs on imports of ion exchange resin from China as part of Section 301 Investigation on China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation.[2] Purolite will be filing a formal plea for exclusion in an attempt to get ion exchange resin off of the List, but we urge Members of this Subcommittee to protest this particular tariff as well. By further reducing the supply of these products in the United States, these tariffs threaten higher prices for U.S. consumers and a higher level of contaminants in Americans' drinking water, food chain, waste water, and chemicals. Most critically, further shortages in the United States mean that drinking water contaminants like per- and polyfluoroalkyl substances ("PFAS"), nitrate, perchlorate, and arsenic may not be treated economically, resulting in rate increases for consumers, or worse, serious contamination events like in Flint, Michigan.

There is no effective substitute for ion exchange resin, and it is not possible to reuse exhausted resin. Accordingly, municipalities and water treatment system manufacturers across the United States have indicated that without ion exchange resins to remove contaminants, EPA-compliant potable water could no longer be provided in a cost-effective manner.

This possibility is especially alarming if you consider the devastating effects that the ingestion of contaminated water could have on people in the United States. For example, water containing elevated levels of PFAS chemicals, which are found in a wide range of consumer products, can cause serious reproductive, developmental, immunological, and liver and kidney problems. Fortunately, as explained in the attached presentation and case study, Purolite has shown that its ion exchange resin is particularly effective at reducing PFAS levels in municipal water to non-detect levels. However, it is unlikely that these municipalities will be able to maintain these reduced levels of PFAS if they are denied access to adequate supplies of ion exchange resin.

For these reasons, we request that the Subcommittee on Environment work to remedy these potentially catastrophic supply issues and urge USTR to exclude ion exchange resin from the additional duties imposed as a result of the Section 301 investigation.

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2 See Notice of Action Pursuant to Section 301: China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation, 83 Fed. Reg. 40823 (August 16, 2018).

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Thank you for your attention to this matter. We would be pleased to provide you any additional information that you may need.

Respectfully yours,

Stefan Brodie
President and CEO
Purolite Corporation

Attachment –
Purolite Presentation and Case Study

Short and Long Chain PFAS Removal with Single-Use Selective Ion Exchange Resin

Francis Boodoo   Director of Applied Technologies
Oliver Baumann   Director of Sales, West, Midwest, Southwest
Nick Backman   Midwest Technical Sales

American Groundwater Trust
PFAS in Michigan
26July2018

Purolite®

60 MGD (42000 gpm) Nitrate Removal Using Resin – Dublin, OH

World's largest nitrate removal plant with 13,000 ft3 of Purolite A520E resin

4.2 MGD TOC/DBP / Fe/Mn Control Using Resin- Green Meadows ,FL

11 MGD Perchlorate Removal with Resin - San Gabriel Valley Water, CA

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2 MGD Arsenic Removal with Resin - Green Valley, AZ

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Topics

- PFAS Background
- Short & Long Chain Removal – pilot & commercial
    - Resin vs GAC
- Cost Comparison – Resin vs GAC
- System Design

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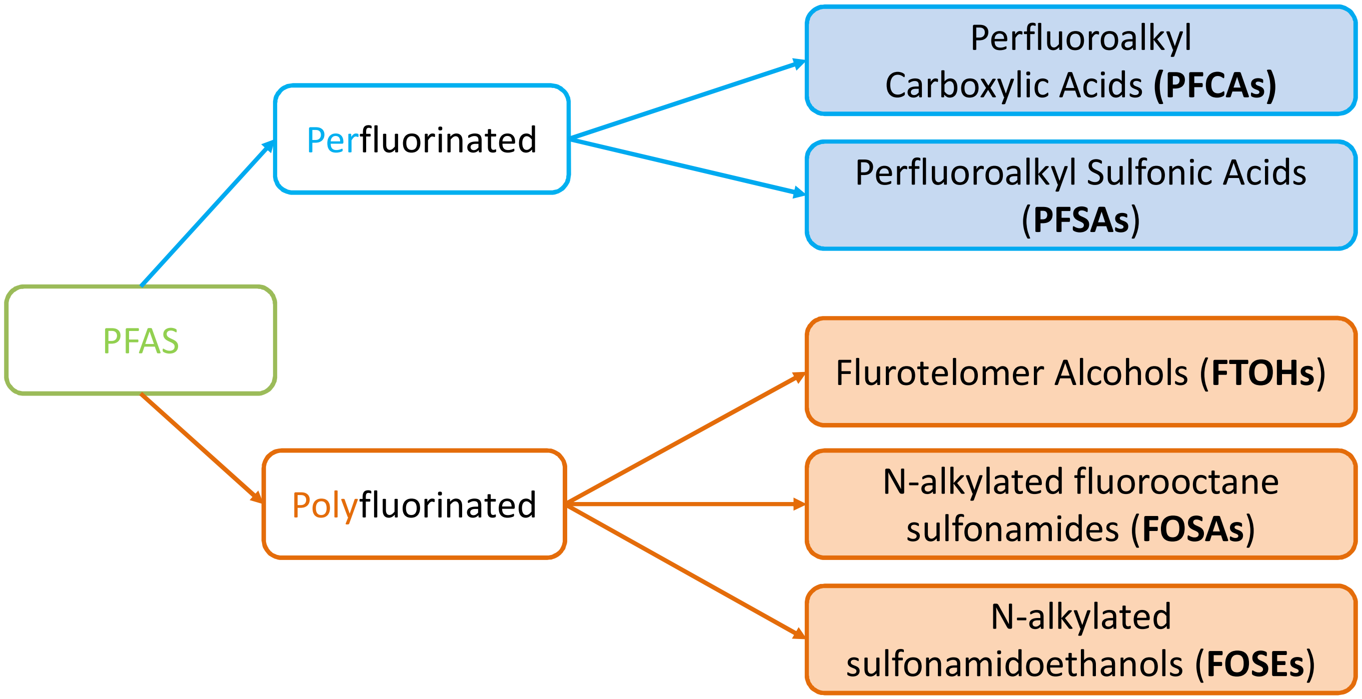
Sources of Perfluoro- and Polyfluoro-alkyl substances (PFAS)

Categories of PFAS (> 3,000 Perfluoroalkyl Substances)



Source: ITRC Perfluorinated Chemicals Information Paper, August 2015

EPA's UCMR3 Results PFOS + PFOA > 10 ppt at Drinking Water Plants

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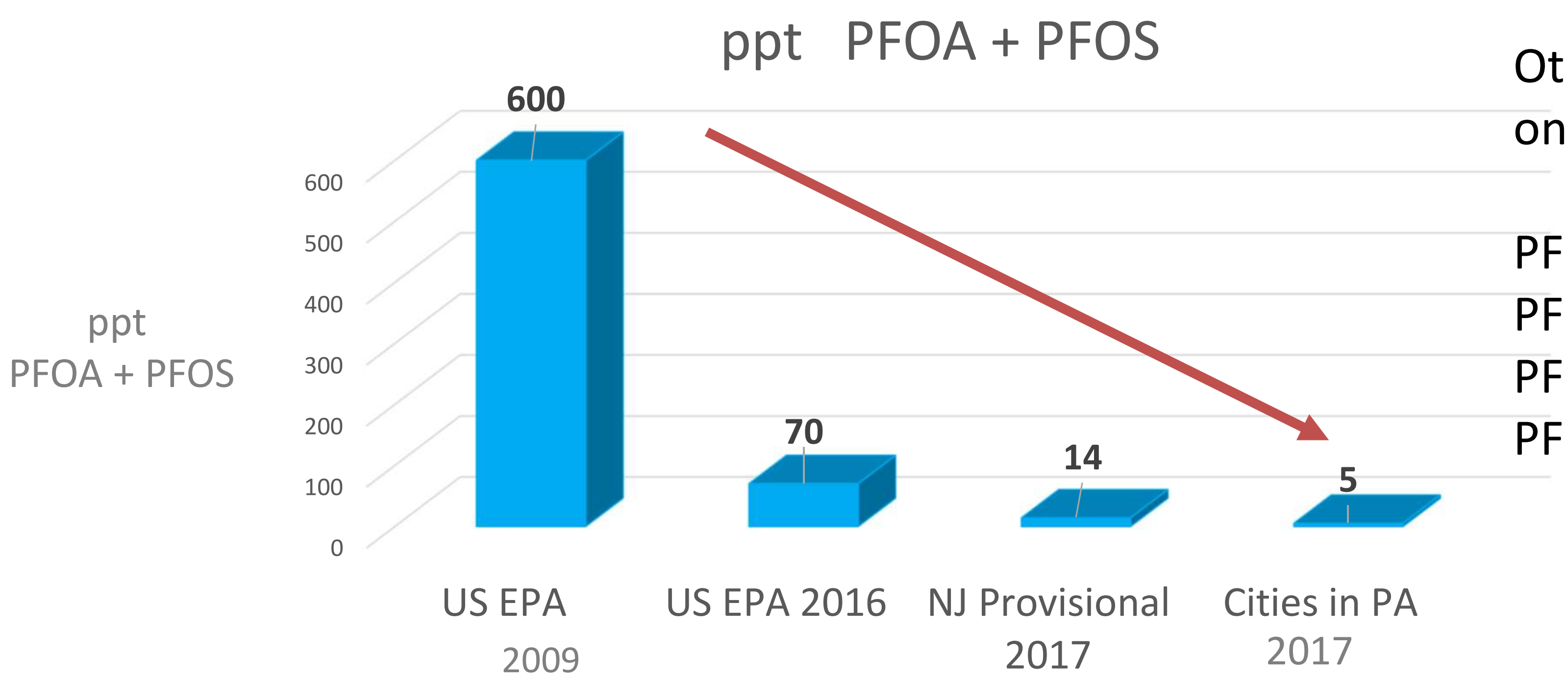
Health Concerns are Driving Regulatory Advisories



Other targets on UCMR 3 list:

PFNA
PFHxS
PFHpA
PFBS

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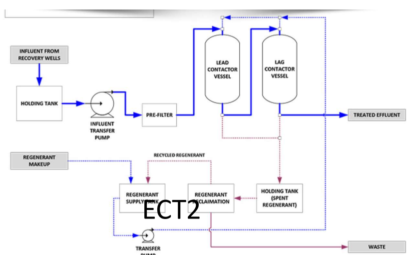
Pump & Treat Options for PFAS Removal

Membrane Filtration

Carbon Adsorption

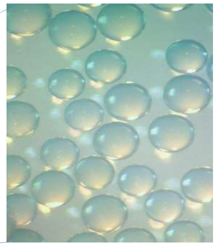


Methanol/Brine Regenerable Resin

Single-Use Resin

Single-Use Selective Resin - Simple & Cost-Effective

PFAS in water



PFAS –free water

< 70 ppt or ND

Short Contact Time ~3 mins
Operator Preferred.

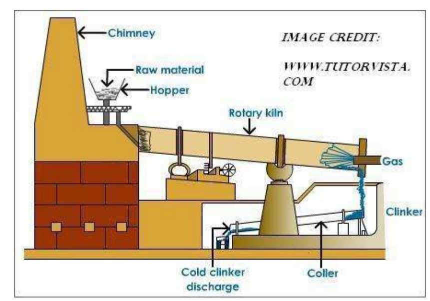
Single-Use Selective Resin + Incineration

PFAS in water

PFAS –free water

PFAS loaded resin

Cement Kiln Incineration
1400°C to 2000°C

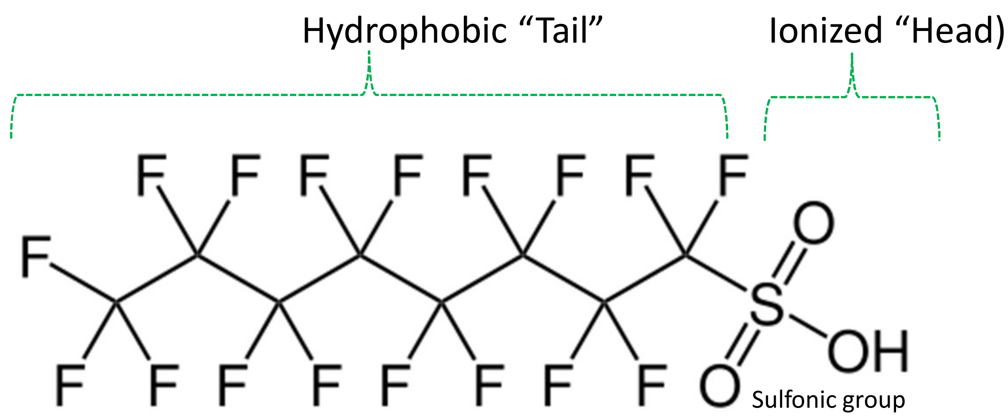


Complete Destruction of PFAS

Purolite®

Superior Dual Removal Mechanisms for IX vs GAC

PFOS – Perfluoroalkyl Sulfonic Acid



GAC
removes by adsorption
using hydrophobic “Tail”

Selective IX Resins
removes by both ion exchange and
adsorption using both “Head” & “Tail”

Purolite®

Proven Capability of Single-Use Resin to Reduce PFAS

Successes with PFA694E Resin

	Inlet PFAS ppt	Site	Year	Type	PFAS Reduced		Capacity
	1,200,000	Military, NC	2017	Non potable	PFOS + PFOA		1 MM Gal to < 70 ppt
	20,000	Military, PA	2017	Potable	PFOS PFOA PFNA	PFBS PFHxS PFHpA	**> 20 mths at ND***
	1,500	City 2	2016	Potable	PFOS PFOA PFNA	PFBS PFHxS PFHpA	**> 24 mths to ND***
	65	City 1	2017	Potable	PFOS PFOA PFHxA	PFBS PFHxS PFHpA	**> 18 mths to ND***

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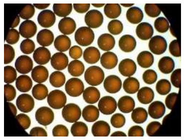
BV = Bed Volumes = Liters of water treated by 1 liter of resin

* Still running – ND varies from 1 to 2 ppt



Benefits of Single-Use Selective Resin

• Simple, field-proven	commercially available
• > 99.99% reduction to ND	short & long chain PFAS
• Lower CAPEX ~ ½ of GAC	3X lower contact time
• Reduced footprint /headspace	important in crowded areas
• High operating capacity	100,000 to 350,000 BV
• Competitive OPEX	typical $0.15 to $0.40 / Kgal

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Commercial and Pilot Results
for
PFAS Removal

Horsham Township
Short & Long Chain PFAS Removal
Bituminous GAC
vs
Single-Use Selective Resin

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Horsham Well 10

1st Pennsylvania DEP Permitted Drinking Water System using Ion Exchange Resin to Reduce PFOS + PFOA to Non-Detect[1]

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[1] ND for PFOA and PFOS varies among labs from 0.6 to 2 ppt

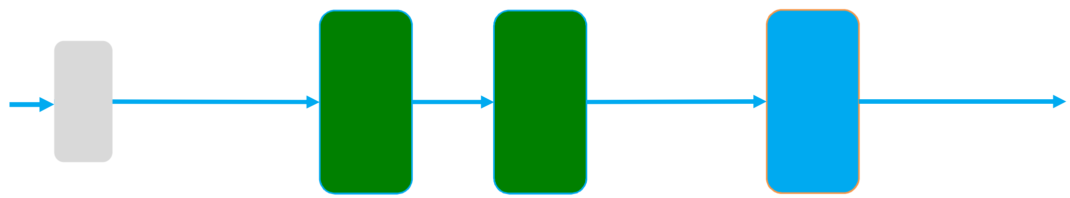
Photo courtesy Altair Equipment
Well 10

Temporary Treatment System Layout for Horsham Well 10

Inlet Water:

PFOS 55 ppt
PFOA 27 ppt
PFBS 8.4 ppt
PFHxA 9.6 ppt
PFHpA 4.7 ppt
PFHxS 36 ppt

Total PFAS 140 ppt



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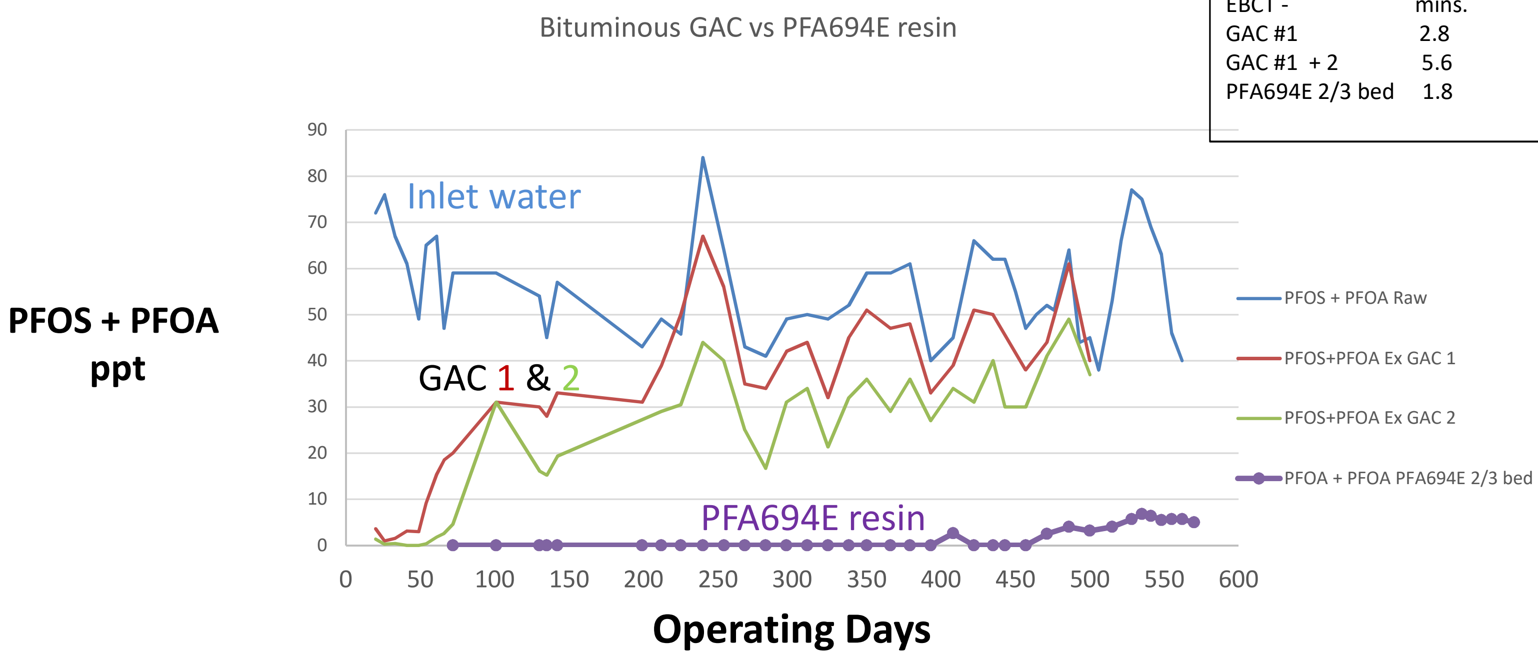
Note: Going forward, the township plans to convert 3 wells using GAC to ion exchange only

PFOS + PFOA Removal – In service for 570 days

EBCT -	mins.
GAC #1	2.8
GAC #1 + 2	5.6
PFA694E 2/3 bed	1.8



1 liter resin treats > 456,000 liters of water to ND

B-GAC at 17,000 BV to MRL of 2.5 ppt at 5.6 mins EBCT; ND varies from 0.6 to 2 ppt

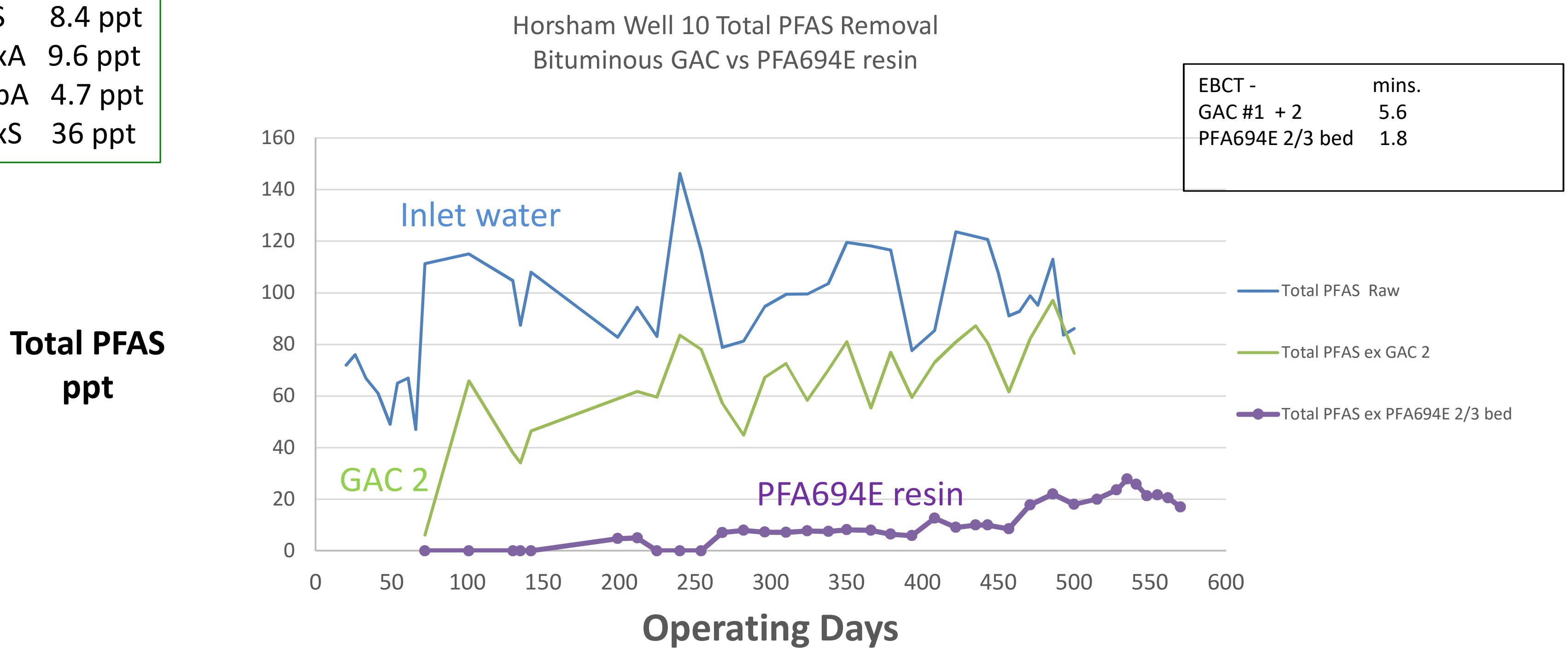
Well 10

Inlet Water:

PFOS	55 ppt
PFOA	27 ppt
PFBS	8.4 ppt
PFHxA	9.6 ppt
PFHpA	4.7 ppt
PFHxS	36 ppt

Total PFAS Removal

(PFBS, PFHxA, PFHpA, PFOA, PFNA, PFHxS, PFOS)



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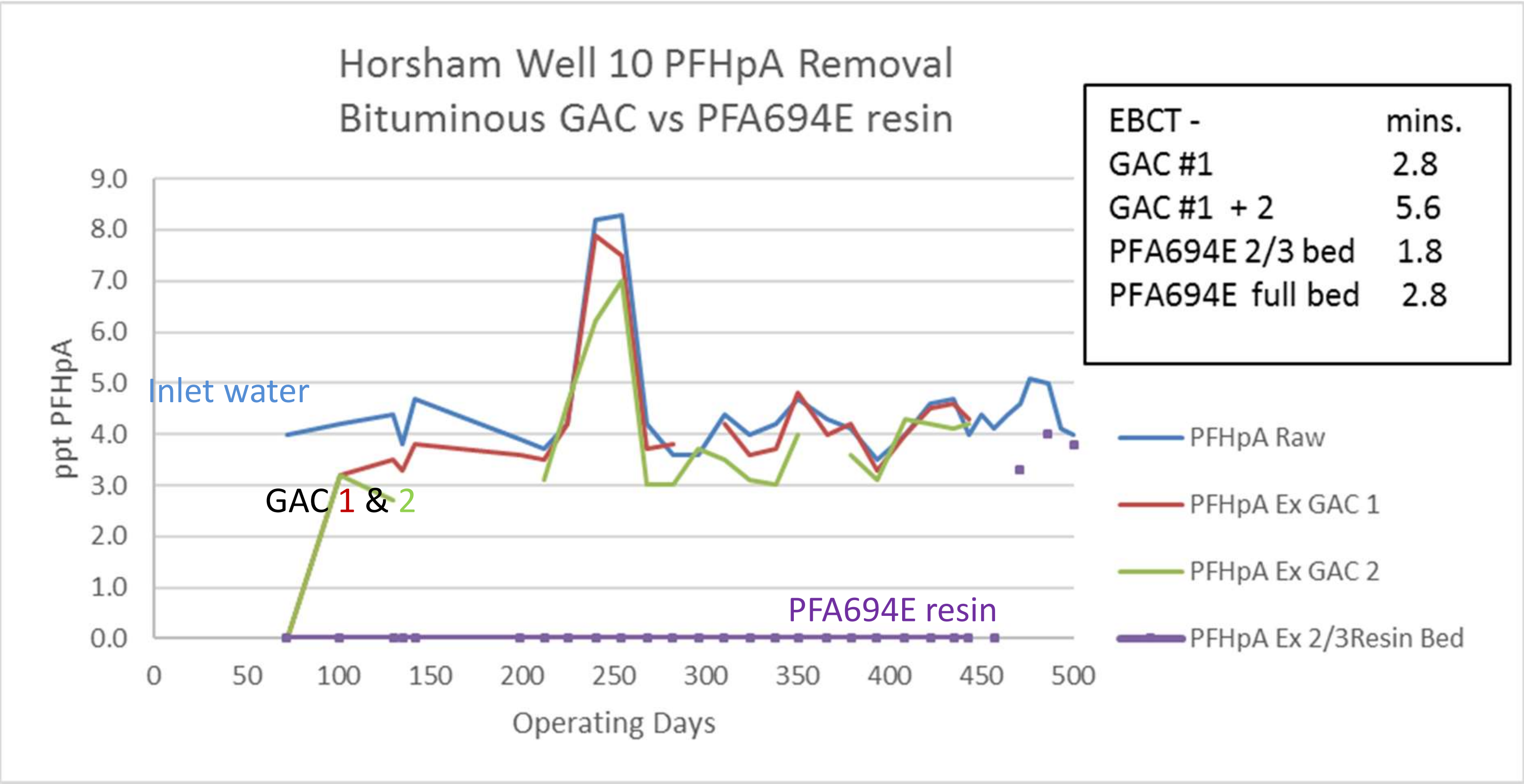
Well 10

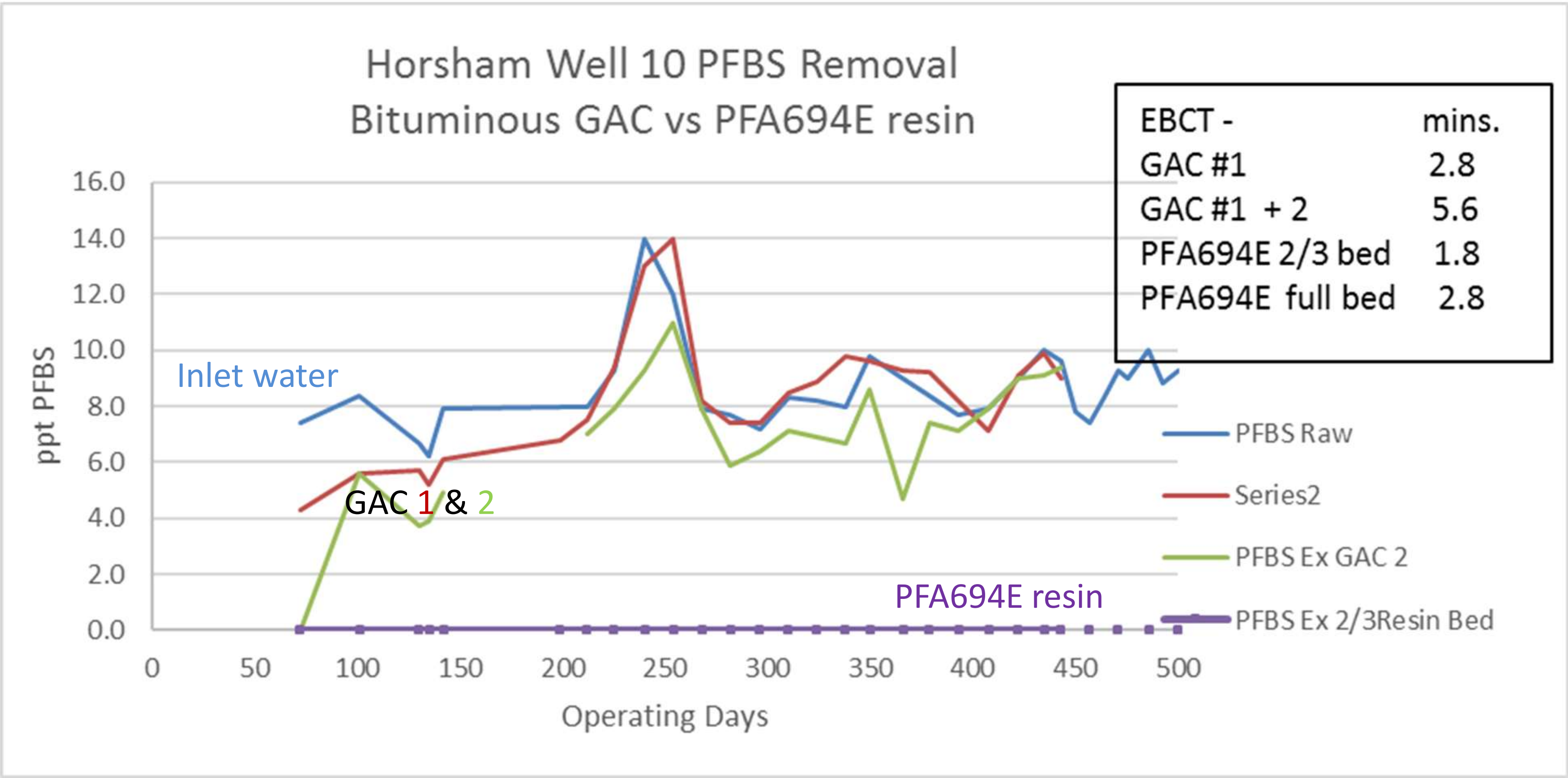
PFHpA Short Chain Carboxylic Type



PFHpA – Perfluoroheptanoic acid, $C_6F_{13}.COOH$; Mol.Wt. 364

Well 10

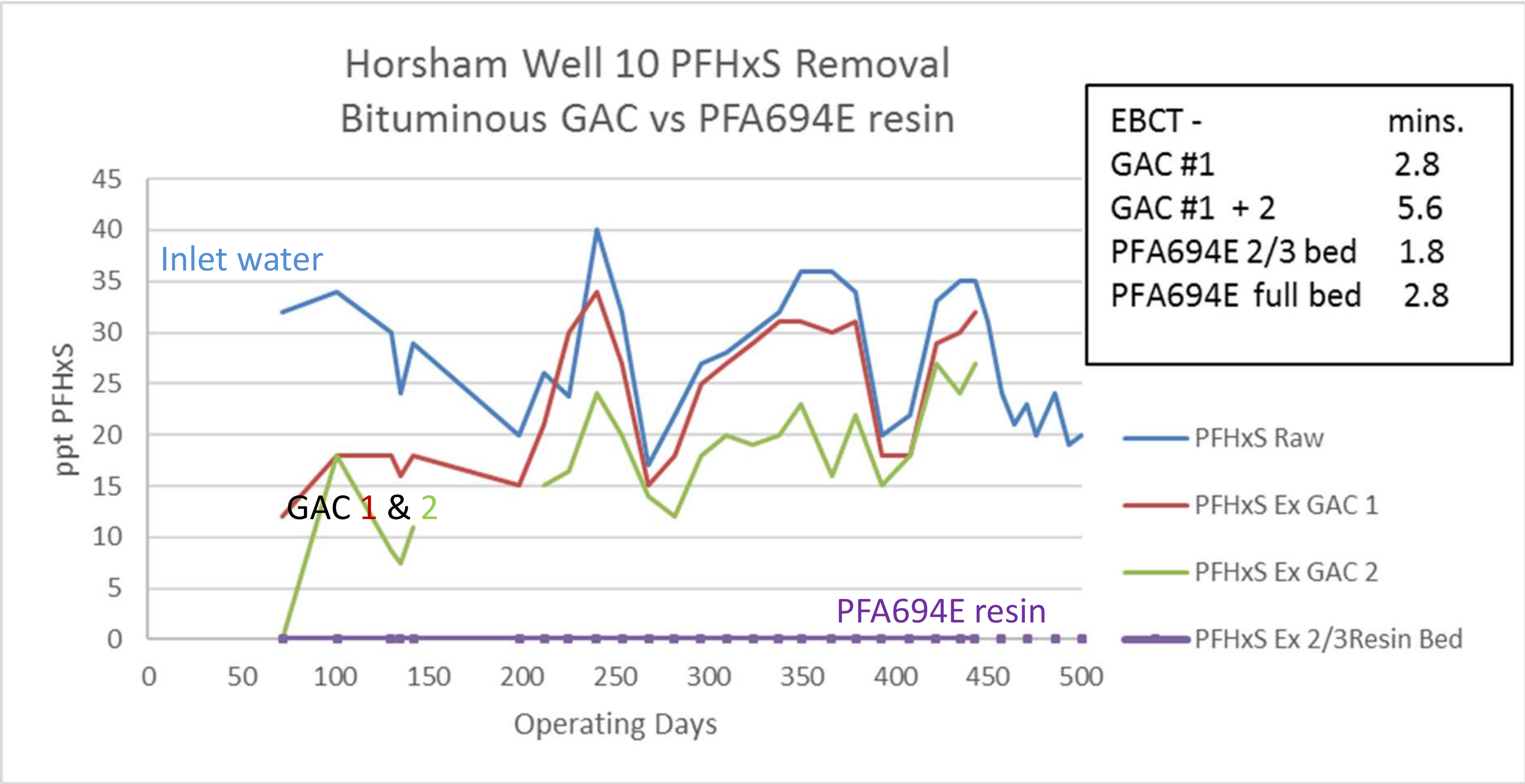
PFBS Short Chain Sulfonic Type



PFBS – Perfluorobutanesulfonate, $C_4F_9.SO_3H$; Mol.Wt. 300

Well 10

PFHxS Long Chain Sulfonic Acid Type



PFHxS – Perfluorohexanesulfonate, $C_6F_{13}.SO_3H$; Mol.Wt. 400

Well 10

Warminster Well 26

Drinking Water Well

(currently sewered because of high VOCs and need to control PFAS plume in aquifer)

Well 26 Water Used for Piloting

Well Water	Concentration - ppt		MDL ppt
PFOA	234	Long chain	0.2 - 1
PFOS	648	Long chain	0.3 - 5
PFBS	33	Short chain	0.2 - 4
PFHxA	141	Short chain	0.3 - 1
PFHpA	52	Short chain	0.2 - 1
PFHxS	316	Long chain	0.3 - 4
PFNA	10	Long chain	0.3 - 1

Total 1434

Competing Contaminants	ppt
TOC	730,000
VOCs (TCE, PCE, CCl4)	230,000

Expected VOCs in the stripper effluent < 500 ppt

Residual VOCs - significant competition with PFAS on GAC

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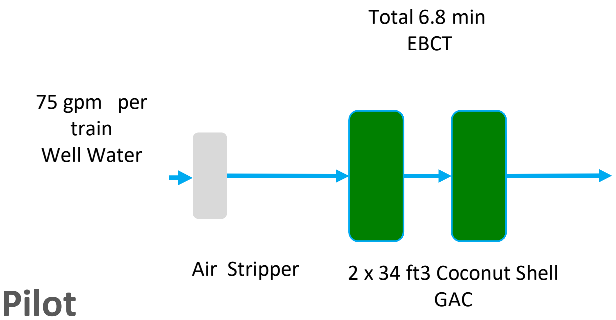
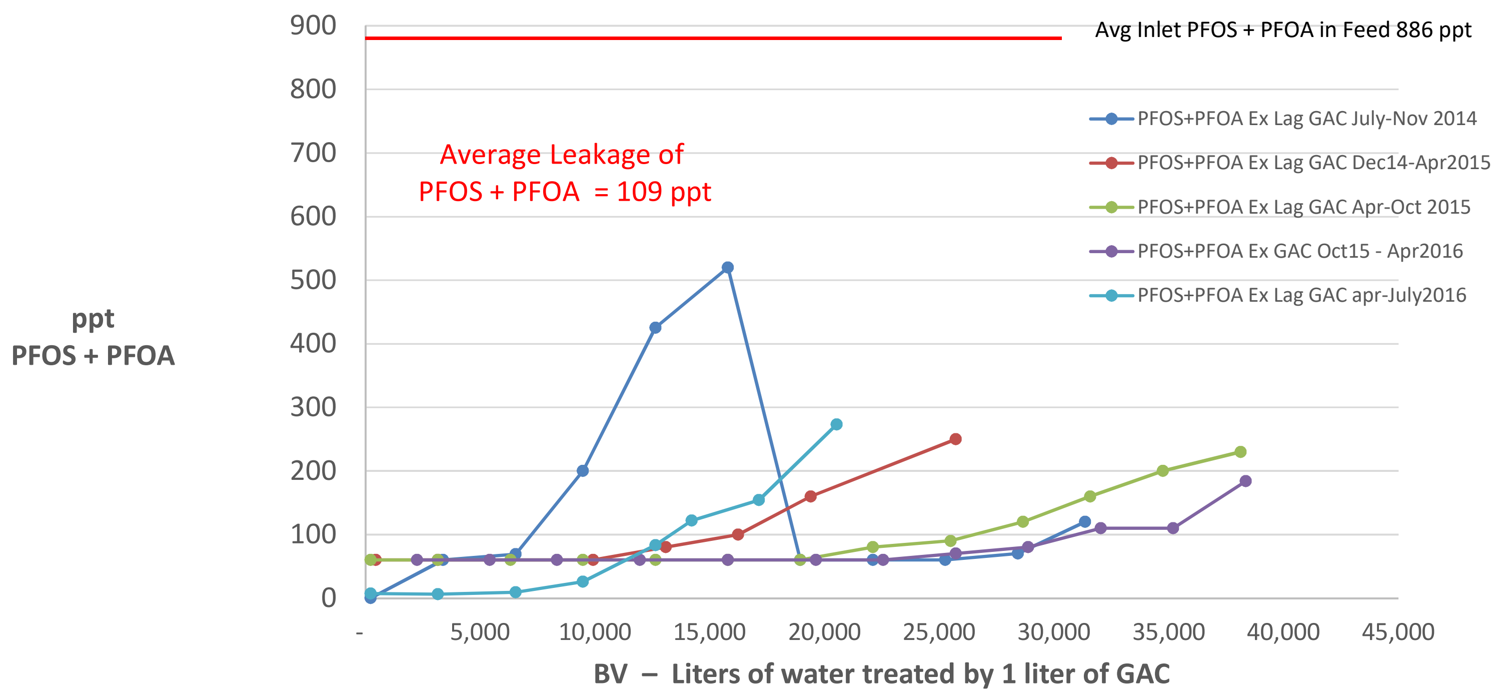
Coconut Shell GAC (before IX Pilot was installed)



Inadequate PFAS control

PFOS + PFOA Leakage Ex Coconut Shell Lag GAC Before IX Pilot



Well 26

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Well 26

3 IX Pilots:

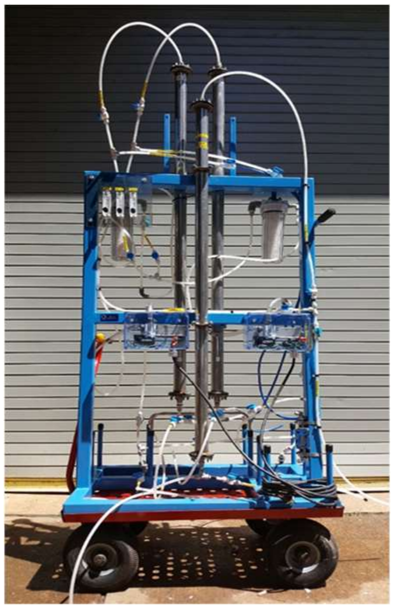
Operated from June 2016 to April 2018 – still running

(1) Coconut Shell GAC full scale > pilot Resin

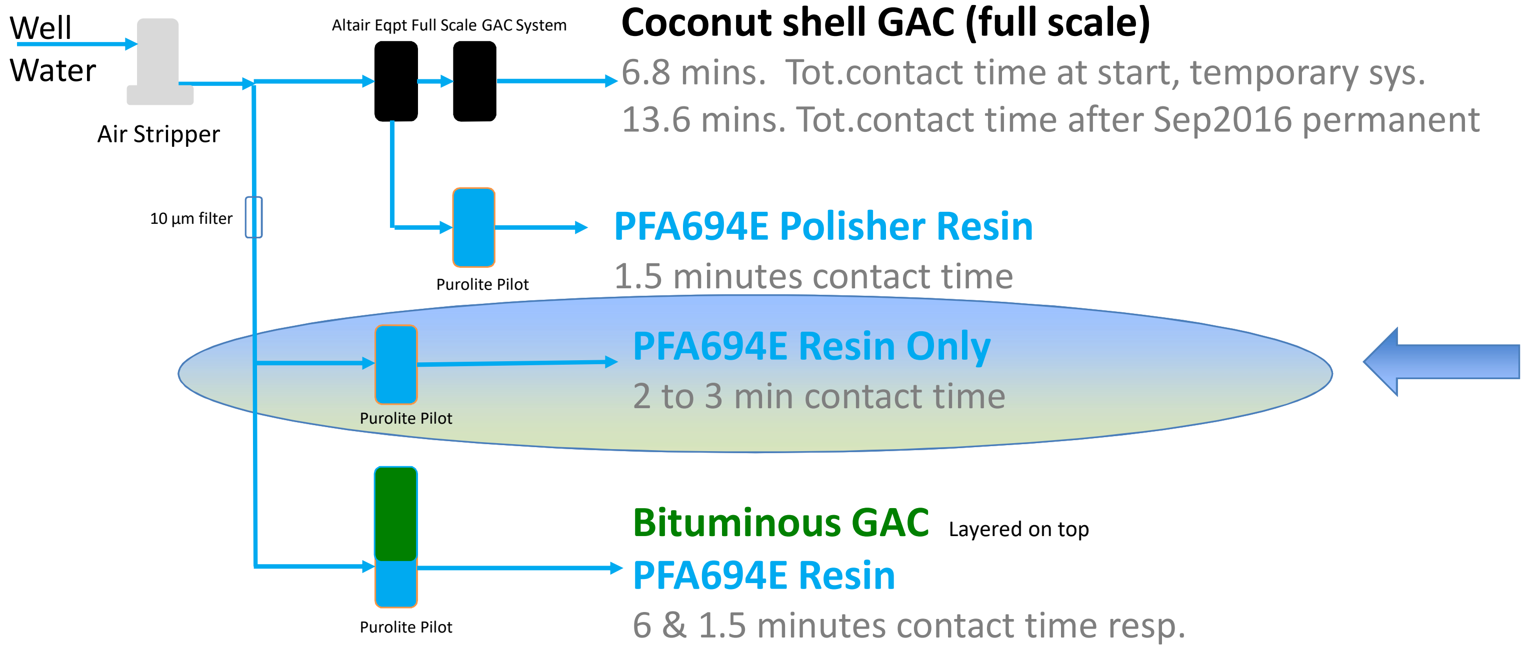
(2) Resin Only pilot

(3) Layered Bituminous-GAC / Resin pilot

Purolite Mobile Skid-Mounted Pilot



2 Liters media per pilot
2” (5 cm) diameter column
Full-Scale 39 inches bed depth
Linear Velocity 6 gpm/ft^2



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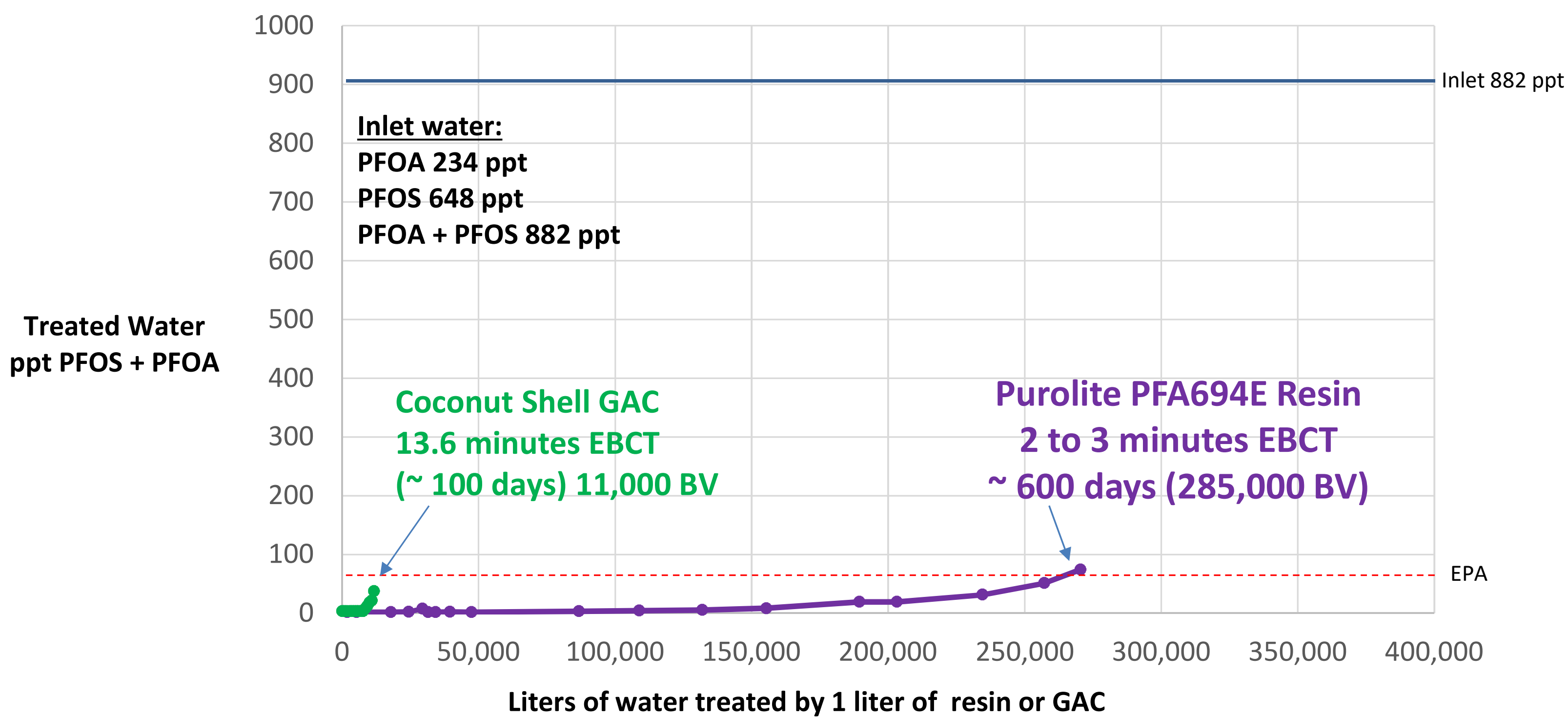
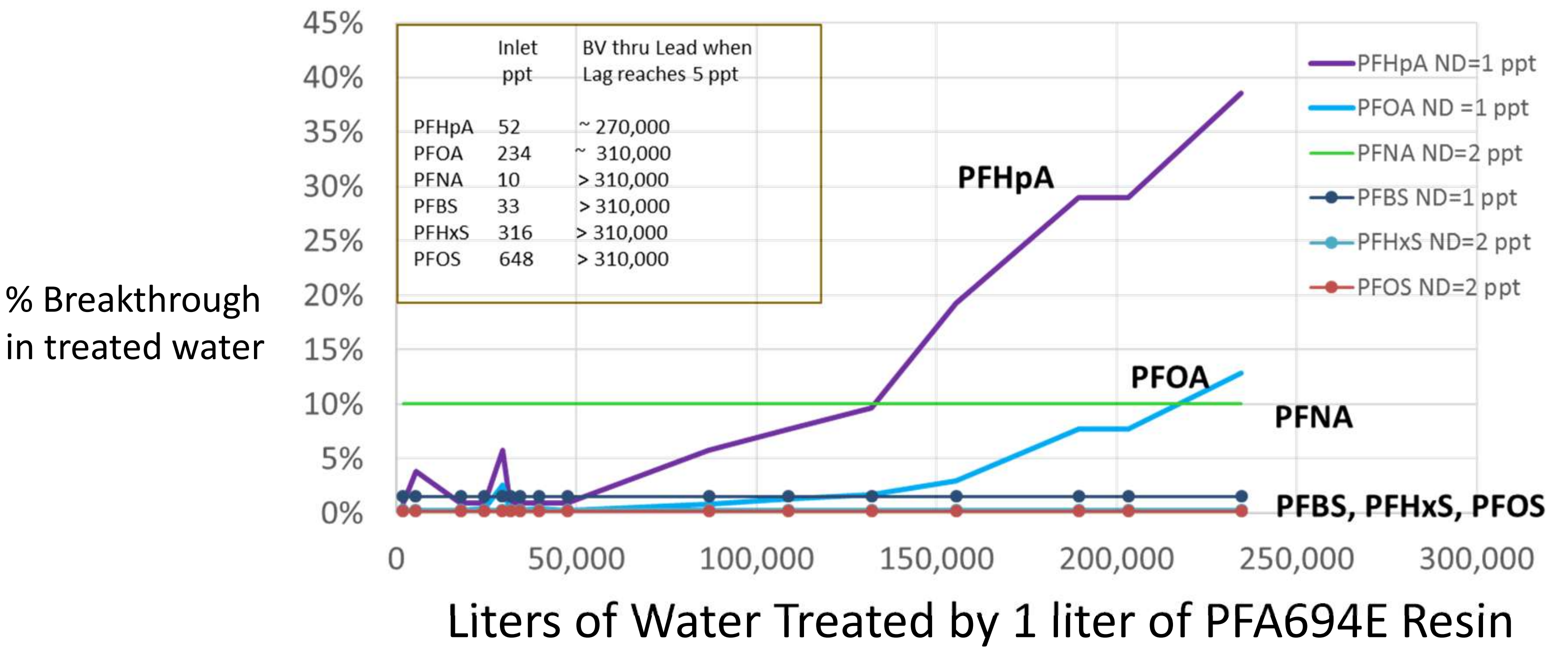
PFA694E Selective Resin vs Coconut Shell GAC



Well 26

Using Resin Only - Removing Short /Long Chain PFAS to < 5 ppt

Order of Selectivity: PFHpA < PFOA < PFNA < PFBS < PFHxS < PFOS



Design Treatment System for 270,000 Bed Volumes

Well 26

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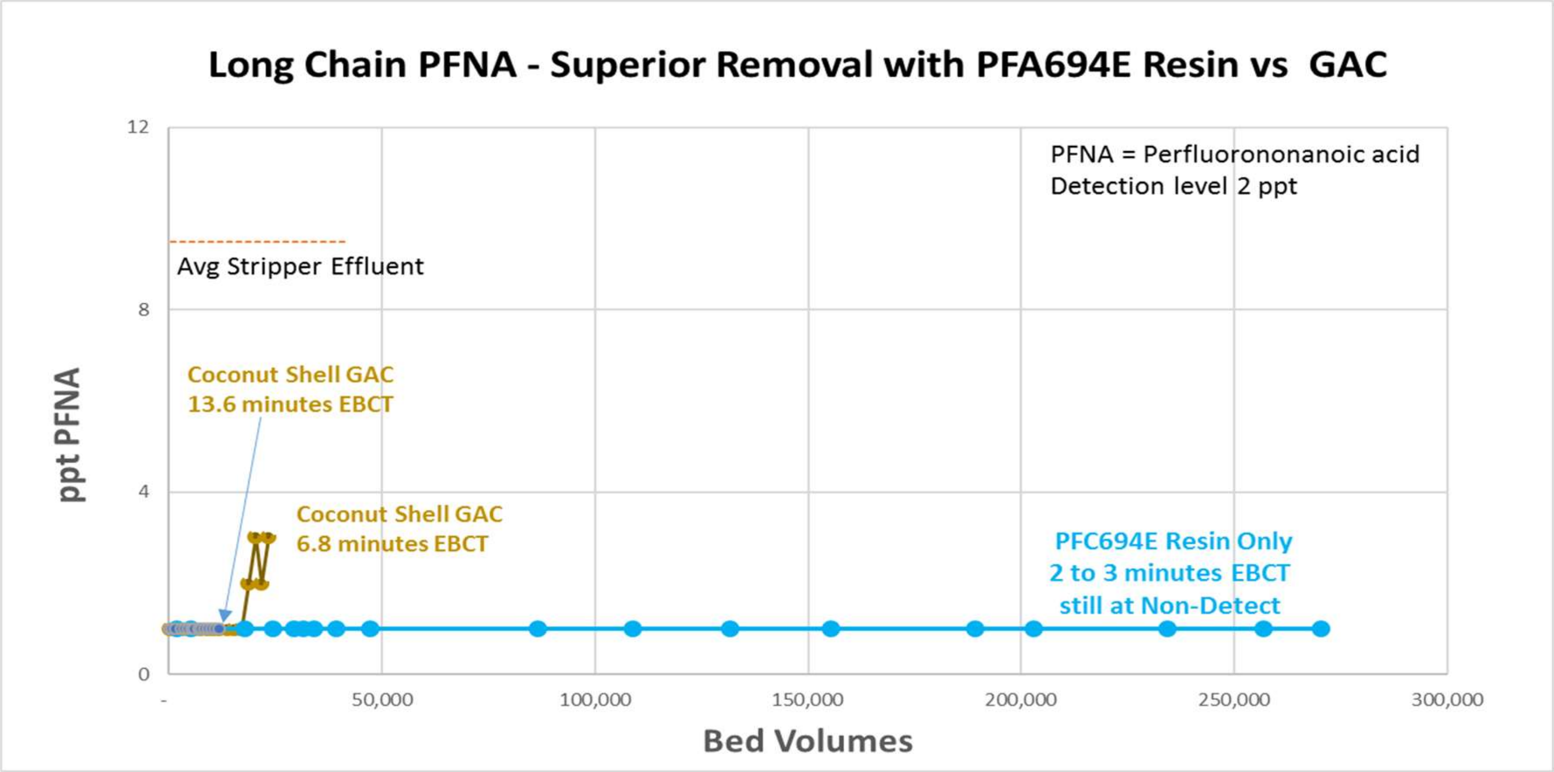
Note: Going forward, the township plans to convert several wells currently using GAC to ion exchange only

PFNA: Excellent Control with PFA694E resin vs GAC

(Note: MCL of 13 ppt PFNA with control at 6.5 ppt is expected to be set very soon in state of NJ)



PFNA = Perfluorononanoic acid - mol.wt. 464; $C_8F_{17}COOH$

Military Site, PA – Full Scale Potable System

Very High Conc'n Inlet: 20,000 ppt PFAS

Goal: Non-Detect for PFOS + PFOA

Photo courtesy Wayne Krager, Altair Equipment

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Military Site, PA: Very High PFAS Levels in Water

		Well Water
		ppt
PFOA	long chain	2,300
PFOS	long chain	13,100
PFBS	short chain	831
PFHpA	short chain	372
PFHxS	long chain	3,640
PFNA	long chain	47

Total PFAS	**~20,000**

Treated Water Goal < ND for PFOS + PFOA

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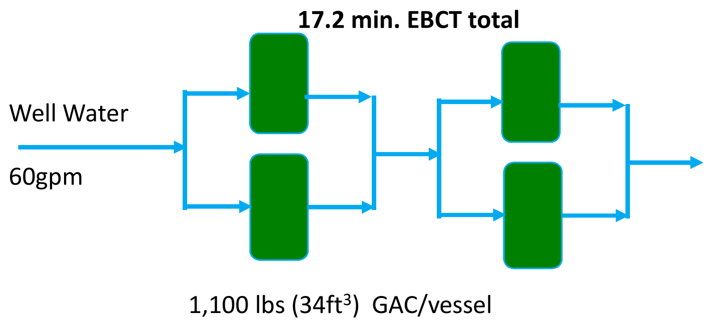
Military Site, PA Goal: Reduce 20,000 ppt PFAS to ND

Before: With GAC only



Coconut Shell GAC System Before Resin was installed

Before: GAC only

~ 5 months to full break ~2500 BV

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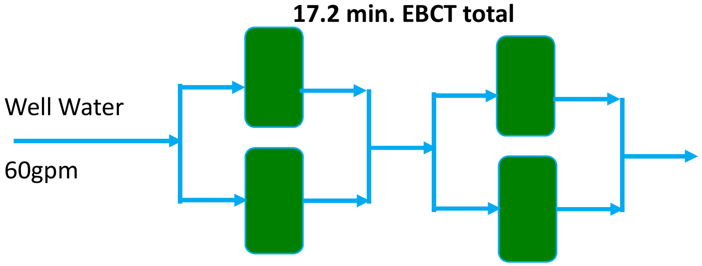
EBCT = Empty Bed Contact Time

Military Site, PA Goal: Reduce 20,000 ppt PFAS to ND

Before: With GAC only

17.2 min. EBCT total



1,100 lbs ($34ft^3$) GAC/vessel

Coconut Shell GAC System Before Resin was installed

Before: GAC only

~ 5 months to full break ~2500BV

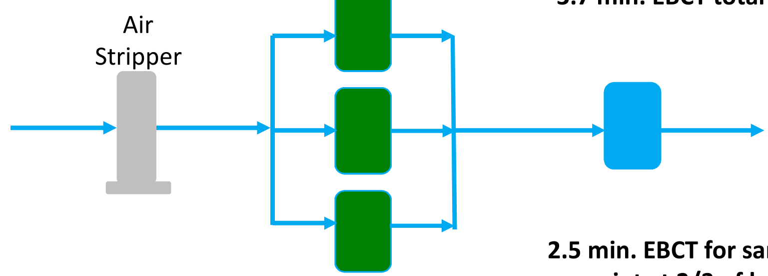
After: GAC + PFA694E Resin Installed

Coconut Shell GAC

12.9 min. EBCT /vessel

PFA694E Single-Use Resin

3.7 min. EBCT total bed



2.5 min. EBCT for sample point at 2/3 of bed

1,100 lbs ($34ft^3$) GAC/vessel

30 ft^3 of Purofine PFA694E resin

After: GAC >> PFA694E Resin Installed

> 20 months still at Non-Detect

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EBCT = Empty Bed Contact Time

Cost Comparison:

Resin vs GAC

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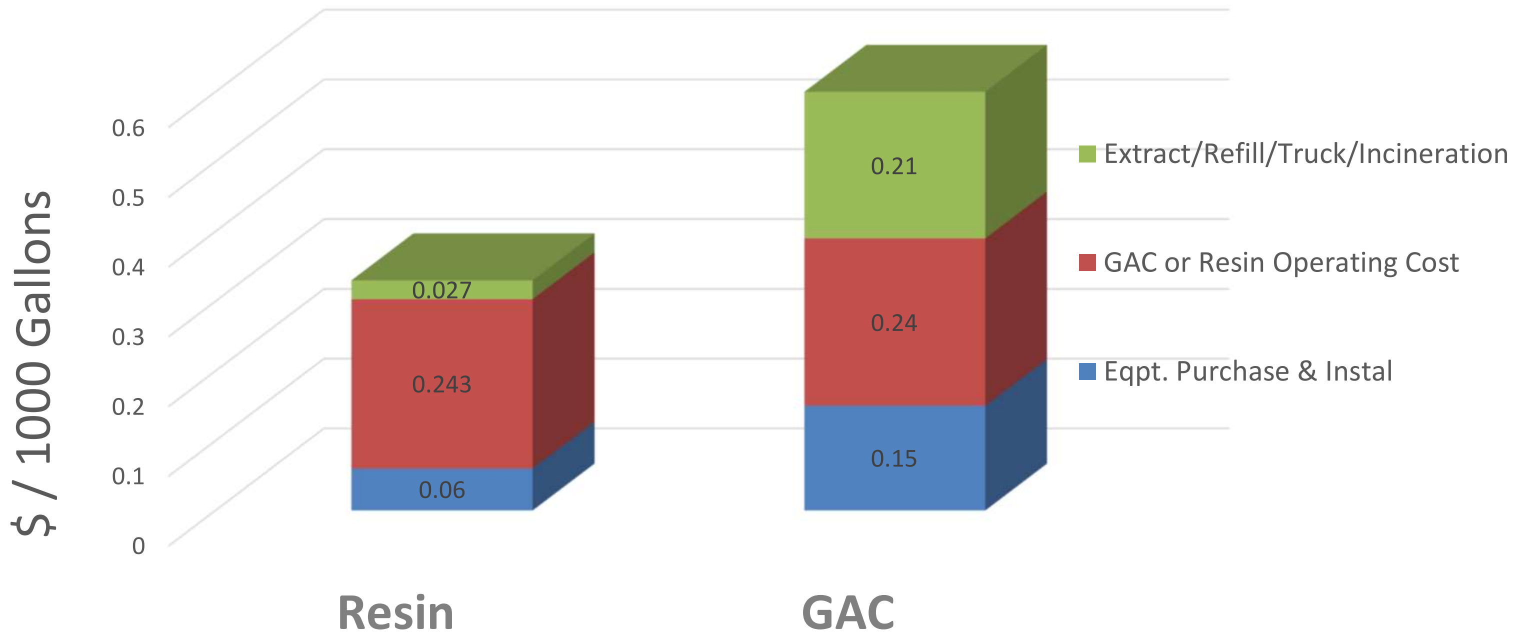
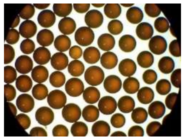
Total Cost $ /1000 gals
Capital + Operating Cost - 500 gpm system



$0.33 /1000 gals **$ 0.60 / 1000 gals**

Treatment to < 70 ppt of combined PFOS + PFOA



Benefits of Single-Use Selective Resin

- Simple, field-proven — commercially available
- > 99.99% reduction to ND — short & long chain PFAS
- Lower CAPEX ~ ½ of GAC — 3X lower contact time
- Reduced footprint /headspace — important in crowded areas
- High operating capacity — 100,000 to 350,000 BV
- Competitive OPEX — typical $0.15 to $0.40 / Kgal

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Design
for
Single-Use
Ion Exchange Resin
System

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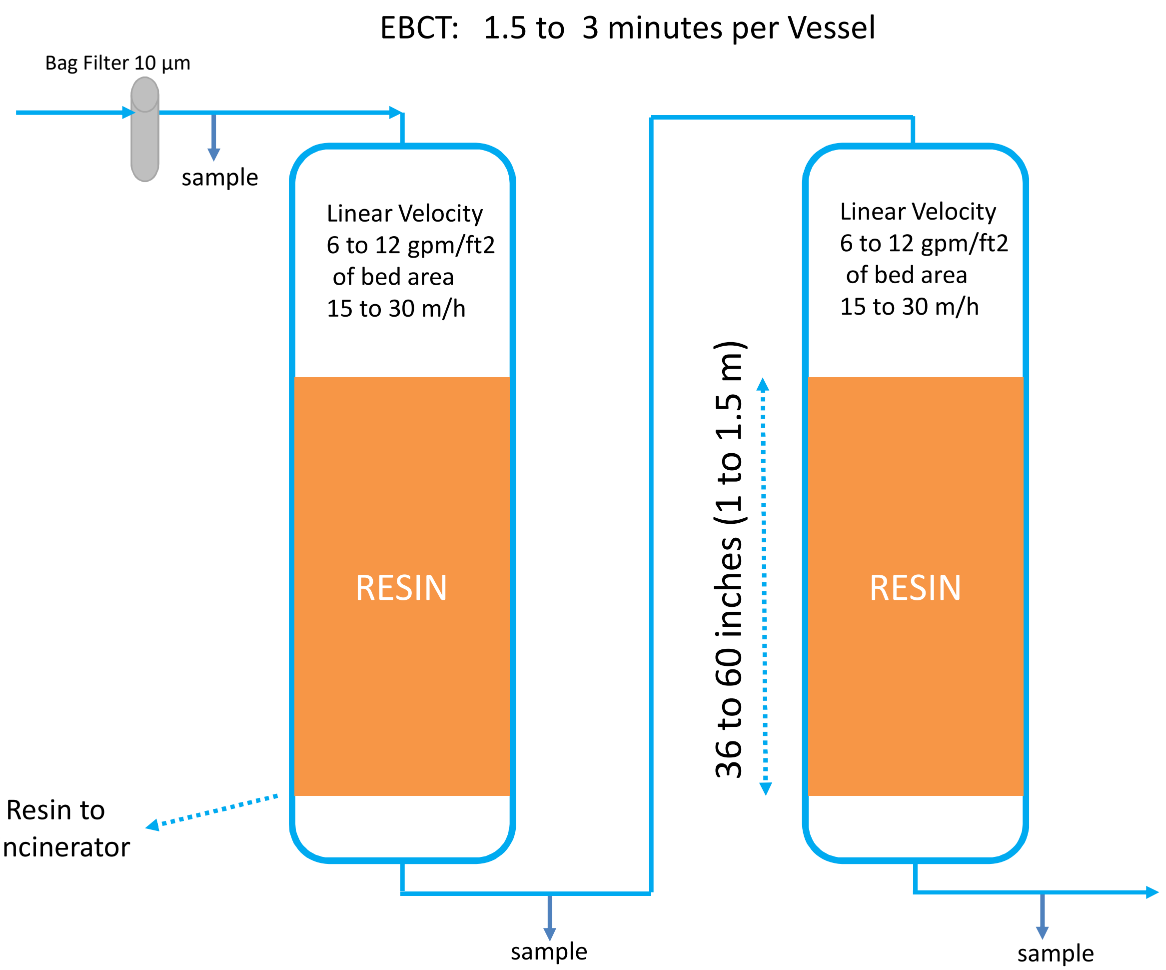
Design Using Lead - Lag Vessels with Single-Use PFA694E Resin



Choosing Between Resin and GAC

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Choose Between PFAS Selective PFA694E Resin & GAC

	GAC	Single-Use RESIN	
Treat to Non-Detect	Fair	Good	
Short Chain PFAS	Fair	Good	
Low PFAS, Low TDS	Good	Good	
Low PFAS, High TDS	Good	Fair	< Consider Regenerable IX
High PFAS, Low TDS	Poor	Good	
High PFAS, High TDS	Poor	Poor	< Consider Regenerable IX
High TOCs > 2 ppm	Poor	Fair	< Consider Regenerable IX
High VOCs > 500 ppt	Poor	Good	

High PFAS: > 2,000 ppt High TDS: > 1000 ppm
High TOC: > 2 ppm; may need pretreatment
High VOC: > 500 ppt, possible with 99% efficient air stripper

Good
Fair
Poor

Purolite®

Thank You!

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Nick.Backman@Purolite.com

800-343-1500

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Backup Slides & Additional Data

Who We Are

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Global Expertise

Purolite®

Purolite is the leading manufacturer
of quality ion exchange, catalyst, adsorbent
and specialty high-performance resins.

Who We Are

We are a team of chemists, engineers, scientists, researchers and support specialists with one common goal — to provide the best solution for your application challenges.

Purolite

Manufacturing Plants

Purolite has full ownership of a network of production facilities in the USA, UK, Romania and China where we administer everything in-house — from polymerization to pack-and-ship.

Sales

With offices in over 40 countries, Purolite's team is agile. We have the largest, most knowledgeable sales force for one reason — to be there when you need us.

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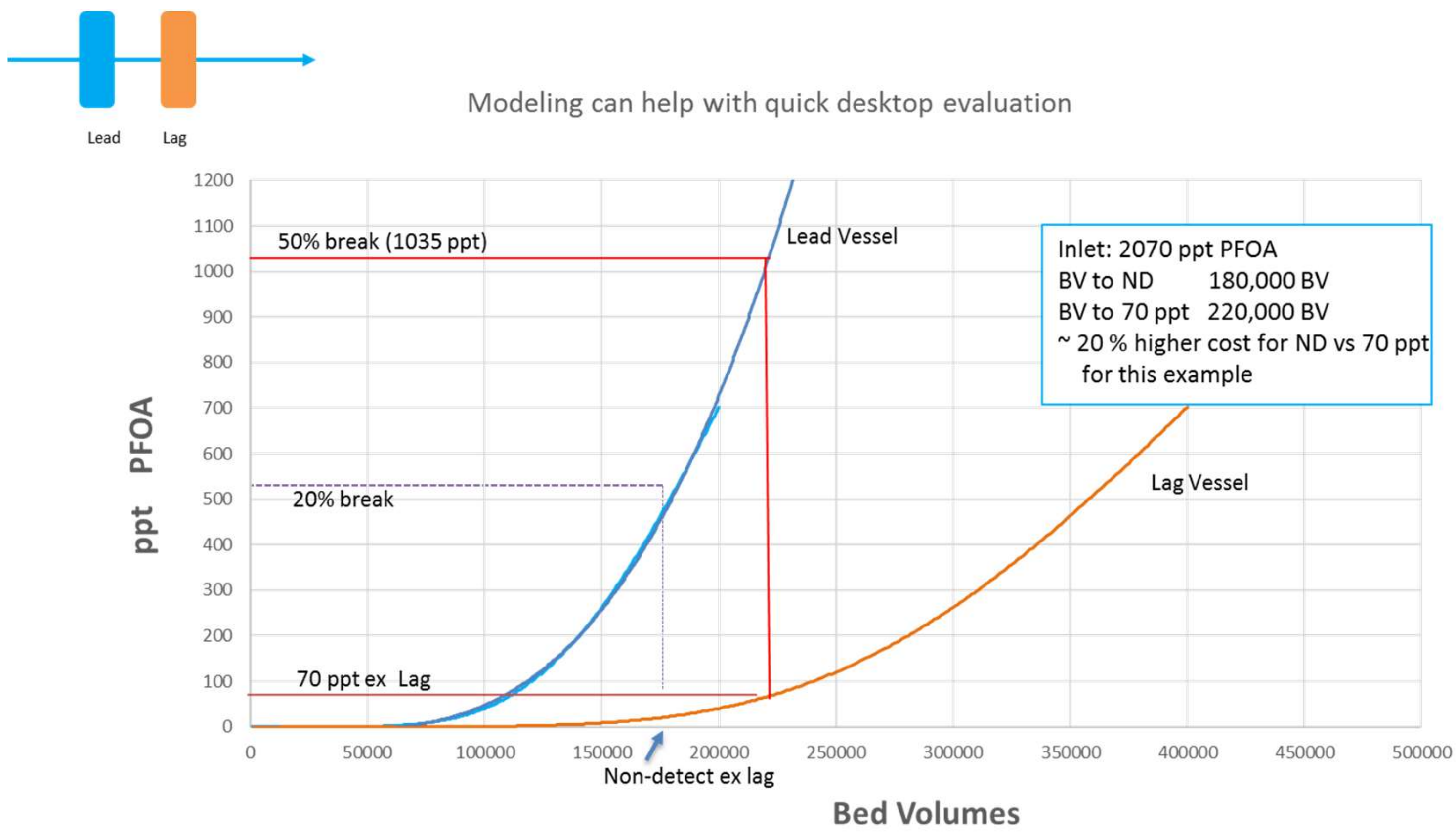
Use Simulation to Determine Number of Vessels Needed to Achieve Either 70 ppt or Non-Detect (ND)



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Design Guidelines for POE / POU Devices to Reduce PFOA, PFOS, PFNA to ND

Parameter	POE	POU
Max Flowrate gpm	10	0.5
Specific flowrate BV/h	20 to 40	10 to 60
EBCT minutes	1.5 to 3	1 to 6
Volume of resin	1.5 ft3 / vessel	2 liters
Service Life minimum	112,000 gals	1000 gals (4000 liters)
Months of life	12	4
Vessel Dimension	10 x 54 FRP tanks	2 x 1 L cartridges

Maximum Inlet Water Quality : PFOA 2000 ppt, PFOS 2000 ppt, PFNA 2000 ppt, TOC 1.5 ppm, TDS 500 ppm
Sulfate 200 ppm, Nitrate 5 ppm as N, Chloride 100 ppm, Alkalinity 200 ppm, Free Chlorine ND, Turbidity 1 NTU

Prefilter: 10 micron cartridge, GAC cartridge for Chlorine

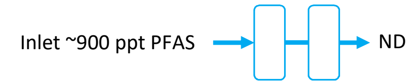
Capital Cost

Example - 500 gpm System (262,800,000 gals/year)

Parameter	PFA694E Resin	GAC
Operation Mode	LEAD >> LAG	LEAD >> LAG
Vessel Diameter - feet	8	12
Linear Velocity – gpm/ft^2 Recommended: 2 to 6 for GAC; 6 to 12 for Resin	9.9	4.4
Bed Depth – feet	4	8
Cubic Feet of media per vessel	200	905
EBCT – minutes (per vessel)	3	13.5
Capital Cost for lead-lag pair of vessels	$298,000	$678,000
Amort. CAPEX @1.5% for 20 years - $/year	**$17,000**	**$40,000**
CAPEX $1000 gallons water treated	**0.06**	**0.15**

- GAC requires 80% more footprint, 50% more head space
- GAC requires special backwash storage tank and bigger pumps which are not considered above

Treatment Cost $ /1000 gals



500 gpm (262,800,000 gals/year)

		Resin	GAC
Operating Capacity – Assumed Bed Volumes		200,000	**25,000**
Volume of media in lead vessels	ft^3	200	900
Gallons treated per charge of media	Gals	299,000,000	170,000,000
Cost of media per fill	$	70,000	41,000
Services (extract/refill, trucking ,profiling, incineration)	$	8,000	36,000
Operating Cost per refill	$	78,000	77,000
Number of refill charges per year		0.9	1.55
Total Operating cost per year	$	70,000	119,000
Operating cost $ /1000 gallons treated		**0.27**	**0.45**
Allocated Capital Cost per year	$	17,000	40,000
Total Capital and Operating Cost per year	$	**87,000**	**159,000**
$ per 1000 gallons water treated		**0.33**	**0.60**

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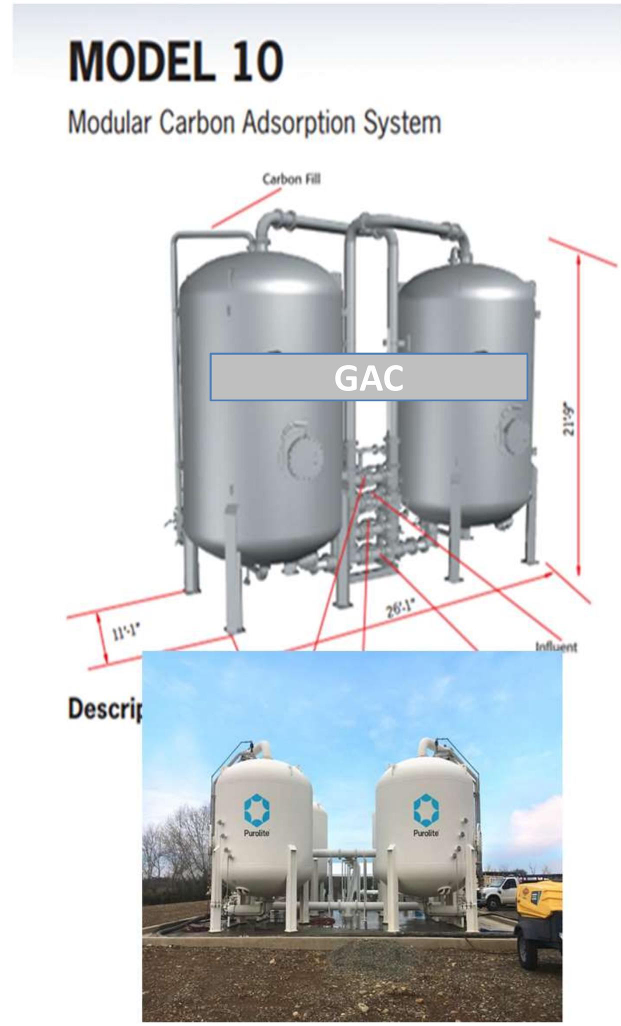
Comparing System Design - Single-Use Resin vs GAC

Parameter	Resin	GAC
Empty Bed Contact Time (EBCT) – minutes per vessel	1.5 to 3	10 to 13
Linear Velocity – gpm/ft2 of bed area	6 to 14 (typical 10)	2 to 6 (typical 4)
Vessel Diameter for 500 gpm flow	8-ft	12-ft
Extra pump and b/wash storage tank	NO	YES
CAPEX	1	2.5X
OPEX	1	1 to 2 X
Headspace	1	2X
Footprint	1	2X



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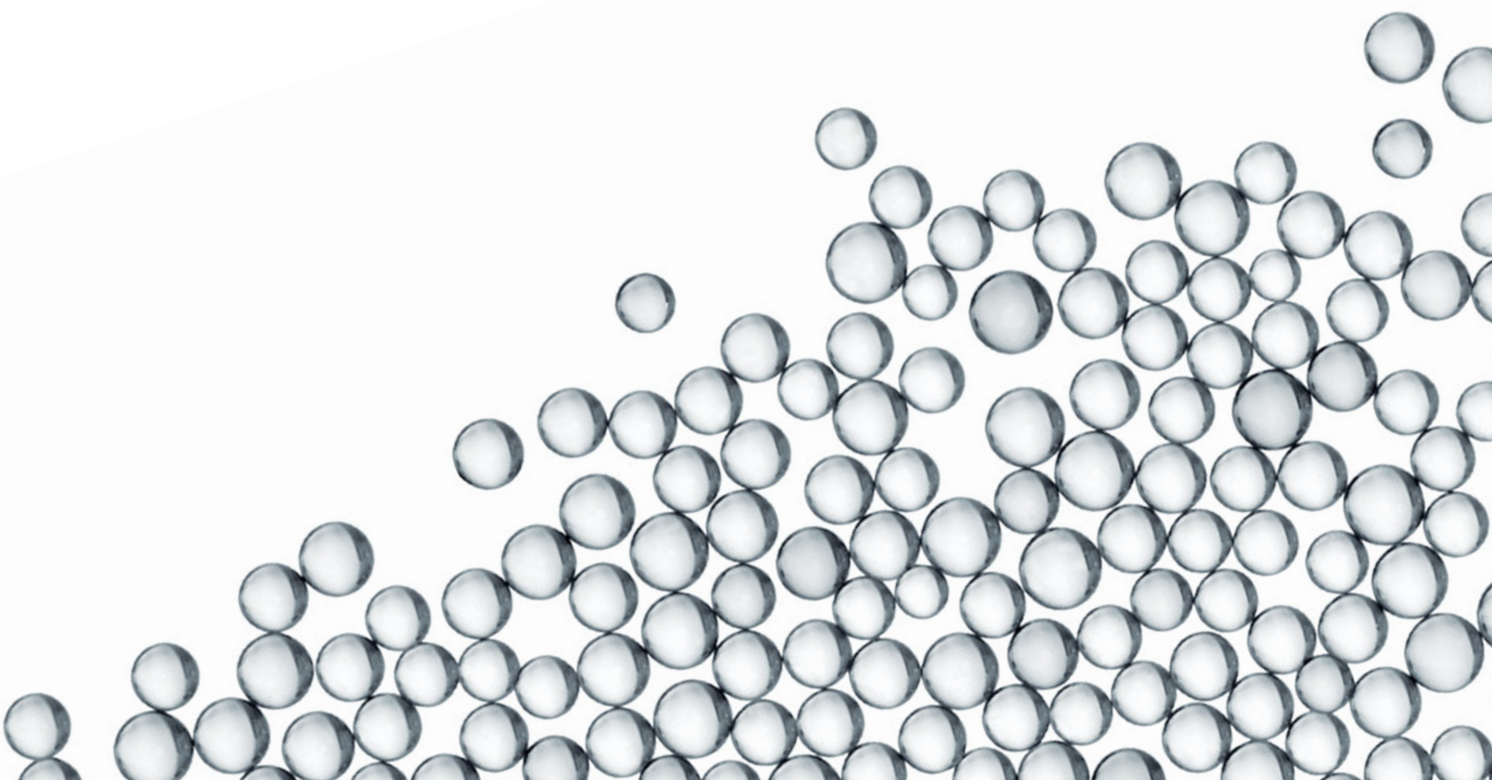
CASE STUDY

Horsham Pilots –

Use of Ion Exchange Resin and Granulated Activated Carbon to Reduce PFAS Levels in Municipal Water to Non-Detect



Background

The township of Horsham, located close to the Naval Air Base in Willow Grove, PA, supplies drinking water to 7,800 residential, commercial and industrial customers using 15 deep water wells. In 2014, five of the wells were confirmed as contaminated with perfluoroalkyl substances (PFAS). Perfluorobutanesulfonate (PFOS) and perfluorooctanoic acid (PFOA) were found in two wells at concentrations exceeding the U.S. Environmental Protection Agency's (EPA) then-prevailing health guidelines of 200 ppt and 400 ppt respectively. These wells were immediately taken out of service. In June 2016, one month after the EPA issued a lower revised guideline of 70 ppt for the combined concentrations of PFOS and PFOA, three more wells were removed from service. The township began purchasing supplemental water from a nearby water supplier and began installing granular activated carbon (GAC) filters to remediate and return the five impacted wells to service. Responding to consumer concerns, the township adopted an aggressive removal plan to reduce average PFOS/PFOA concentrations to less than 1 ppt (essentially to non-detect levels) in its entire water system by the end of 2016.

In addition to GAC filtration, the township started up a 50 gpm selective ion exchange (IX) resin pilot in November 2016 on Well #10 to evaluate the performance of the resin in consistently reducing PFOS/PFOA to non-detect levels. A temporary one-year permit was obtained from Pennsylvania Department of Environmental Protection (P.A. DEP) to install the resin pilot downstream of an existing GAC pilot that was started up 20 days earlier. This was the first permit issued by the state of Pennsylvania for treating PFAS in drinking water using ion exchange resin.

Influent Water Characteristics

Total influent PFAS concentration during the test period from November 2016 to April 2018 was an average of 108 ppt, a minimum of 87 ppt and a maximum of 147 ppt. At the time of this report, the pilot was still operational. Individual concentrations are shown in Table 1. Average influent values for PFOS and PFOA were 34 and 20 ppt, somewhat lower than EPA's 70 ppt combined guideline. Other influent parameters included sulfate at 8 to 23 ppm, nitrate at 10 to 11 ppm, alkalinity at 148 to 232 ppm, chloride at 35 to 50 ppm, pH at approximately 7.5, TDS from 296 to 358 ppm, suspended solids from 0.5 to 0.6 ppm, TOC at 0.2 ppm and one sample detection for 1,1-dichloroethane at 37 ppt.

Table 1. Influent PFAS Characteristics of Well 10 *

	PFBS ng/L	PFHpA ng/L	PFHxS ng/L	PFHxA ng/L	PFNA ng/L	PFOS ng/L	PFOA ng/L	PFAS ng/L
Laboratory detection level	1	1	2	1	2	2	1	
Minimum	6.2	3.5	17.0	6.4	0.0	27.0	13.0	77.6
Average	8.7	4.5	27.9	8.8		34.1	20.0	103.2
Maximum	14.0	8.3	41.0	13.0	1.9	48.0	40.0	147.0

** PFBS =perfluorobutanesulfonate; PFHpA = perfluoroheptanoic acid; perfluorohexanesulfonate; PFHxA = perfluorohexanoic acid; PFNA = perfluorononanoic acid*

Design Details

Well #10, with a peak design flowrate of 100 gpm, was used for large-scale piloting at a reduced flowrate of 50 gpm under the terms of the permit from the P.A. DEP. The water was first passed through a 20-micron suspended solids filter, then in series through 2 x 2.5-ft diameter stainless steel vessels, with each vessel containing 20 cubic feet of bituminous GAC. Empty bed contact time (EBCT) for each charge of GAC amounted to 2.8 minutes or a total of 5.6 minutes for the two GAC vessels; linear velocity was approximately 10 gpm/ft^2. The township recognized that EBCT was lower than the 10 – 20 minutes specified in the P.A. Public Water Supply (PWS) design manual. Additionally, linear velocity—even though it complied with the PWS—was higher than the typical 4 gpm/ft^2 used for GAC. However, the township and DEP considered the design acceptable for the low levels of PFAS measured and for the temporary nature of the pilot. After initial treatment by the GAC pilot, the water was passed through a 2.5-ft diameter vessel containing 20 cubic feet of Purolite's Purofine® PFA694E selective resin. Bed depths for both the GAC and resin media were approximately 34 inches. Sampling points were installed on the outlet of each vessel. An extra sampling point was installed in the resin polishing vessel at ⅔ of the resin bed depth. This allowed monitoring corresponding to EBCT of 1.8 minutes at the ⅔ sampling point and 2.8 minutes EBCT for the entire resin bed. The ⅔ sampling point would provide advanced notice of PFAS breakthrough.

System Performance

The GAC part of the pilot became operational on November 11, 2016 while the resin part started up 20 days after on November 30, 2016. For reporting purposes, the township decided to use a minimum reporting level (MRL) of 2.5 ppt for each of PFOS and PFOA; values below the MRL would be considered non-detect (ND). The concentration of PFOS and PFOA sampled at the ⅔ sampling point of the resin bed remained consistently at non-detect levels until rising to 2.6 ppt on day 408. Levels then fell back below ND and then rose to 4 ppt on day 486, see Figure 2. Levels exceeded ND in the effluent from the first GAC vessel on day 54 and from the second GAC vessel on day 75. This represents a capacity of 19,000 bed volumes, based on the combined volume of GAC in the two vessels. Once the PFOA concentration reached 2.6 ppt at the ⅔ sampling point for the resin, the treated water from the resin was diverted to the sewer—keeping with the DEP permit. The pilot has been operational now for 570 days, amounting to capacity of 440,000 bed volumes for the resin component.

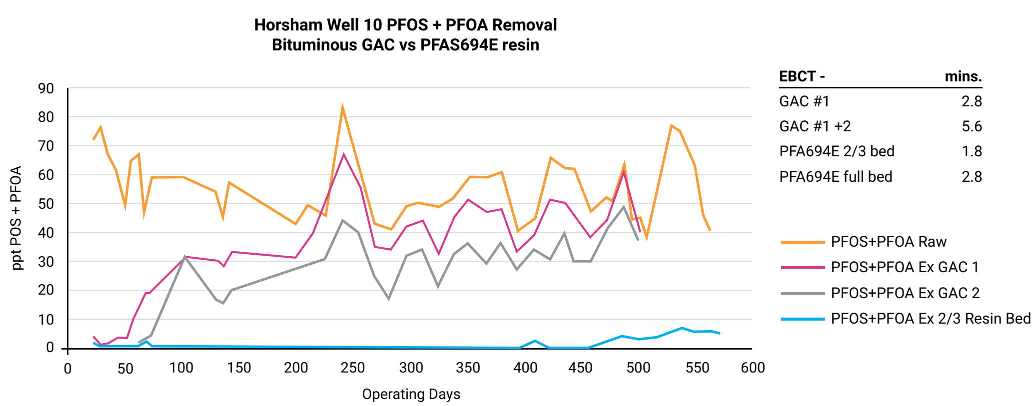


Fig. 2 Combined PFOS / PFOA Breakthrough

With permission from DEP, the two GAC vessels were taken out of service on day 528 while the raw water was routed directly to the resin vessel. The resin continues to perform well, with combined concentrations of PFOS and PFOA in treated water at the ⅔ resin sampling point being 5 ppt and ND from the vessel outlet. Once more data is generated, P.A. DEP will consider granting a long-term permit for use of a resin-only treatment system.

Even though PFOS and PFOA were the initial targets for reduction, consistent reduction of other short- and long-chain PFAS to non-detect levels was also achieved after passage through the resin. For conciseness, only total PFAS breakthrough graphs are shown in Figure 3, but the order of breakthrough observed was PFHxA < PFHpA < PFOA < PFNA < PFBS < PFHxS < PFOS.

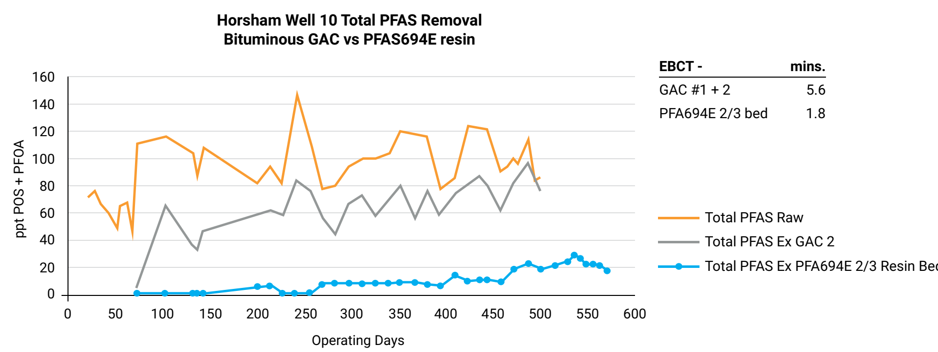


Fig. 3 Combined Breakthrough of Total PFAS

Costs

The proposed permanent full-scale system is designed for a peak flow rate of 100 gpm with a pair of lead-lag vessels for the media. Design for ion exchange will include 1 x 20-micron cartridge filter followed by 2 x 4-ft diameter vessels with resin bed depth of 36 inches and EBCT of 2.8 minutes. Design for GAC will 1 x 20-micron cartridge filter followed by 2 x 6-ft diameter vessels with GAC bed depth of 60 inches and EBCT of 10.6 minutes. Capital equipment cost estimates for ion exchange and GAC are $169,000 and $325,000 respectively, inclusive of initial media fill. Annual operating cost estimates, including replacement media, labor, trucking, spent media profiling and incineration is estimated at approximately $8,000 and $78,000 respectively for ion exchange and GAC, using operating capacity estimates of 350,000 bed volumes and 34,000 bed volumes respectively – approximately $0.15 and $1.48 per 1000 gallons treated respectively by the resin and GAC systems.

Horsham's lead-lag GAC and resin system (L to R) GAC, GAC, Resin.

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