


eVOQUA
WATER TECHNOLOGIES

Carbon and Resin Solutions for PFAS Removal
Webinar
March 6, 2018

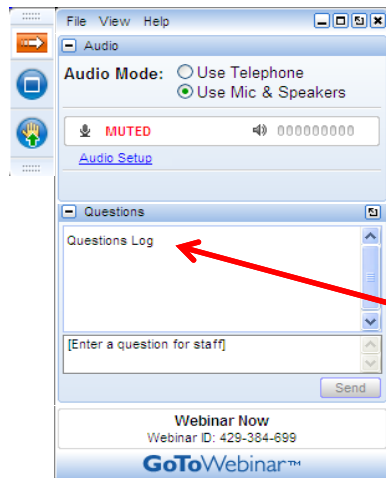
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TRANSFORMING WATER. ENRICHING LIFE.

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How to Participate Today



- **Audio Modes**
 - Listen using Mic & Speakers
 - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**



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Webinar Overview

- PFAS Overview
- Treatment Options
- Granular Activated Carbon (GAC)
 - GAC overview
 - GAC evaluation methods
 - PFAS removal examples
- Anion Exchange
 - Ion exchange overview
 - PFAS removal examples
- Questions



John Lombardo
Product Manager



Caitlin Berretta
Technical Business
Development Manager - East



Dr. Adam Redding
Scientist



Cathy Swanson
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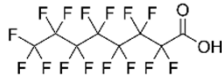


Tom Mallmann
Scientist



What are Perfluoroalkyl Substances or PFAS?

- Per- and polyfluoroalkyl substances (PFAS) are used to make products resistant to stain, heat, oil, grease, and water.
- These include:
 - PFOA (perfluorooctanoic acid)



- PFOS (perfluorooctane sulfonic acid)

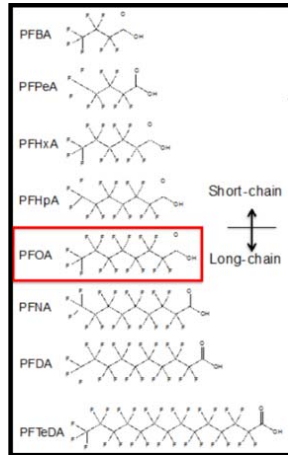


- Carbon-fluorine bond is one of the strongest in chemistry: very stable compound!

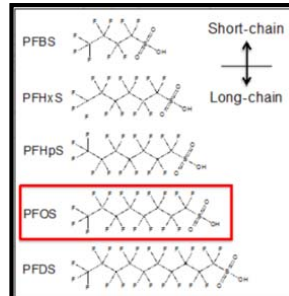


Types of PFAS: Where do PFOA & PFOS fit?

Carboxylic Acids

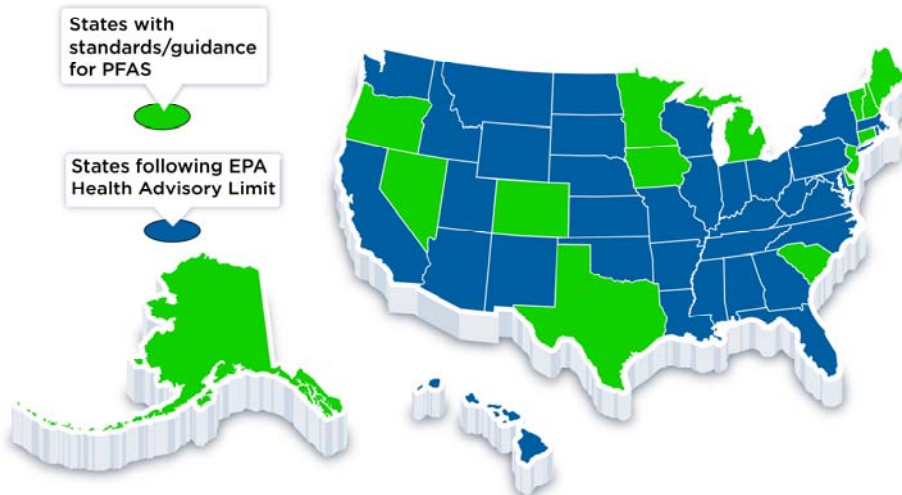


Sulfonic Acids



And many more

State and Federal Oversight



Information from ITRC, updated 11.2017

PFAS Removal Solutions: Each Water Is Unique



Granular Activated Carbon

- Most proven technology
- Reduces liability
- Removes other organic contaminants
- Minimal maintenance

Effective Products:

AquaCarb® CX Carbon
UltraCarb® 1240AW Carbon



Single Pass Ion Exchange

- Lower EBCT / Higher flowrate
- Small footprint
- High throughput
- No chemicals or liquid waste
- Minimal maintenance

Effective Products:

PSR2 Plus



Membranes

- Highly effective
- Removes dissolved solids

Effective Products:

Vantage® Product Line



Granular Activated Carbon (GAC) Basics

- Strong affinity for organic contaminants
- Performance determined by porosity and surface chemistry
- Porosity varies with source material and activation method
- Surface chemistry varies mainly with activation method



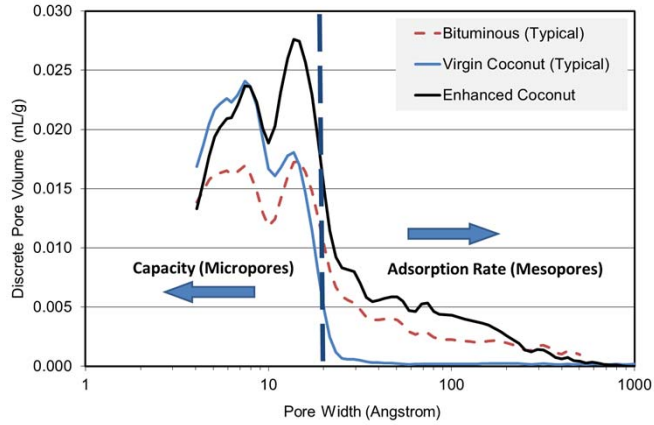
Common Sources

- Coconut Shell
- Coal: Bituminous, Anthracite, Lignite
- Wood



GAC Basics – The Importance of Porosity

- Pore size distribution determines performance
- Pore size is classified into three categories:
 - Micropores (capacity)
 - Mesopores (adsorption rate)
 - Macropores
- **More mesopores = faster adsorption**



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PFAS Removal by Evoqua's GAC

- **AquaCarb® CX** and **UltraCarb® 1240AW** porosity well suited for PFAS removal
- **High rate of diffusion** assures performance into GAC structure
- **Lighter density GAC** fills the same vessel using a lower weight while achieving the same empty-bed contact time
- **Removes other organic contaminants** such as TOC, taste & odor
- **Reduces long term liability** for generator by achieving **full destruction of PFAS** through reactivation



Carbon Reactivation for PFAS

Total Destruction of Contaminants

- **Evoqua has 3 reactivation plants**
 - Darlington, PA *
 - Red Bluff, CA *
 - Parker, AZ
- **Reactivation:**
 - **Total destruction of PFAS and all other organic contaminants**
 - Economical alternative to re-bedding with virgin carbon
 - Recycles a valuable resource
 - Reduces generator's liability for the spent carbon
 - Certificate of Destruction Available



Parker, AZ

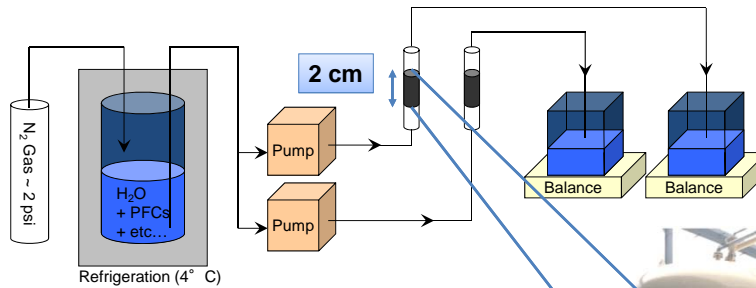


Darlington, PA & Red Bluff, CA

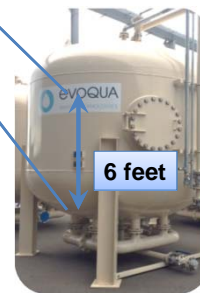
***NSF61 certified potable reactivation available**



Performance Testing: RSSCT (ASTM D6586)



- **RSSCT = Rapid Small-Scale Column Test**
- Only ASTM approved method
- Simulates months of runtime within days

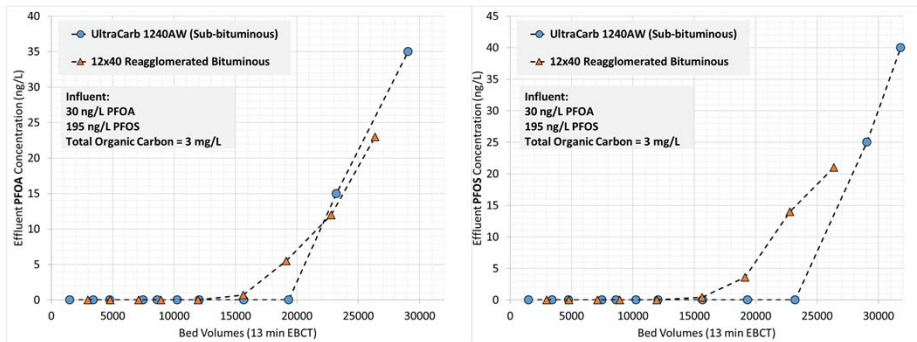


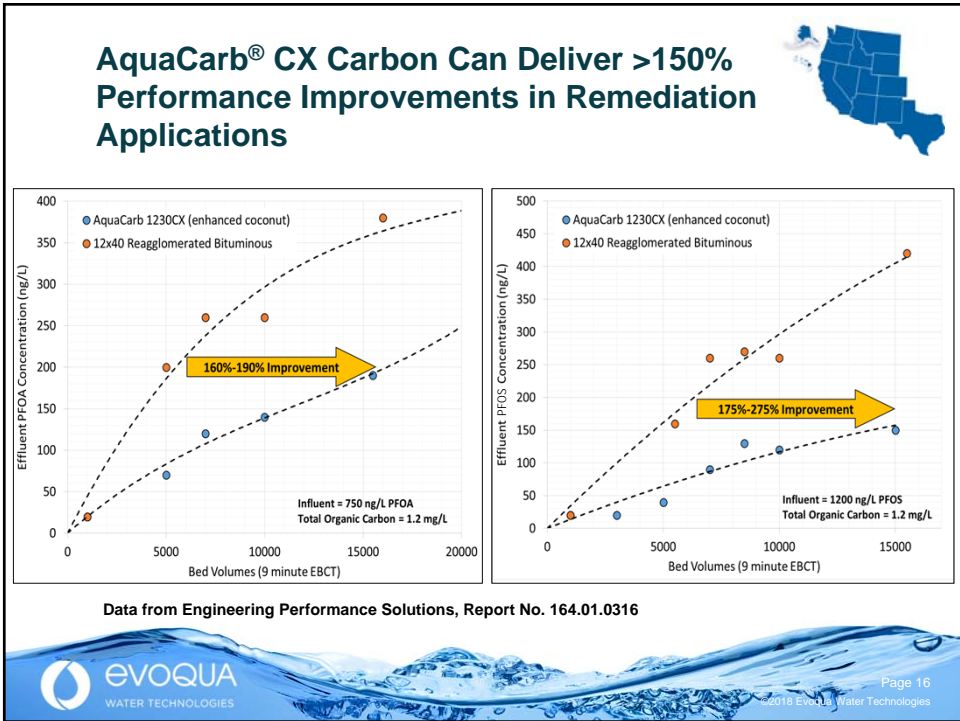
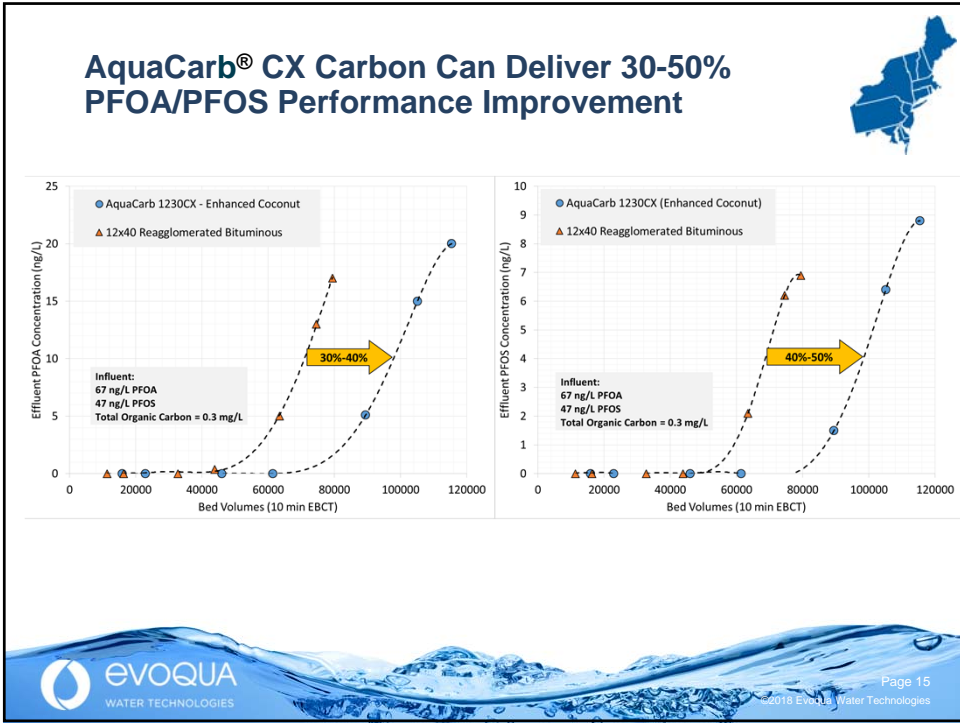
Performance Testing: Pilot Skid

- Uses small diameter (3" to 6") columns to simulate operating conditions of full-scale adsorber
- Matching hydraulic loading rate and shortening bed depth (e.g. 1/2 full scale) can decrease time to reaching conclusions
- Requires more time and labor but can produce more accurate prediction of bed life

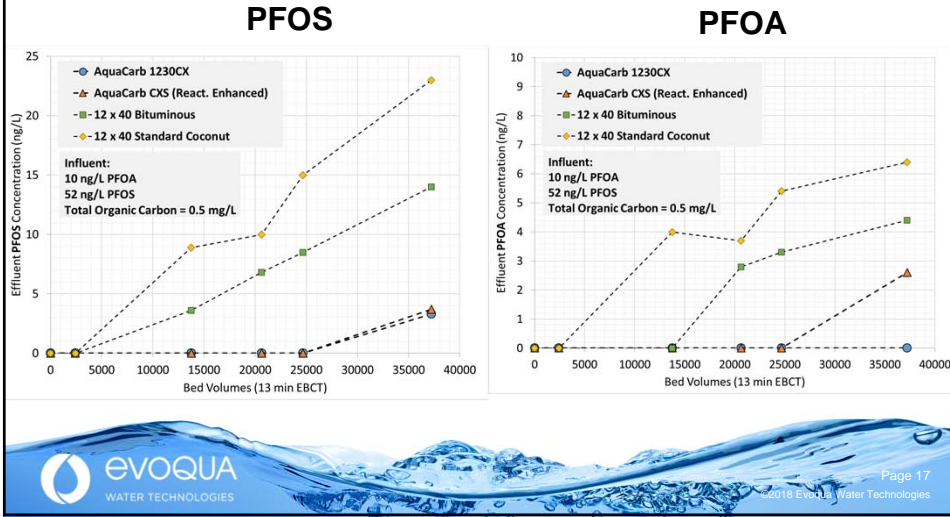


UltraCarb® 1240AW Carbon is Effective at Removing PFOA/PFOS in Surface Water

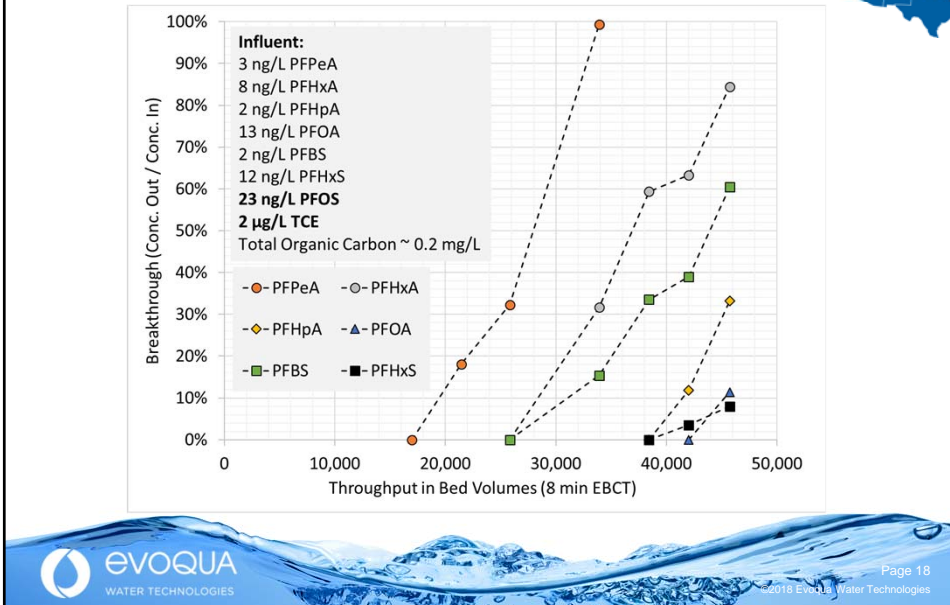




Reactivated AquaCarb® 1230CX can surpass or match virgin carbons.



AquaCarb® 1230CX removes short-chained PFAS.



PFAS Removal by PSR2 Plus Resin

- Resin affinity for PFAS depends on anion functional group and length of perfluorinated alkyl group
 - Sulfonates preferred over carboxylates
 - Longer perfluorinated chains preferred over shorter chains
- High PFAS selectivity means **long throughputs** even though concentrations of nitrate, sulfate, chloride and bicarbonate are far higher than the concentrations of PFAS



Least Selective

- HCO_3^- – Bicarbonate
- Cl^- – Chloride
- SO_4^{2-} – Sulfate
- NO_3^- – Nitrate
- PFBA
- ClO_4^- – Perchlorate
- PFOA
- PFOS

Most Selective

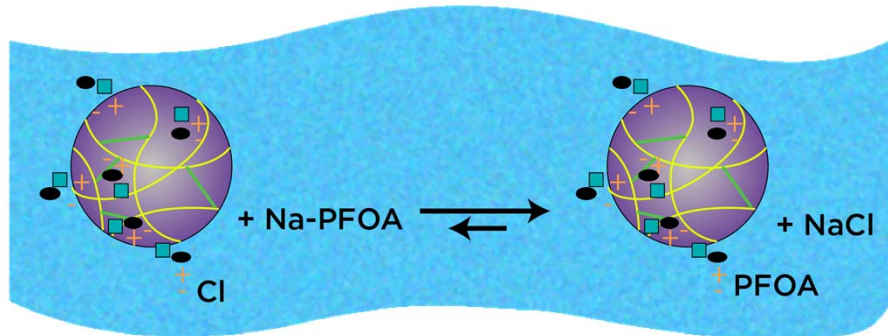


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Ion Exchange

- Ion Exchange, or IX, is based on the principle of exchanging a harmless ion for the contaminant



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PFAS Removal by PSR2 Plus Resin

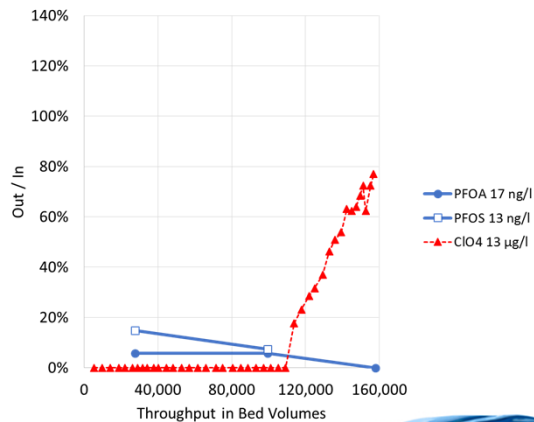
- A NSF 61 approved resin originally developed for perchlorate removal. Found to have higher selectivity for PFOA/PFOS than other perchlorate-selective resins and far higher selectivity than other classes of anion exchange resin. **PSR2 is the most commonly used resin for perchlorate removal**
- Resins remove both **shorter** chain and long chain PFAS
- Short empty bed contact time (2 min) → **smaller equipment footprint**
- High selectivity for PFOA and PFOS → large treatment volumes
- Minimal maintenance required – runs until spent and then dispose of resin
- Solid waste sent to waste-to-energy facility or incinerator; PFAS are destroyed and **generator liability is removed**



Resin Full Scale Data

- Full Scale Perchlorate system shown to remove PFOS and PFOA well
- Perchlorate broke through before PFAS
- PFAS analytical methods have improved since 2008
- Four additional sites have shown PFOA/PFOS at non-detect more recently when treating perchlorate full scale

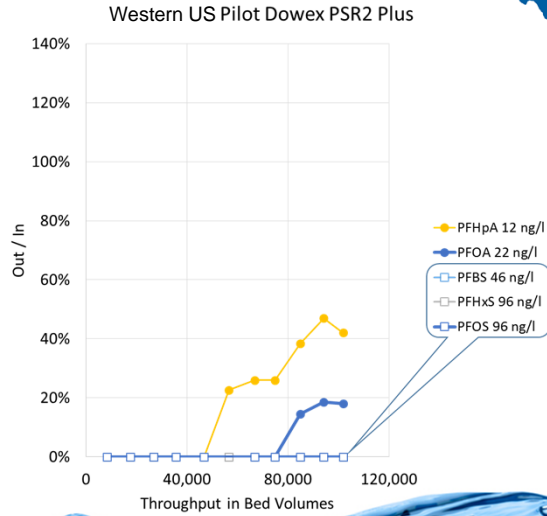
Southern California 1000 gpm Perchlorate-Removal System
2008 Data



Western US Pilot with Resin



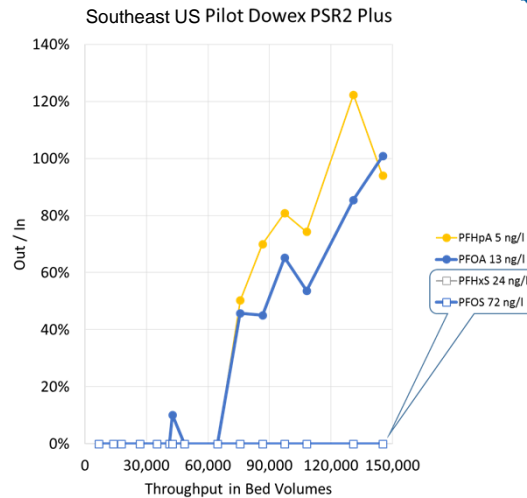
- Water agencies had an immediate need for treatment. After 100,000 BV quit pilot and put in full scale system treating ~1500 gpm.
- Possible iron fouling



Southeast US Pilot with Resin

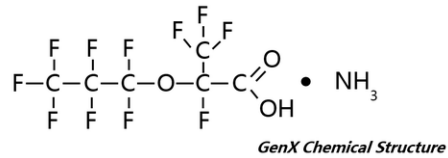


- This water was very high TOC and was not suited to GAC treatment
- 14 ppm TOC
- Resin turned black within 24 hours yet still provided removal



Multiple PFAS Removal with Surface Water

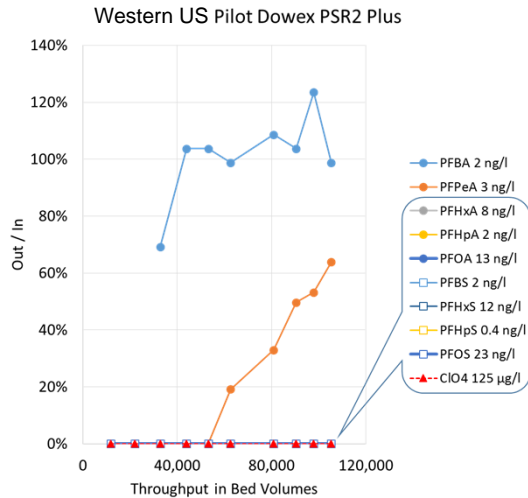
- Ongoing research on ethers and GenX
- Consistently see perfluorosulfonic acids removed better than perfluorocarboxylic acids
- Resin showing good removal capabilities



Ongoing Pilot with Typical Groundwater



- Low TDS
- Low TOC
- Excellent removal with resin
- 7 months into an 18 month pilot



Summary: Each Water Is Unique

- We customize a solution just for your community based on local water conditions



We Are Easy To Do Business With

- Our priorities are community safety and the environment
- We take quick action to ensure clean, safe water
- National coverage – big cities, small towns
- We have easy financing options for your community or application
 - Lease-to-own
 - Rental
 - Capital purchase
 - Build/Own/Operate



WHAT CAN WE DO FOR YOUR COMMUNITY?

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References

1. [US EPA: Basic Information about Per- and Polyfluoroalkyl Substances \(PFASs\)](#)
2. [US EPA: Basic Information about Per- and Polyfluoroalkyl Substances \(PFASs\)](#)
3. [Toxicology of Perfluorinated Compounds](#)
Thorsten Stahl, Daniela Mattern, and Hubertus Brunn
Environmental Sciences Europe 2011 23:28
4. [Center for Disease Control: Factsheet: Perfluorochemicals \(PFCs\)](#)
5. [Vermont Department of Environmental Conservation: Vermont Groundwater Protection Rule and Strategy](#)
6. [US EPA: Factsheet: PFOA & PFOS Drinking Water Health Advisories](#)
7. [Detection of Poly- and Perfluoroalkyl Substances \(PFASs\) in U.S. Drinking Water Linked to Industrial Sites, Military Fire Training Areas, and Wastewater Treatment Plants](#)
Xindi C. Hu, David Q. Andrews, Andrew B. Lindstrom, Thomas A. Bruton, Laurel A. Schaidler, Philippe Grandjean, Rainer Lohmann, Courtney C. Carignan, Arlene Blum, Simona A. Balan, Christopher P. Higgins, and Elsie M. Sunderland
Environmental Science & Technology Letters 2016 3 (10), 344-350

