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Granular Activated Carbon: *A Proven Solution for PFC Removal*



January 30, 2017

Introduction

- Calgon Carbon Corporation is the world's largest producer of Granular Activated Carbon (GAC)
- Our mission: pure water, clean air, better living
- We solve purification and separation problems with an array of technologies (Activated Carbon, IX, UV, AOP, Perlites, D.E.)
- Water treatment is core competency with a diverse product portfolio

\$535 million

2015 net sales

70+ years

experience

1,400+ employees



23 offices

sales and service

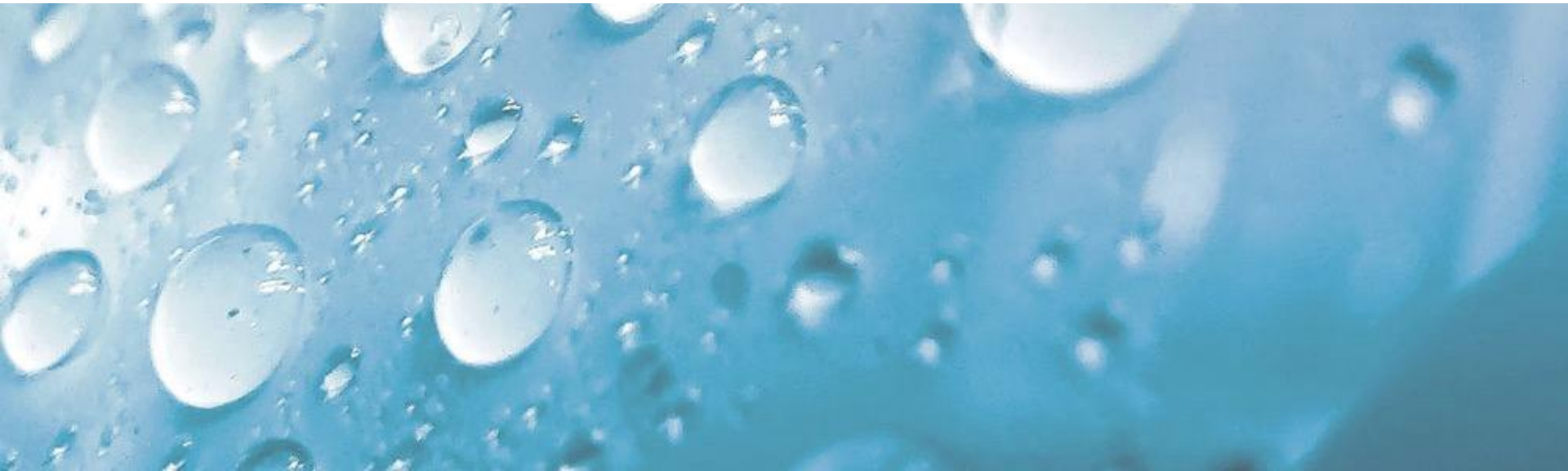
21 facilities

manufacturing, reactivation,
equipment

240 patents

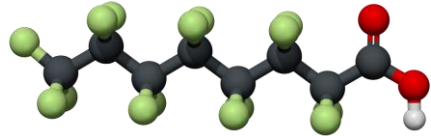


Protecting Communities from Perfluorinated Compounds

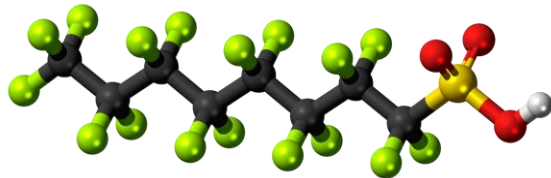


PFC Overview

Man made fully fluorinated organic compounds



PFOA Molecule



PFOS Molecule



Health Advisory:

70 ppt
Combined
PFOA / PFOS

Why PFCs Are a Problem

- Contaminates drinking water and food
- Highly persistent / resistant to degradation
- Accumulate in the body

Where they come from....

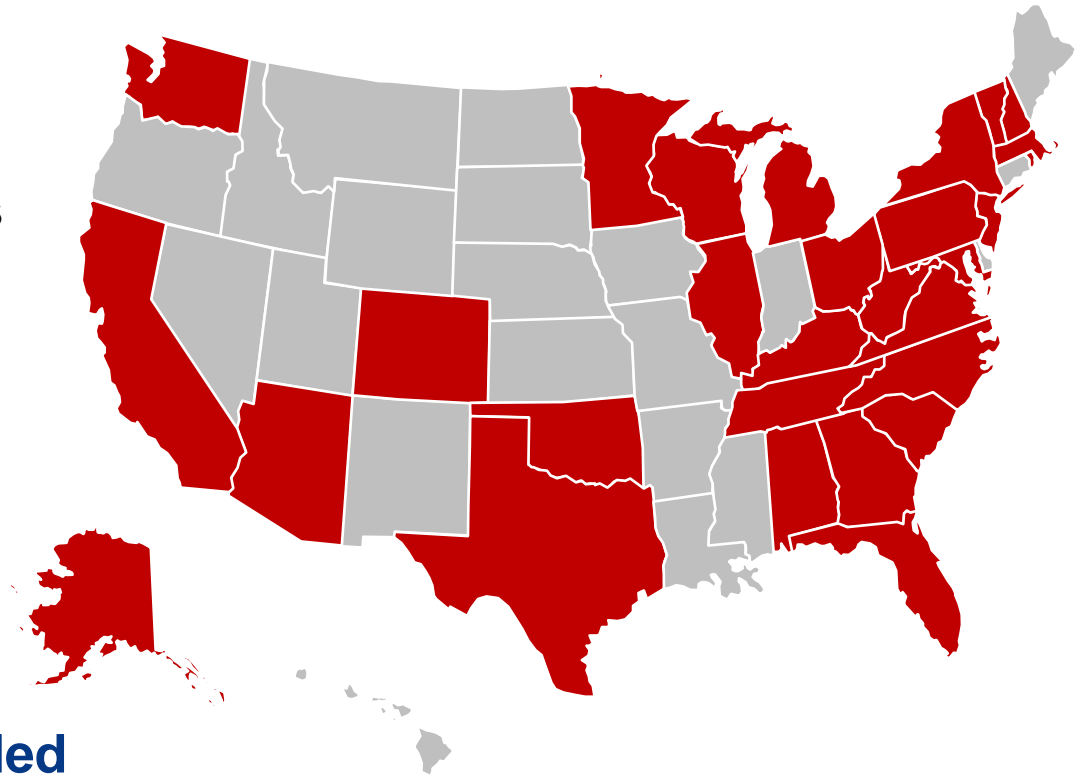


Where are PFCs?

U.S. Drinking Water Contaminated by PFCs*

According to the U.S. EPA:

- 94 Public drinking water systems with PFC's
- Across 28 States (Red Highlight)
- 6.5 Million Americans affected
- Not including private wells



Contaminated non-drinking water sources are not included

....THE PROBLEM IS ONLY GROWING!

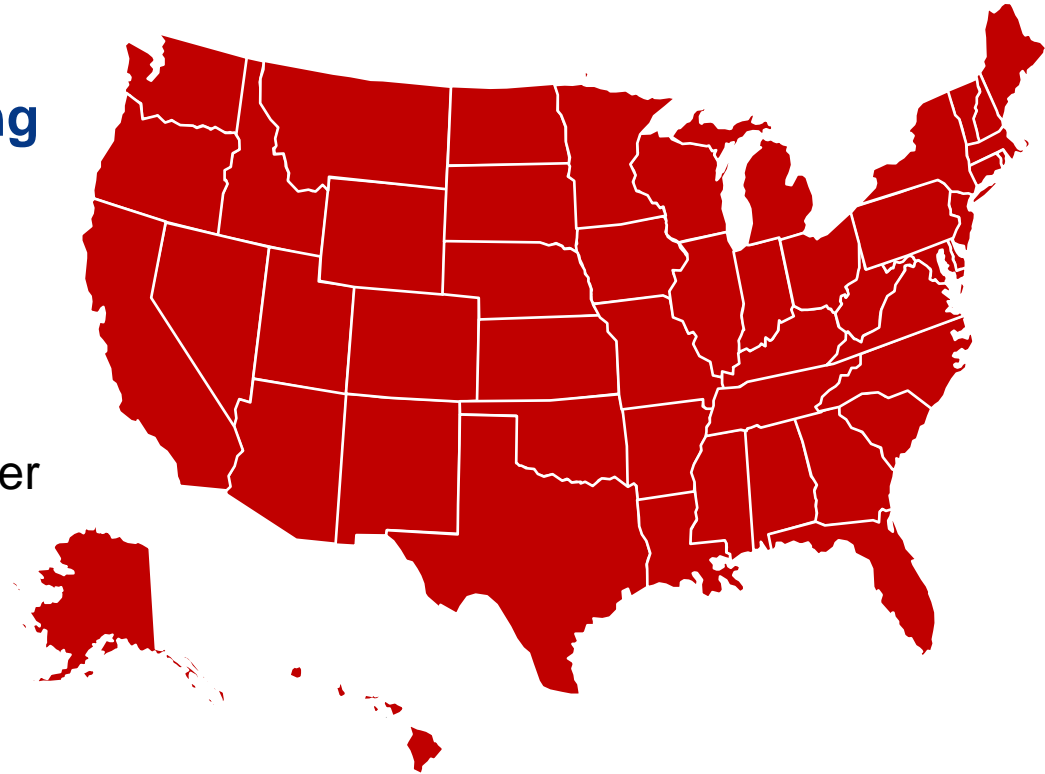
*source <http://news10.com/2016/06/02/pfoa-by-the-numbers-a-widespread-contamination-and-how-it-affects-your-health/>

Where are PFCs?

Potentially PFC Contaminated DoD Sites *

Based on the use of fire fighting foams....

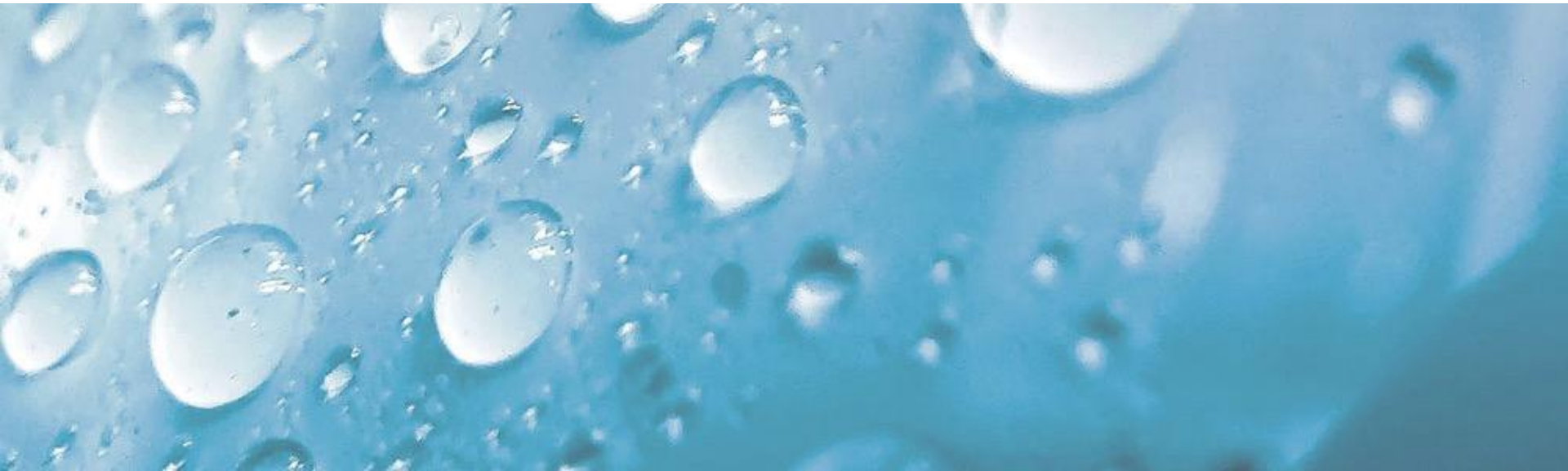
- DoD identified over 200 bases potentially contaminated
- Across 49 States (Red Highlight)
- Testing currently underway
- May impact adjacent municipal water utilities



*source <http://news10.com/2016/06/02/pfoa-by-the-numbers-a-widespread-contamination-and-how-it-affects-your-health/>



How GAC Can Help



Economic Benefits of GAC



The average family of 4 consumes 65,700 gallons of water annually

Tap water filtered by GAC costs a family of 4 roughly \$2.00/Month (per AWWA)

The average 2015 price for bottled water is \$1.22/gallon

GAC is a Proven Technology



Leading technology for removal of PFCs from drinking water and groundwater



>15 years and >20 large installations in municipal/ industrial segments & > 1000 POET GAC systems treating residential well sites



GAC is safe & environmentally responsible - safest way to treat is to remove contaminants

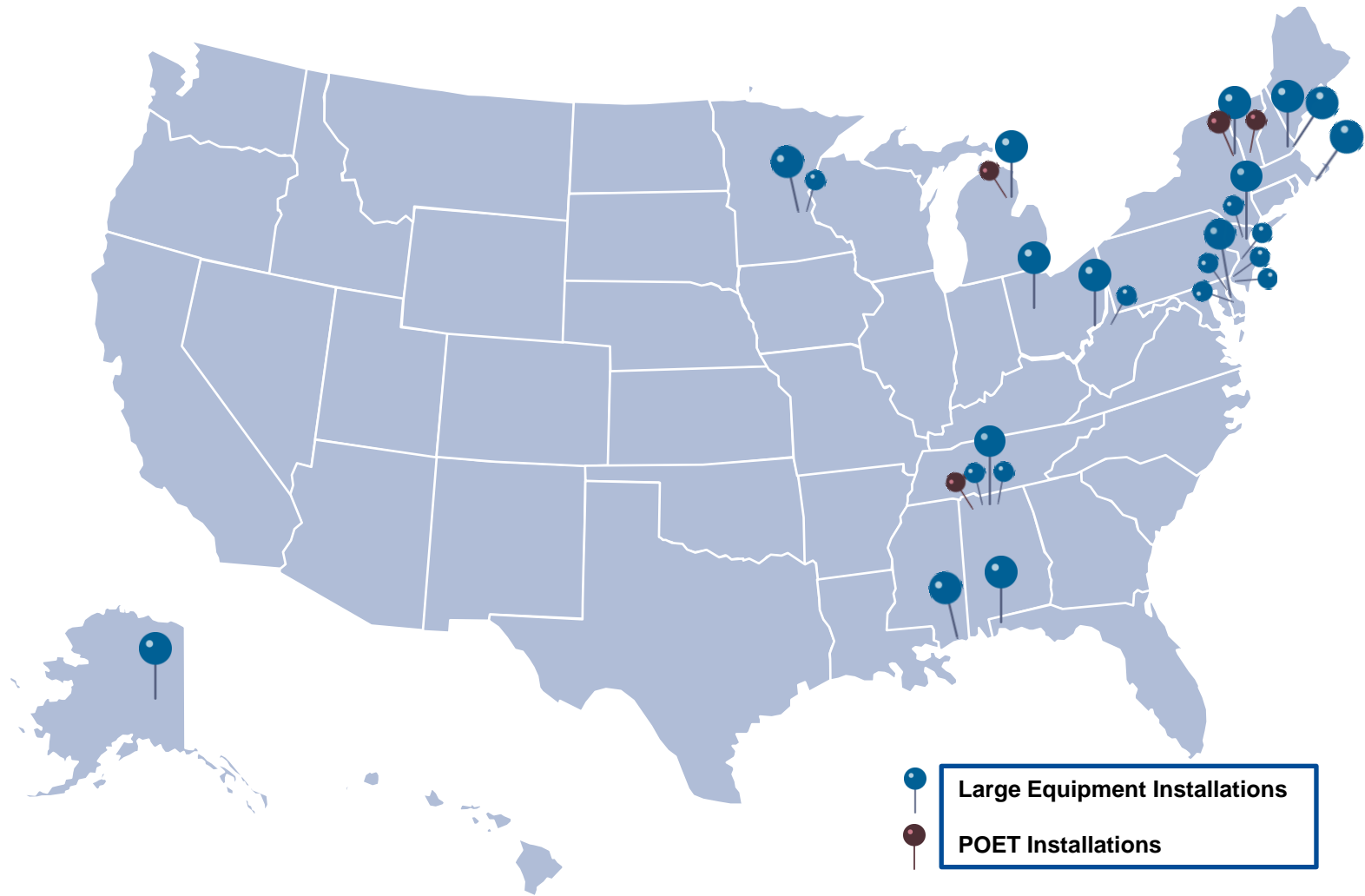


Cost effective & simultaneously removes other emerging contaminants which addresses future compliance requirements



Reactivation of spent GAC thermally destroys adsorbed contaminants including PFC's

Calgon Carbon PFC Treatment Locations





Why FILTRASORB® GAC is superior

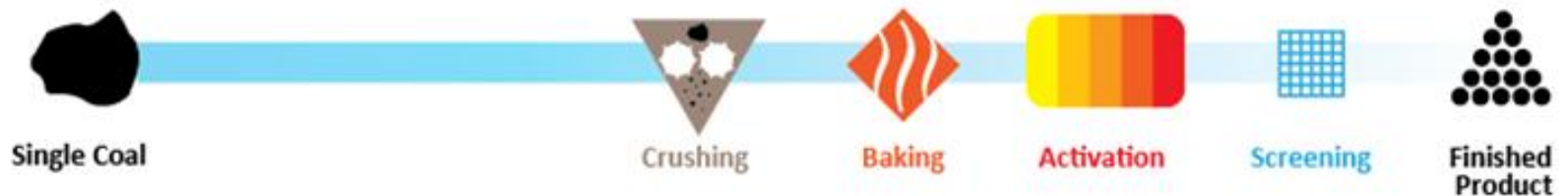


FILTRASORB® GAC

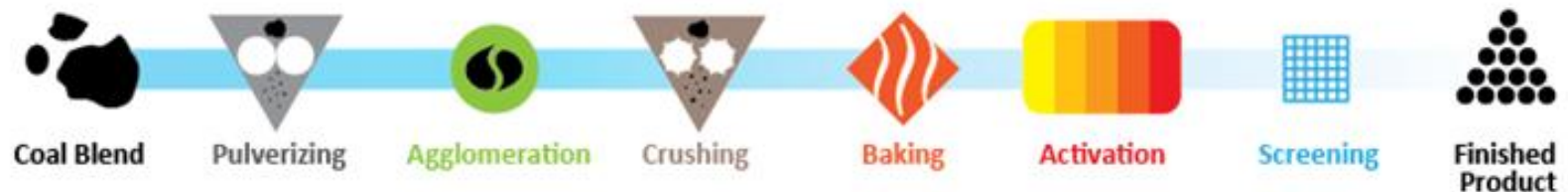
Domestically mined, domestically manufactured GAC

Bituminous coal-based re-agglomerated GAC has shown to have better performance in water applications than direct activated coal and coconut based carbons

Direct Activation



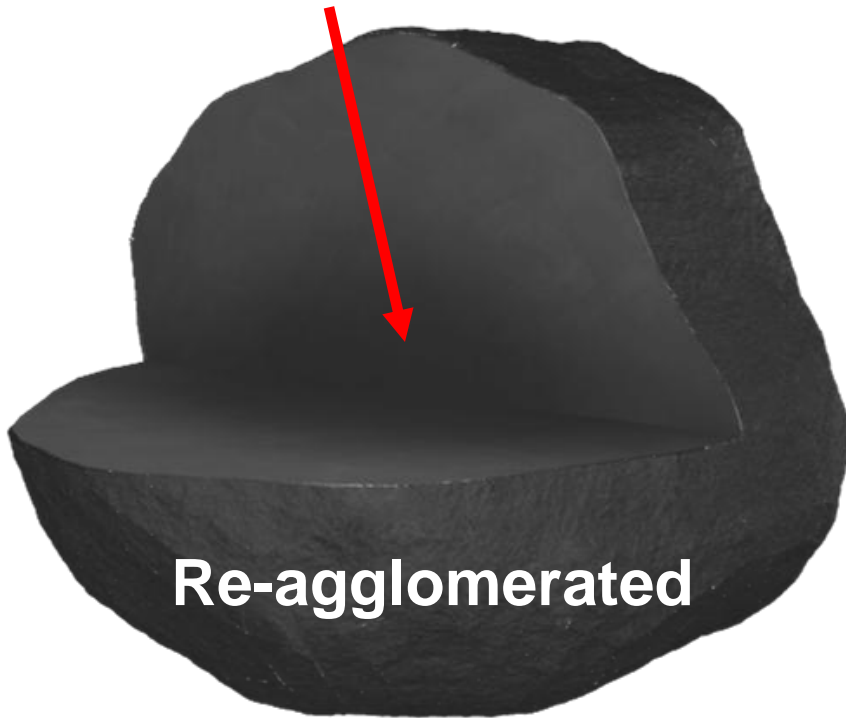
Reagglomeration



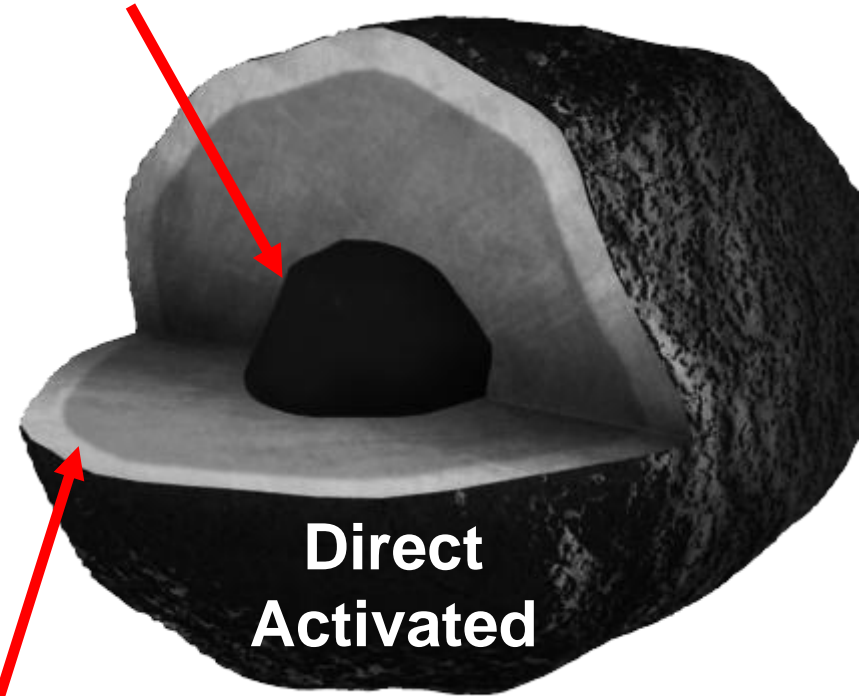
Granular Activated Carbon

Product differences: Re-agglomeration versus Direct Activation

Even Activation



Low Activation



Over activation in the outer Part of the granule

Activated Carbon Starting Materials





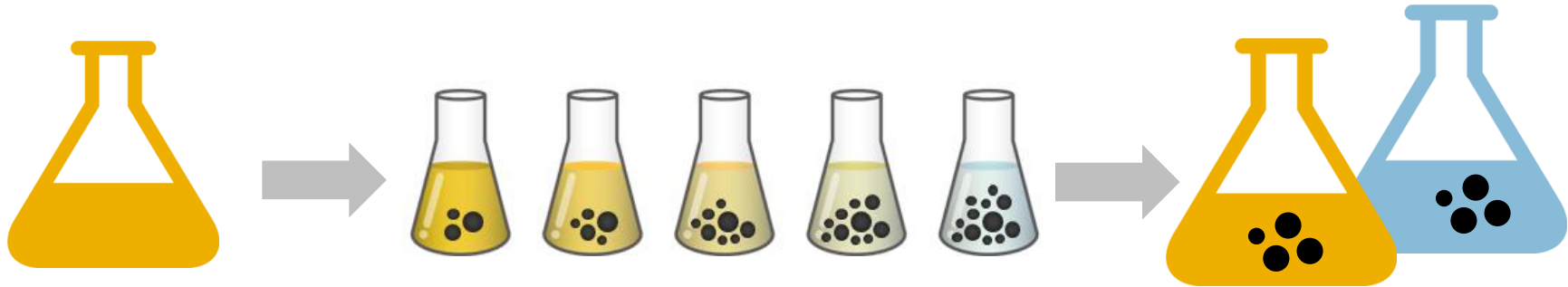
The Importance Of Testing



Importance Of Testing

- **PFCs/PFASs are found in trace amounts in water**
- **Testing is recommended – customer raw water sample**
 - Isotherm
 - Quick test method for feasibility
 - Accelerated Column Tests (ACT)
 - Simulates full scale performance
 - Provides important information: carbon type, breakthrough data, usage rates
 - System design is critical
- **Drinking water applications**
 - Typically low concentrations (ppb, ppt)
 - Background TOC can be 10-100X the PFC/PFAS concentration
 - Modeling such scenarios is difficult (even with other, non-PFC compounds)
 - ACT or RSSCT is beneficial
- **If client timing does not permit testing, CCC recommends as a start: 10 minutes EBCT (Empty Bed Contact Time) per adsorber, with 2 adsorbers in series**

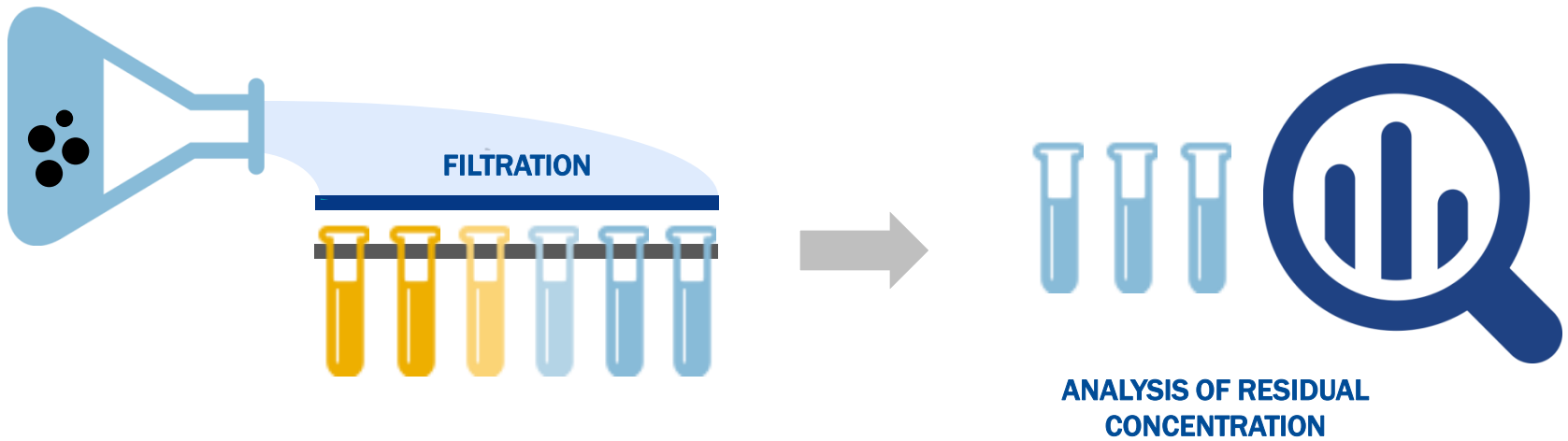
Isotherms



100 ML OF SOLUTION TO BE TREATED

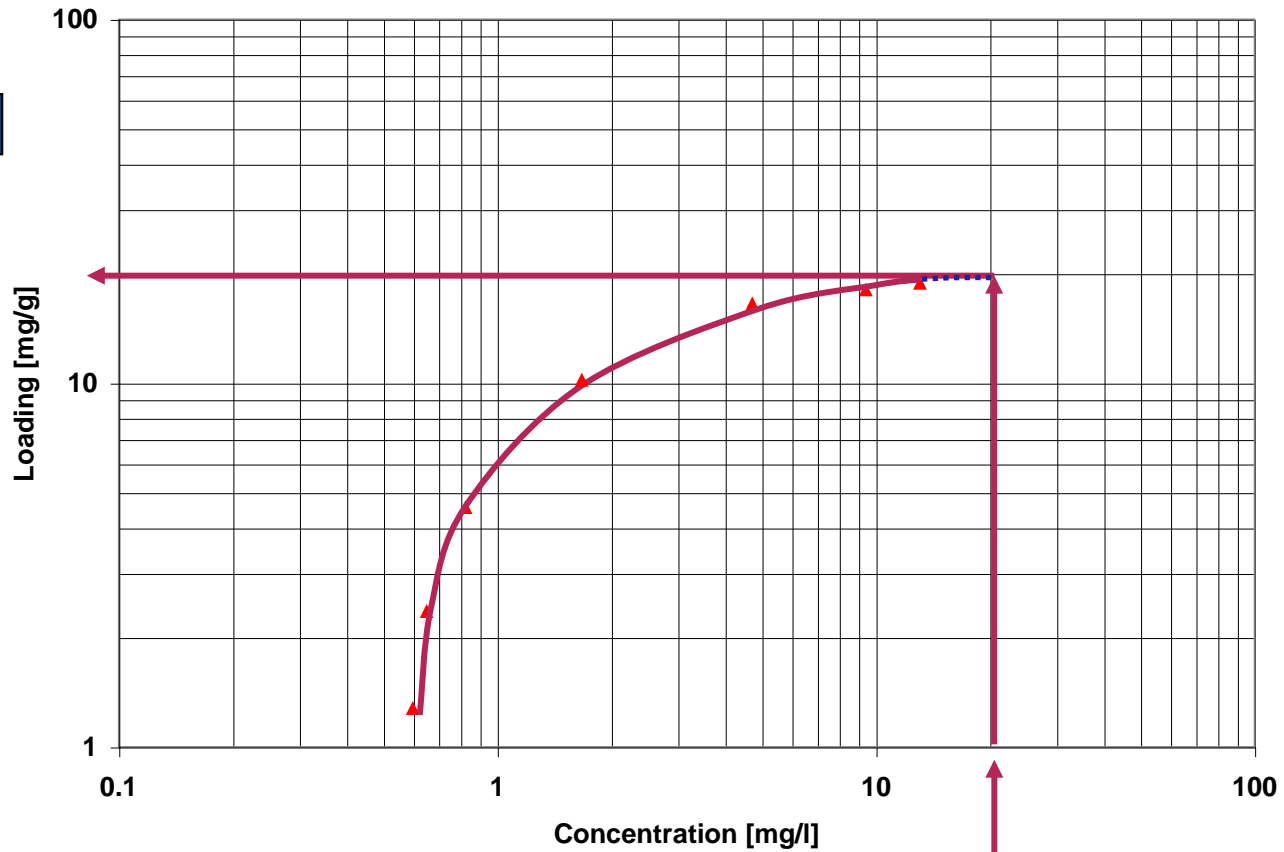
SOLUTION IN CONTACT WITH INCREASING AMOUNT OF CARBON

EQUILIBRIUM REACHED



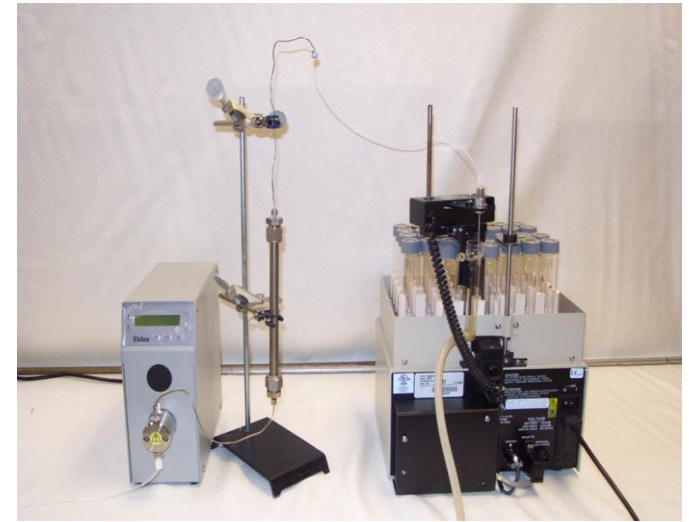
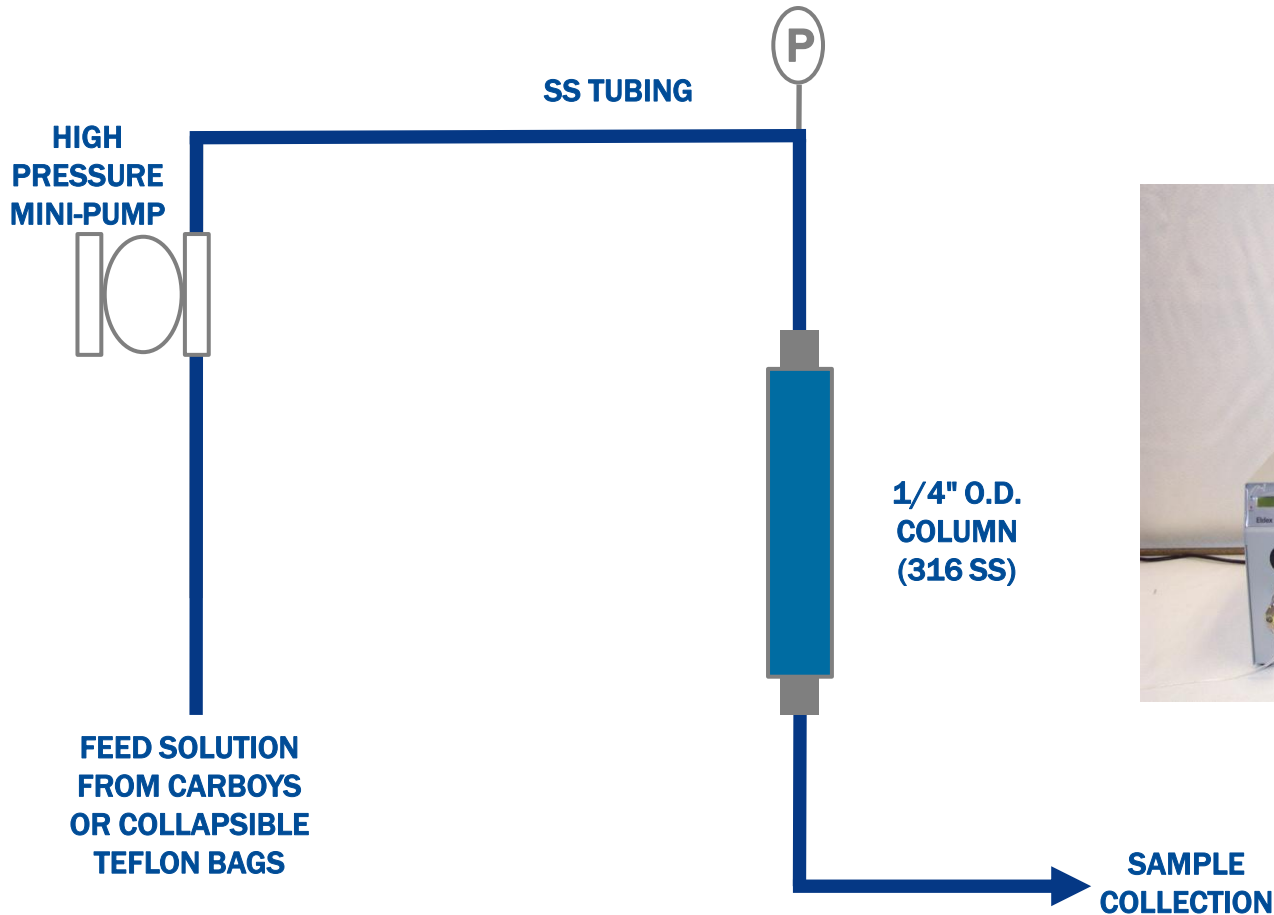
Isotherm

GAC Loading

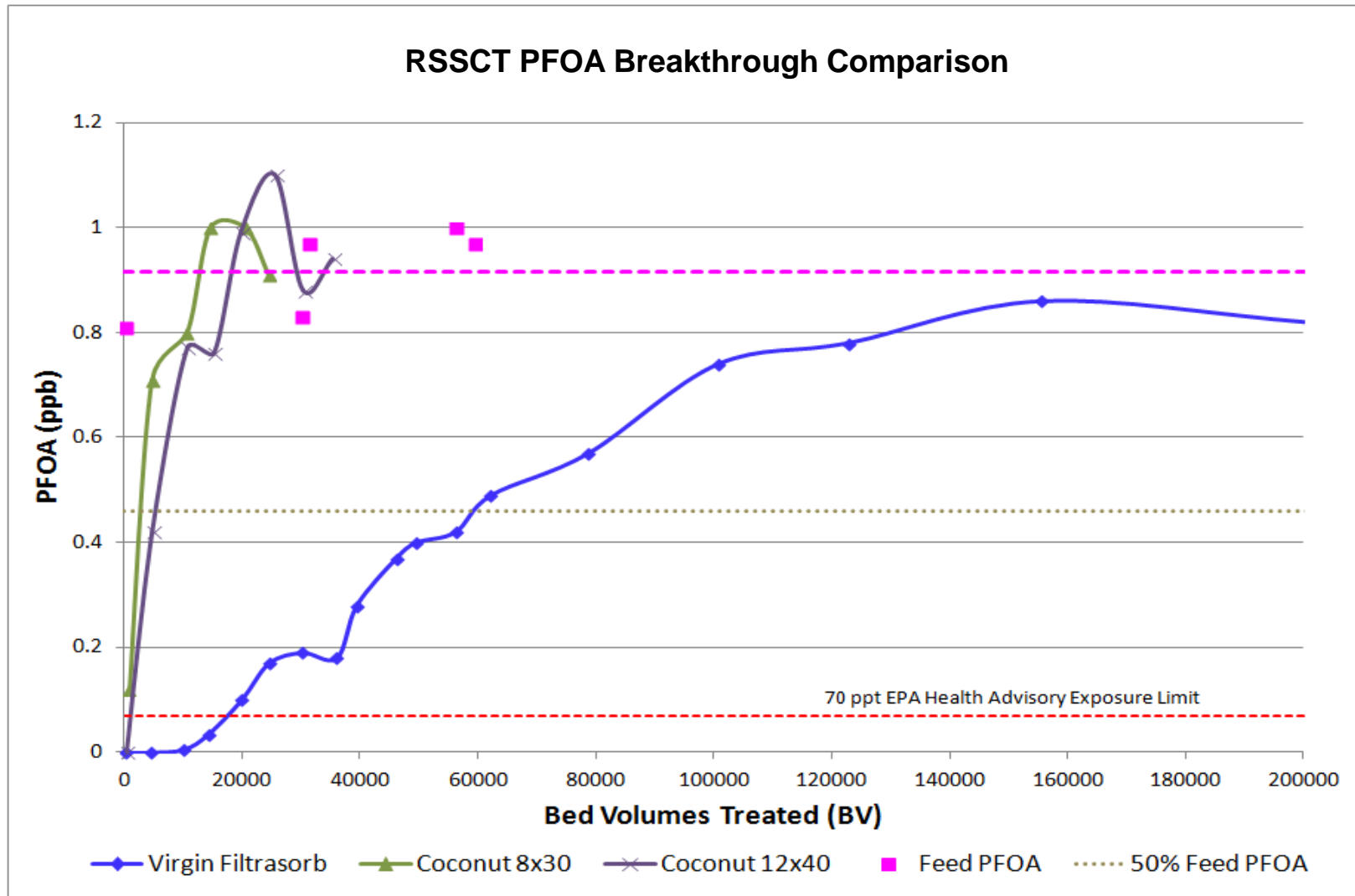


Inlet concentration

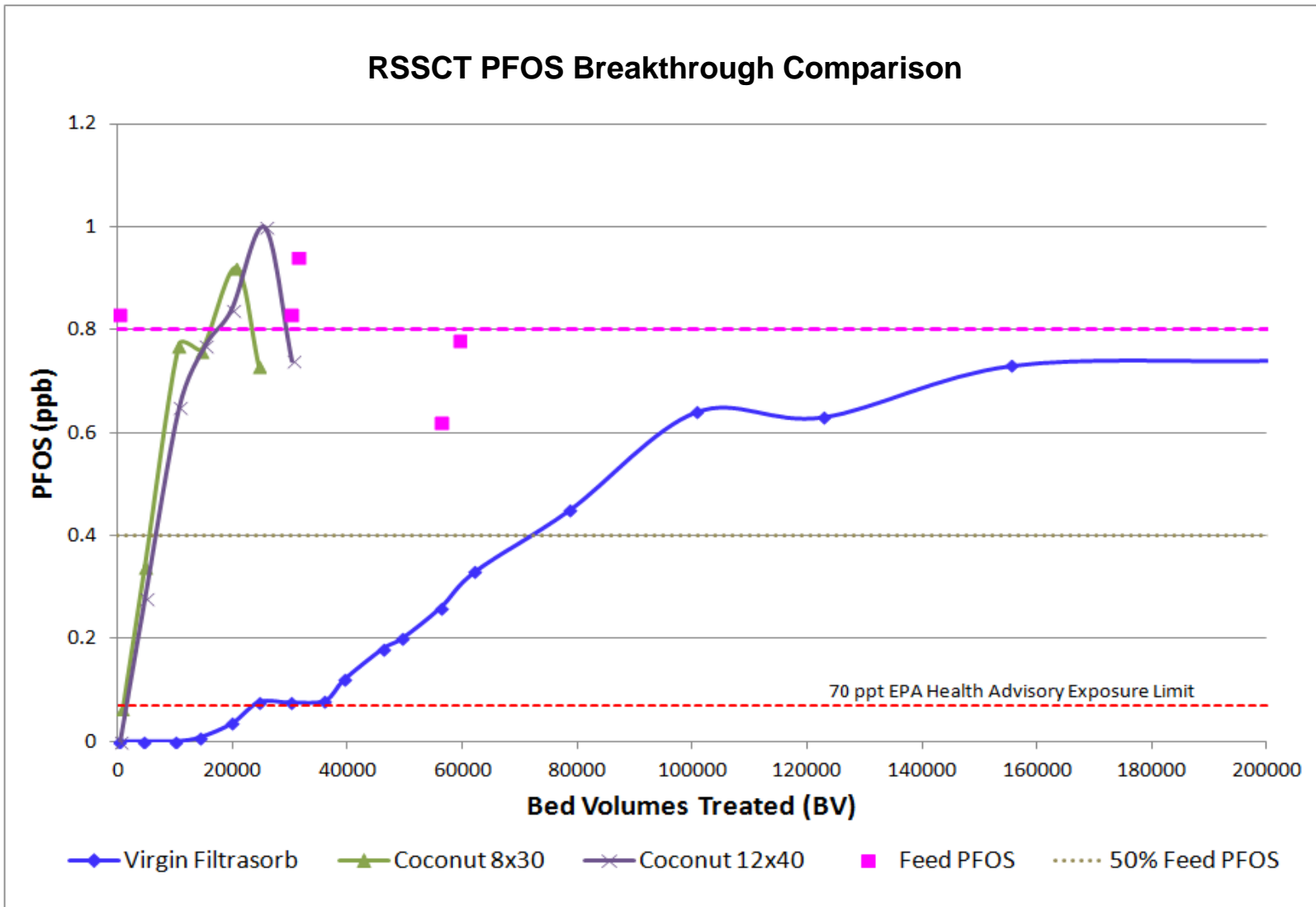
RSSCTs / ACTs Test Methods



FILTRASORB® Comparative Performance Data



FILTRASORB® Comparative Performance Data



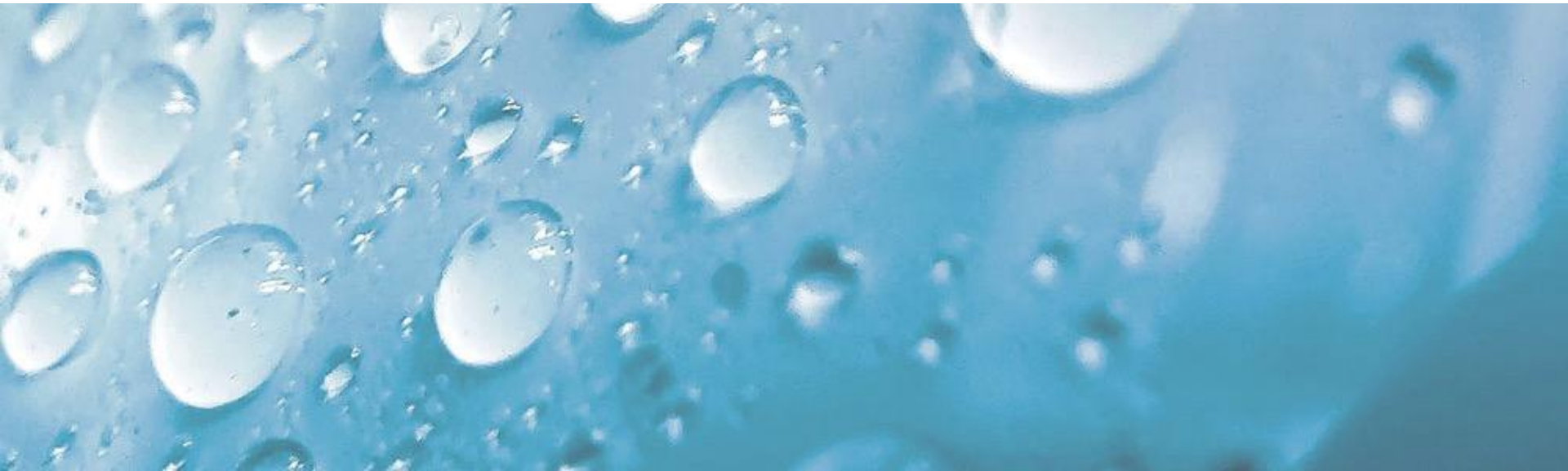
Conclusions from Analysis

- Bituminous coal-based re-agglomerated GAC significantly outperforms coconut based GAC
- Lab analysis supports bituminous coal-based re-agglomerated GAC is the best product for PFC removal





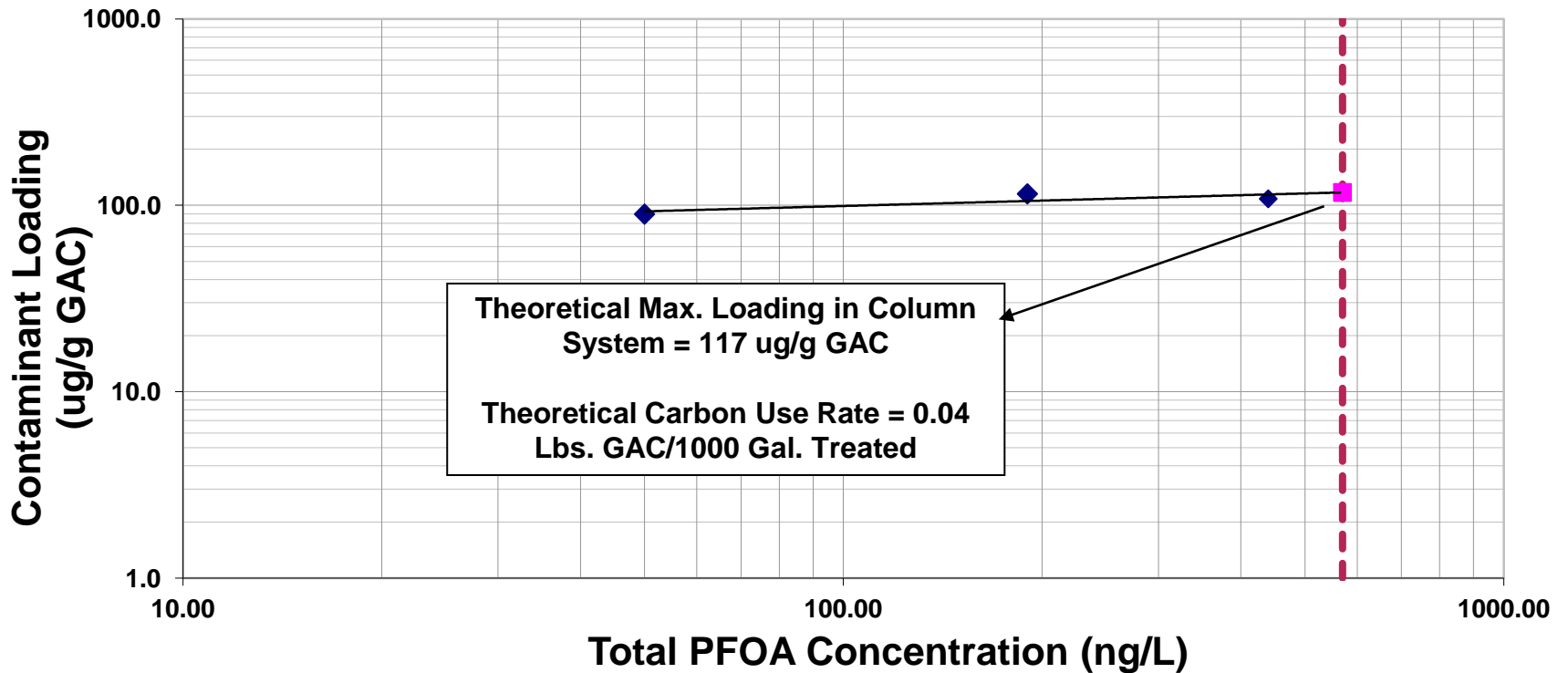
Case Study



PFC Isotherm- NY Water Source

PFC Removal FILTRASORB® Isotherm Plot

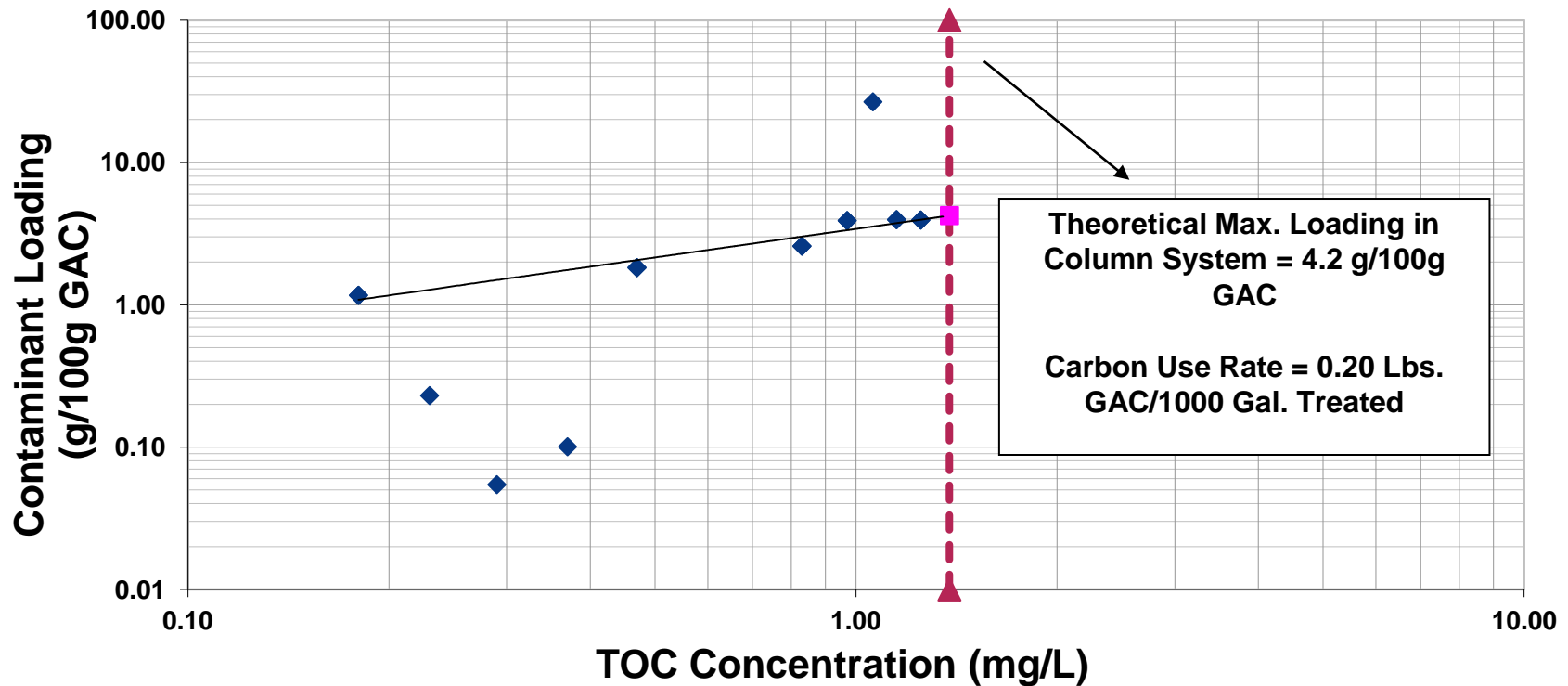
PFOA at 550 ppt



TOC Isotherm- Same NY Water Source

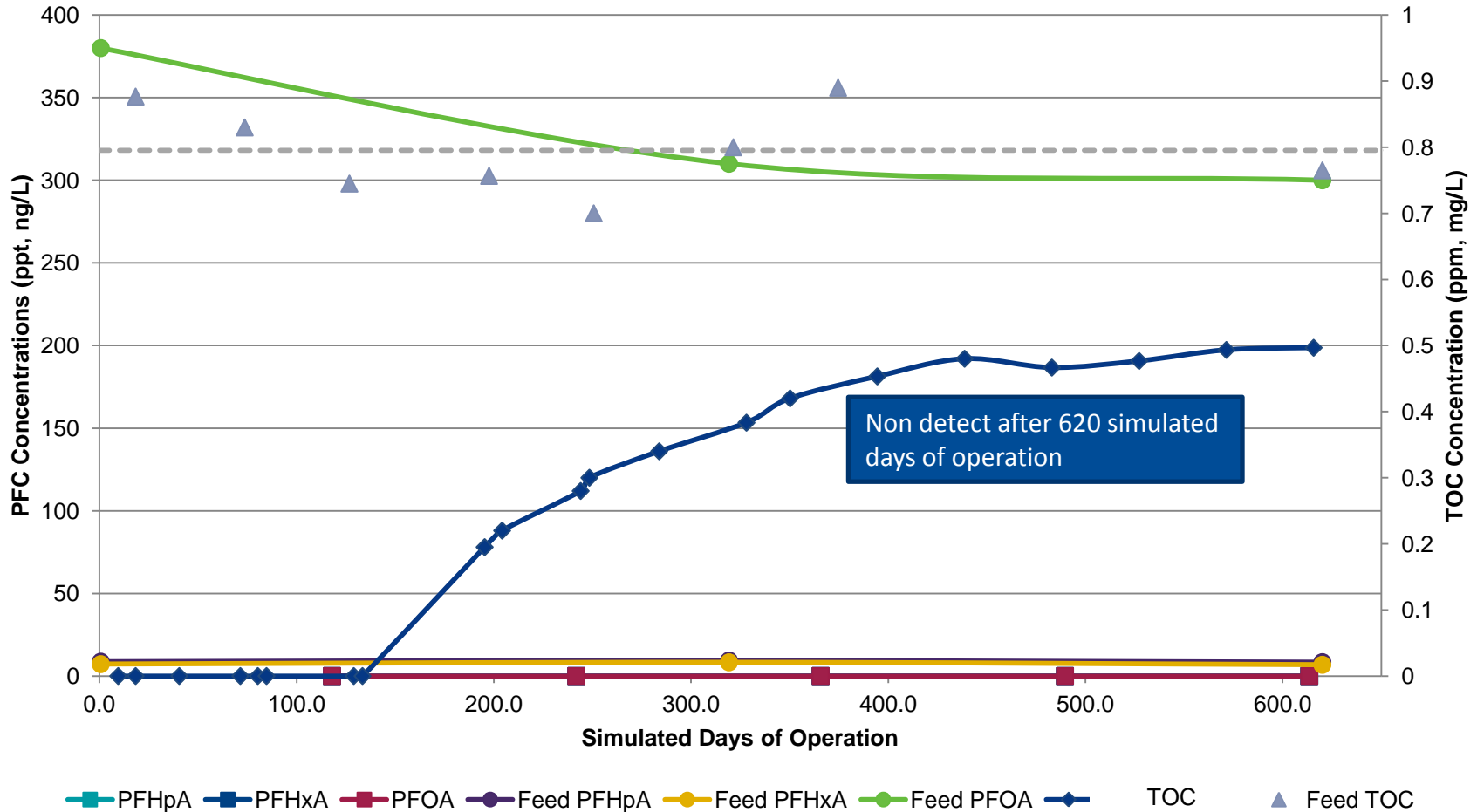
TOC Removal FILTRASORB® Isotherm Plot

TOC at 1.38 ppm



PFC/TOC Customer ACT Data

Simulated Days of Operation for PFCs and TOC

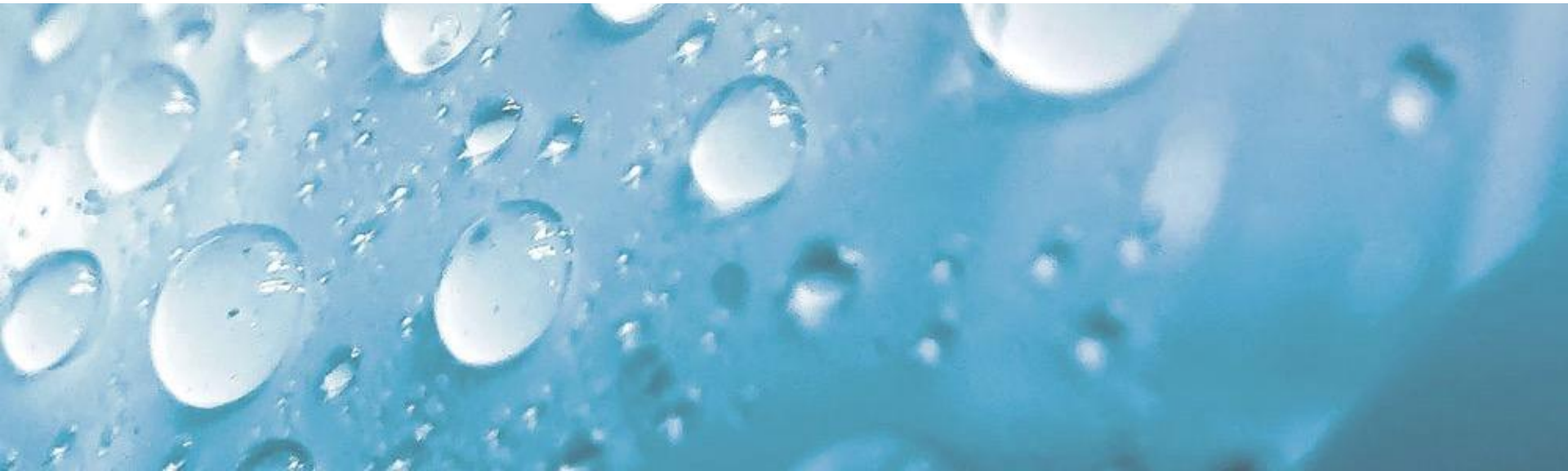


Conclusions from Case Study

- FILTRASORB® can remove PFCs to non-detectable levels
- TOC does not appear to compete strongly with PFC
- FILTRASORB® is effective for > 620 simulated days of operation
- Temporary System: 2 x 10' diameter vessels, 20,000 lbs GAC each
- Permanent System: 2 x 12' diameter vessels, 40,000 lbs GAC each



Equipment and Reactivation



Carbon Adsorption Equipment

Numerous “base” options - customized for customer’s requirements...

Model 8



Model 12



Model 14



Model 10



Model 12-40



Reactivation of GAC






- Carbon reactivation is a thermal treatment process in which adsorbed chemical constituents are removed from spent activated carbon
- The desorbed chemical constituents are thermally destroyed in the reactivation process
- Carbon is then reusable
- Frequency of reactivation is dependent on application



CCC has over 10 years of experience reactivating carbons with PFCs

PFC Removal: GAC vs. RO vs. IX

Treatment Option	Pros	Cons
<p>GAC</p> 	<ul style="list-style-type: none"> •Significantly lower capital costs •Significantly lower O&M costs •Reactivation saves cost, destroys PFCs, & removes liability •Established BAT for a long list of organic contaminants 	<ul style="list-style-type: none"> •High NOM can increase use rates
<p>RO</p> 	<ul style="list-style-type: none"> •Removes salts / inorganics that GAC cannot 	<ul style="list-style-type: none"> •Concentrated waste water disposal liabilities & costs •More energy / CO₂ intensive •High maintenance cleaning and replacement of fouled membranes •Removes healthy minerals
<p>Ion Exchange</p> 	<ul style="list-style-type: none"> •Resin can be regenerated •May be more economical for certain source waters (i.e. high levels of nitrate) 	<ul style="list-style-type: none"> •High cost of reagent •Regeneration produces disposal liabilities & costs

CCC Advantage

CCC has offered the preferred and total treatment solution for PFC removal for 15 years with the FILTRASORB® product line

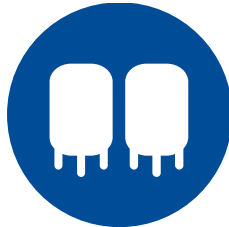
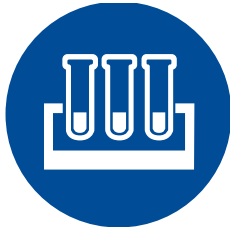
GAC is the leading technology for removal of PFCs

Calgon Carbon is ready to respond immediately with technical services, equipment and carbon supply

Spent carbon can be returned to CCC for reactivation thus thermally destroying the PFCs and eliminating future liability



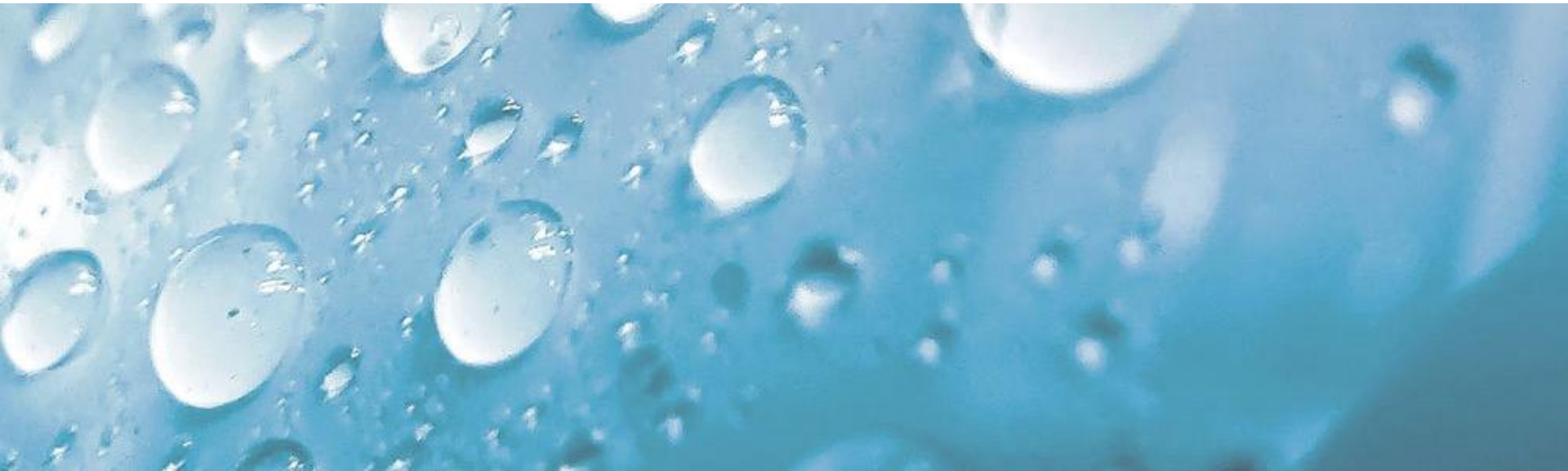
Calgon Carbon Solutions



- Provide a proven and cost-effective packaged solution
- Perform laboratory and field testing
- Ensure proper equipment design
- Rapid deployment of temporary treatment systems
- Experienced sales, field service and applications engineering teams
- Carbon reactivation services



Questions





Thank you.

www.calgoncarbon.com/PFOA

Send additional questions to: pfcsolutions@calgoncarbon.com

