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The Webinar Will Begin Shortly

While we wait... take a moment to connect with OCWD
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Beyond Removal: Destroying PFAS in Reverse Osmosis Concentrate



Tuesday, September 1, 2026

Before We Get Started

Attendees are muted to reduce background noise

Webinar is being recorded and will be published on OCWD's YouTube Channel

Use the Q&A box to submit questions on today's topic

Email info@ocwd.com for any follow-up questions

Meet Our Speakers



Dr. Manmeet (Meeta) Pannu
Senior Scientist
Orange County Water District



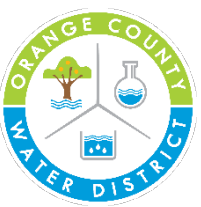
Zia Klocke, P.E.
Product Manager
E2METRIX



Beyond Removal: Destroying PFAS in Reverse Osmosis Concentrate

OCWD Webinar
9/1/2026





Thank you!

Acknowledgement To Partners



E2METRIX™
AN OVIVO COMPANY

KJ | Kennedy Jenks

 — BUREAU OF —
RECLAMATION

OC SAN
ORANGE COUNTY SANITATION DISTRICT

■ Project Team:

- OCWD: Han Gu, Megan H. Plumlee
- E2METRIX: Katie Henderson, Jaclyn Scratton, Jacob Hereford, Ihsen Ben Salah, Farah Ben Salah, Ivan Garcia
- Kennedy Jenks: Charlie Liu

■ Funding Agency

US Bureau of Reclamation (USBR), Grant # R24AC00104-00

■ OC Sanitation District

- Vanh Phonsiri, Joseph Manzella, OC San Lab staff
- OCWD Staff: Don Supernaw, Andrew Huang, OCWD Operations staff
- R&D Interns: Leonardo (Leo) Mazuco Jaroszewski, Roberto Ruiz, Jinka Kawasaki, Quincy Loyola, Kristeen Truong, Molitia Eleasaro, Sophia Moser-Smith, Jocelyne Guzman

Agenda

Introduction

- OCWD
- PFAS

Prior PFAS Work on Groundwater

GWRS

PFAS in ROC

On-site Mini-Pilot

- Adsorption Study
- Bench-Scale EO Destruction

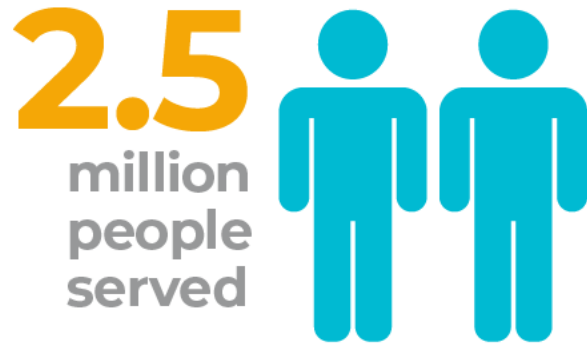
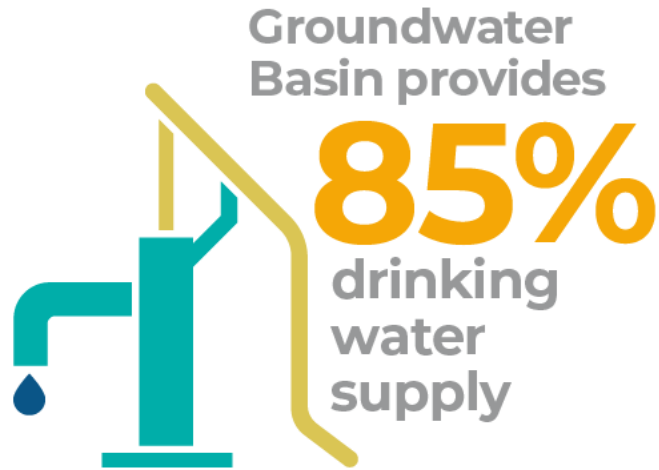
On-site Large-Scale Pilot

- Adsorption Study
- EO Destruction

Lessons Learned and Next Steps



OCWD AT-A-GLANCE



We are a groundwater management agency, providing wholesale groundwater to local drinking water retailers.

A close-up photograph showing a black frying pan and a teal-colored jacket. Both the pan's surface and the jacket's fabric are covered with numerous water droplets of varying sizes, demonstrating the waterproof properties of the materials. The pan is in the foreground, and the jacket is partially visible behind it.

A large fire truck is spraying a powerful jet of water onto the tail section of a white commercial airplane. The water is creating a large splash and mist. The scene is set on an airport tarmac under a clear blue sky with some clouds. The tail of the plane is visible, and the water is being directed at it from the right side of the frame.

OC(=O)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)C(F)(F)

A close-up shot of a clear glass being filled with water from a silver pitcher. The water is splashing and bubbling inside the glass. In the background, a large industrial water treatment facility with circular tanks and buildings is visible under a clear sky.

9

PFAS drinking-water standards

Maximum contaminant levels (MCLs) listed in EPA's 2024 final National Primary Drinking Water Regulation

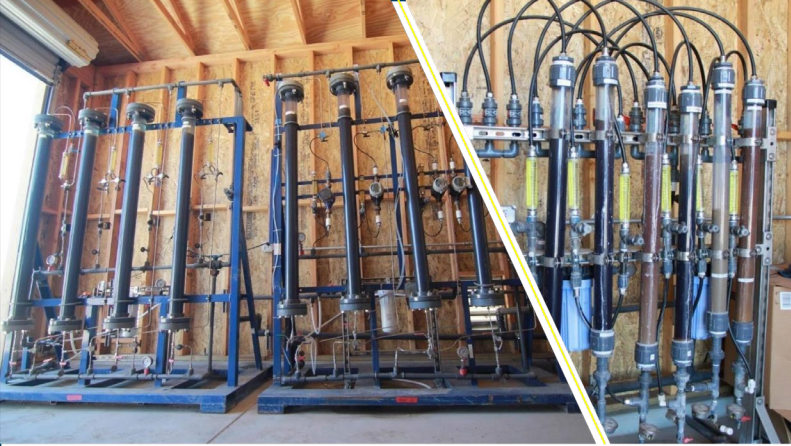
PFAS / regulated mixture	MCL (enforceable) ppt
PFOA	4.0
PFOS	4.0
PFHxS	10
PFNA	10
HFPO-DA (GenX Chemicals)	10
Mixture of ≥2: PFHxS, PFNA, HFPO-DA and PFBS	Hazard Index = 1

Regulatory status (May 2026): EPA proposed retaining the PFOA and PFOS standards and rescinding the PFHxS, PFNA, HFPO-DA and Hazard Index provisions. The proposal is not yet final.

California Division of Drinking Water advisory levels | ppt (ng/L)

PFAS	Notification Level (NL) ppt	Response Level (RL) ppt
PFOA	4.0	10
PFOS	4.0	40
PFHxS	3.0	10
PFHxA	1,000	10,000
PFBS	500	5,000

NLs are health-based advisory levels. RLs identify concentrations at which DDW recommends source removal or other required response actions. Values current as of December 2025.



PRIOR WORK

PFAS Groundwater Study

Adsorption was a good treatment option for PFAS removal at well-head

PILOT-Phase I and II (GAC, IX and AA)

Received: 18 April 2022 | Revised: 22 August 2022 | Accepted: 23 August 2022
DOI: 10.1002/aws2.1308

ORIGINAL RESEARCH



Pilot-scale comparison of granular activated carbons, ion exchange, and alternative adsorbents for per- and polyfluoroalkyl substances removal

Ricardo Medina¹ | Manmeet W. Pannu¹ | Scott A. Grieco² |
Michael Hwang³ | Christine Pham¹ | Megan H. Plumlee¹

Received: 20 December 2023 | Revised: 20 March 2024 | Accepted: 12 April 2024
DOI: 10.1002/wer.11035

SHORT COMMUNICATION



Variable PFAS removal by adsorbent media with sufficient prediction of breakthrough despite reduced contact time at pilot scale

Manmeet W. Pannu¹ | Andrew Huang² | Megan H. Plumlee²

BENCH TESTING

Received: 9 January 2023 | Revised: 12 April 2023 | Accepted: 12 May 2023
DOI: 10.1002/aws2.1345

EMERGING CONTAMINANT ARTICLE



Comparing PFAS removal across multiple groundwaters for eight GACs and alternative adsorbent

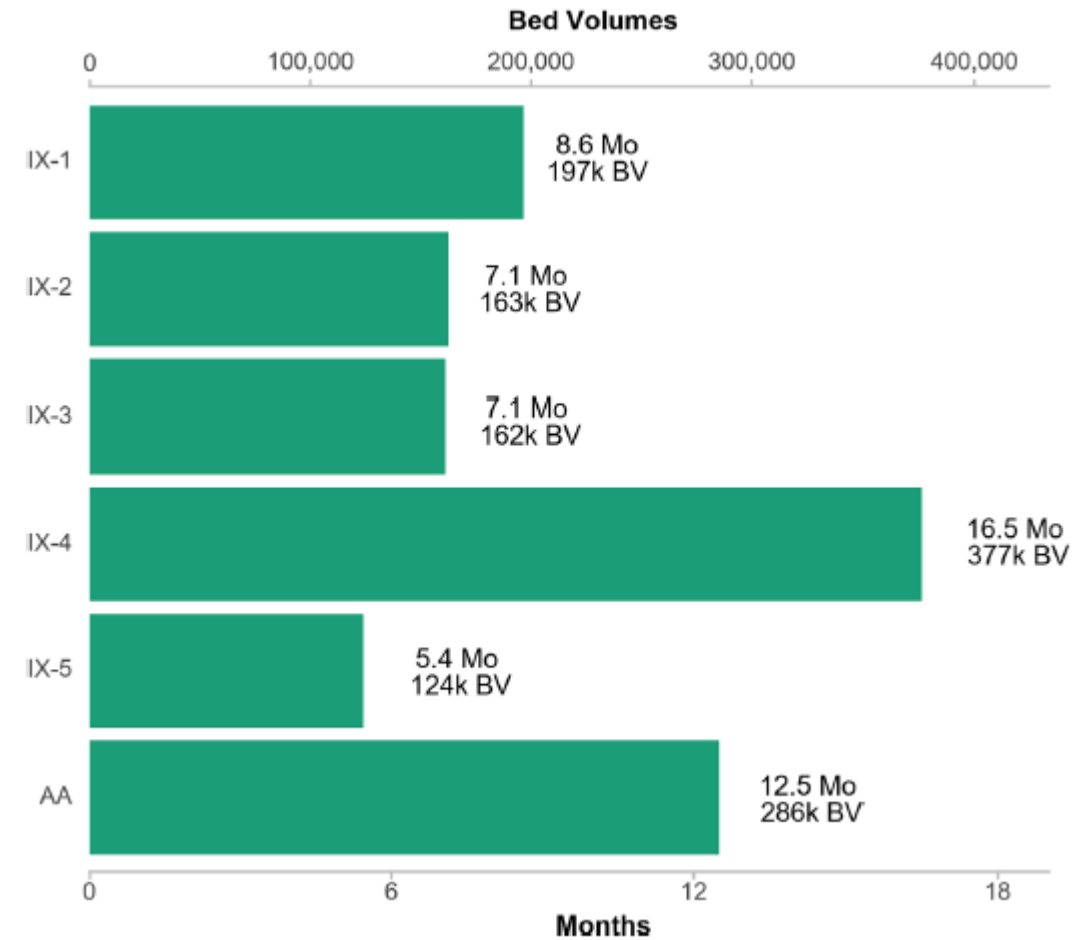
Manmeet W. Pannu¹ | Joseph Chang² | Ricardo Medina¹ |
Scott Grieco³ | Michael Hwang⁴ | Megan H. Plumlee¹



PRIOR WORK

PFAS Groundwater Study

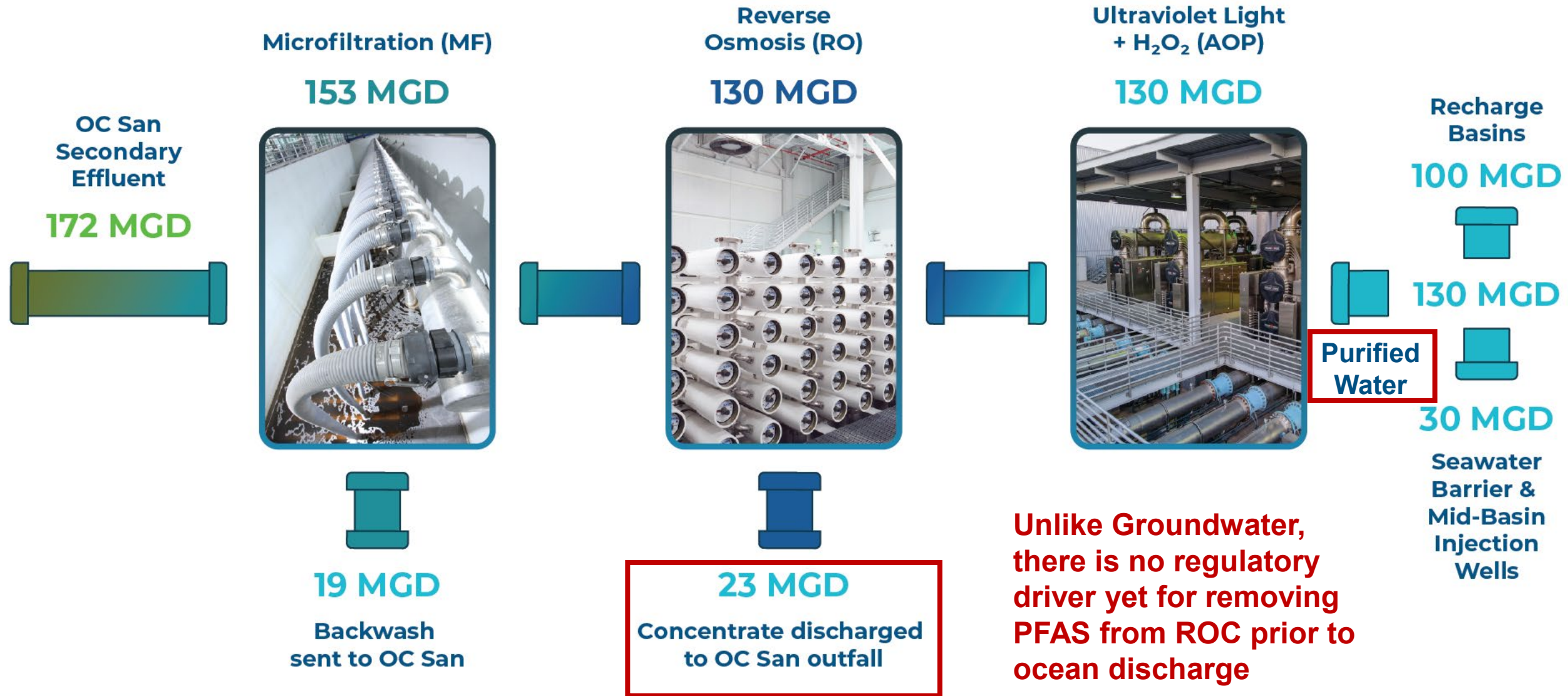
Adsorbents were ranked for PFAS removal in Groundwater in pilot study (left) and bench study (right)



RANK	GROUNDWATER WELL A		GROUNDWATER WELL B	GROUNDWATER WELL C
1	Cetco FS-200	=	Evoqua PSR2+	Evoqua PSR2+
2	Calgon CalRes 2301		Purolite PFA694E	Purolite PFA694E
3	—		Jacobi PFCR-2	—
4	—		ResinTech SIR-110-HP	—

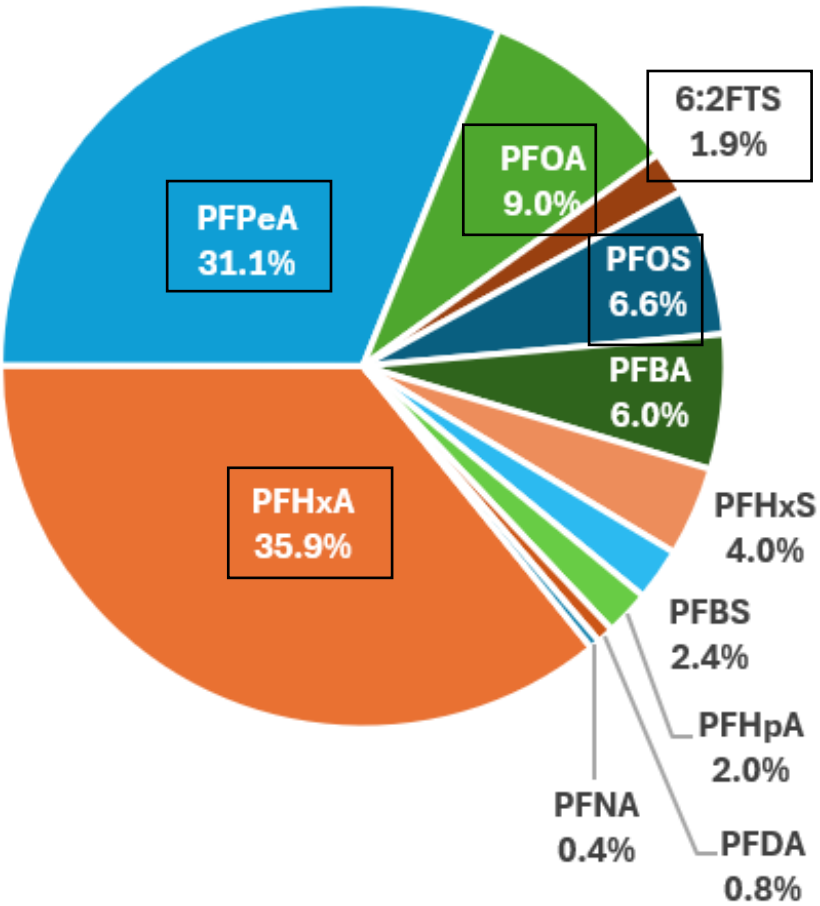
This work has been published in the final report of WRF project 5153

No PFAS Concerns for our Purified Recycled Water



Measured PFAS Concentrations in ROC

- PFHxA
- PFPeA
- PFOA
- 6:2FTS
- PFOS
- PFBA
- PFHxS
- PFBS
- PFHpA
- PFDA
- PFNA



PFAS class	Analyte	Mean ± SD (ng/L)
PFCAs	PFHxA	314 ± 321.5
	PFPeA	272 ± 276.6
	PFOA	78.8 ± 37.4
	PFBA	52.7 ± 11.8
	PFHpA	17.7 ± 5.0
	PFDA	6.6 ± 1.8
	PFNA	3.9 ± 1.3
	6:2 FTS	16.9 ± 7.5
Sulfonates / 6:2 FTS	PFOS	57.6 ± 27.8
	PFHxS	35.0 ± 7.7
	PFBS	20.6 ± 3.4
	PFNA	3.9 ± 1.3



R&D Intern Leo on a sampling day

ROC Water Quality Summary

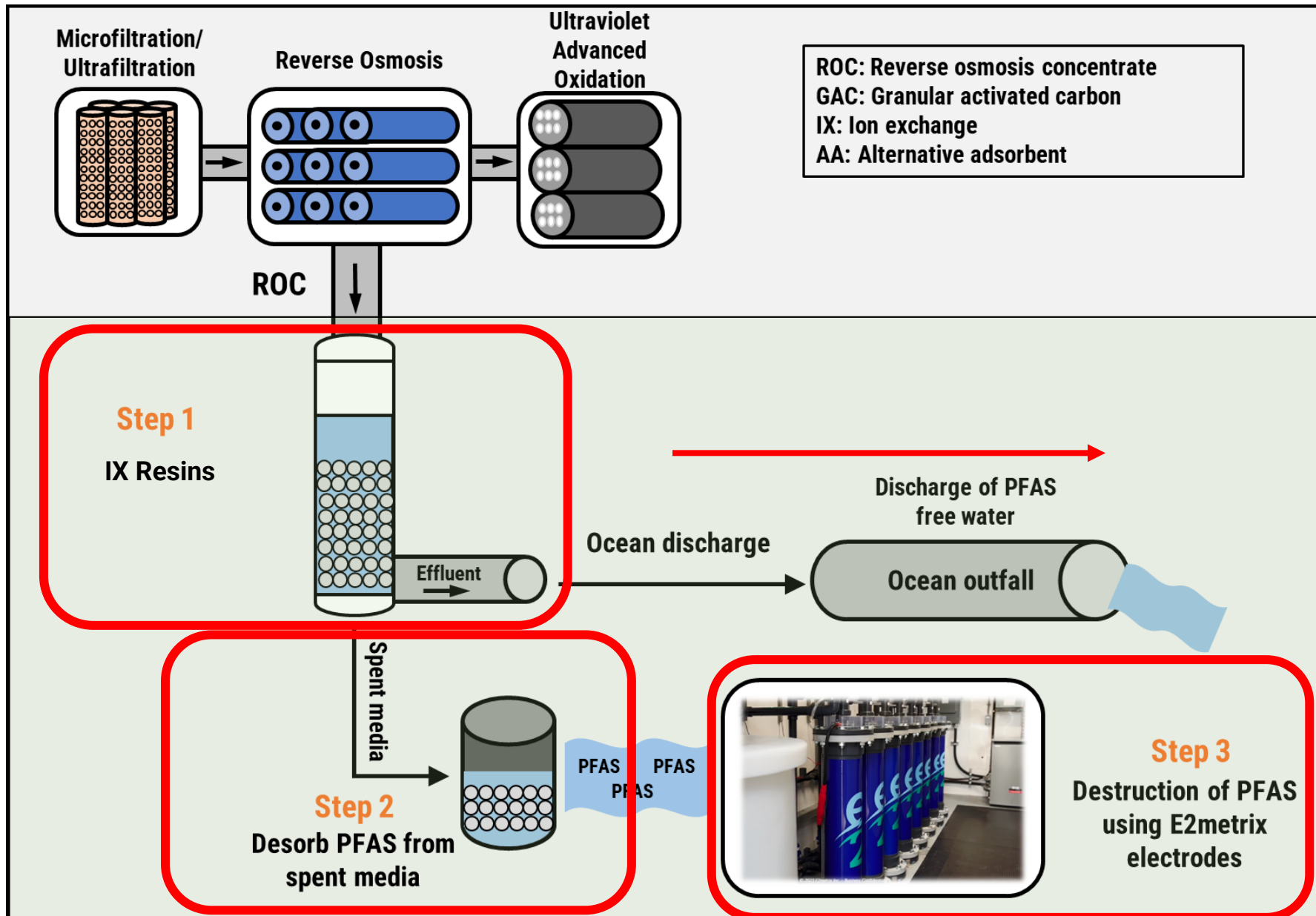
Water-quality parameter	Average ± SD
TOC (mg/L)	24.3 ± 0.08
TDS (mg/L)	6,120 ± 102
Iron (µg/L)	404 ± 76
Sulfate (mg/L)	1,213 ± 70
Nitrite nitrogen (mg/L)	0.3 ± 0.26
Manganese (µg/L)	182 ± 24
Zinc (µg/L)	86.3 ± 10
Orthophosphate (mg/L)	4.93 ± 1.5
Chloride (mg/L)	1,413 ± 94

- High TOC
 - compete w/PFAS for adsorption sites
- High TDS; High salt
- High concentrations of anions like sulfate, chloride
 - anions compete for adsorption sites on resins
- High Manganese
 - fouling concern

Evaluate the feasibility of removing PFAS from ROC
via adsorption and subsequent PFAS destruction

ACCUMULATE and DESTROY

Novel Approach for ROC Treatment of PFAS



Initial Testing and Testing Phases

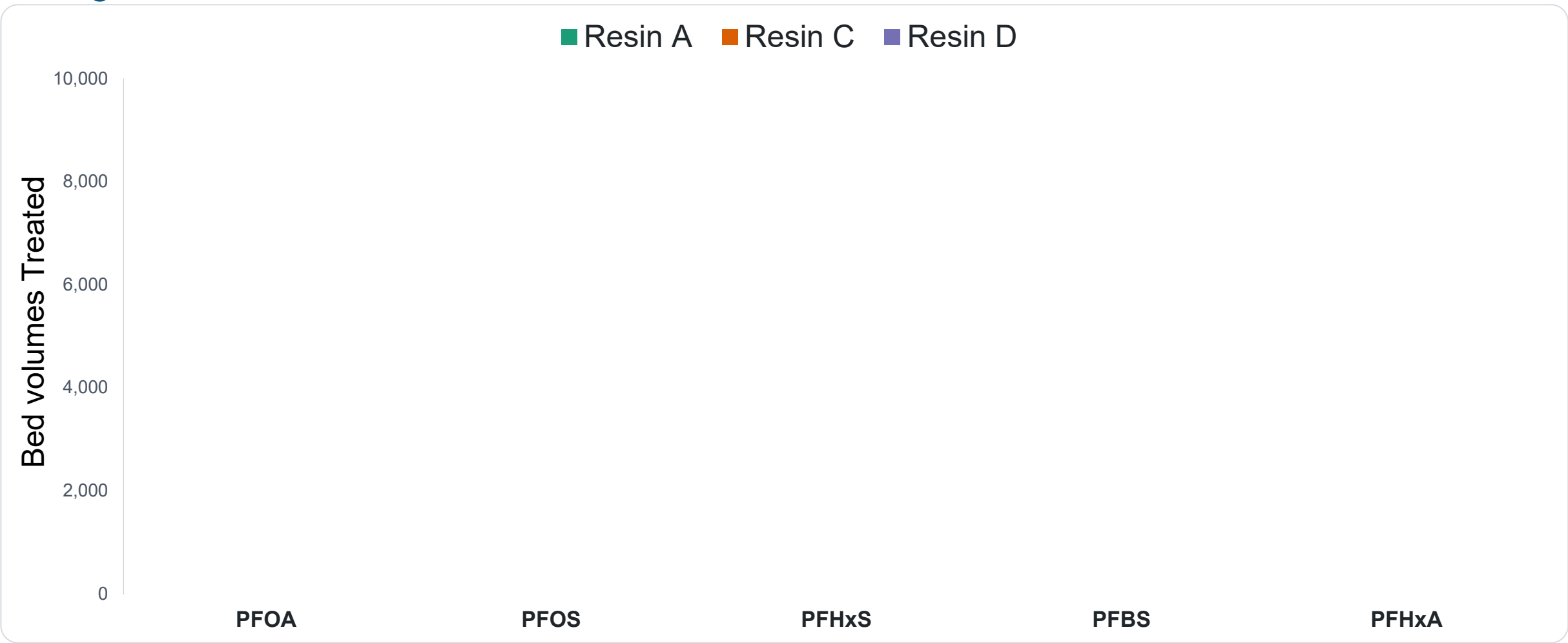
- **Phase 1:** Preliminary with mini-pilot
 - Phase 1.1: Baseline testing of **6 IX** supplied by Ovivo; 2 min EBCT
 - Phase 1.2: Impact of EBCT on treatment; 4 and 8 min EBCT
 - Phase 1.3: Regeneration testing + destruction (lab-scale)
- **Phase 2:** Testing at Large-Scale Test Units in Trailers (Zia will present)



EBCT: Empty Bed Contact Time: Related to the time the water is in contact with a media. Total Volume/Flow Rate

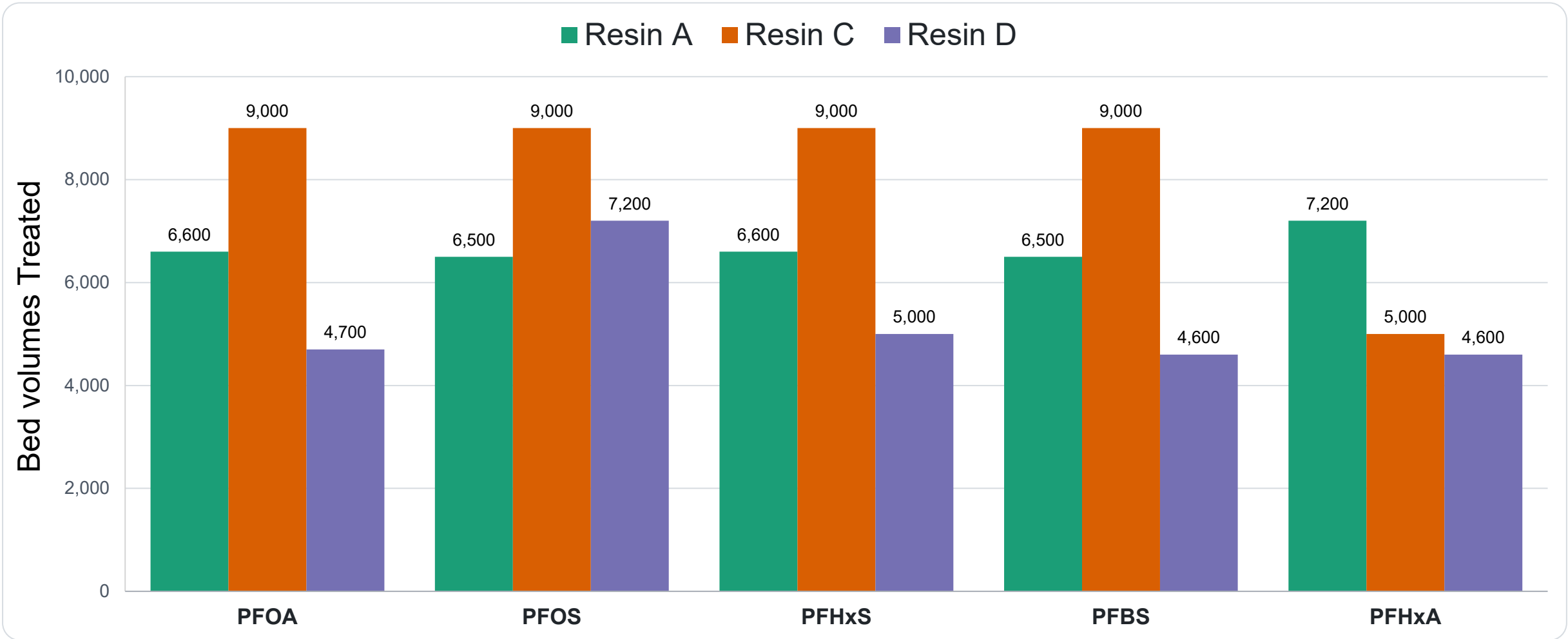
Phase 1.1 Data: Bed volumes to 100% Exhaustion

Bed volumes treated are calculated by dividing the volume of water treated by the volume of media in the vessel. A greater number of bed volumes treated before exhaustion indicates longer-lasting media.



Phase 1.1 Data: Bed volumes to 100% Exhaustion

Bed volumes treated (Resin performance) was Resin C > Resin A > Resin D



Phase 1.2 Data: Testing a larger EBCT

Bed volumes passed to C/Co of 50%

Longer EBCT delayed the breakthrough of different PFAS

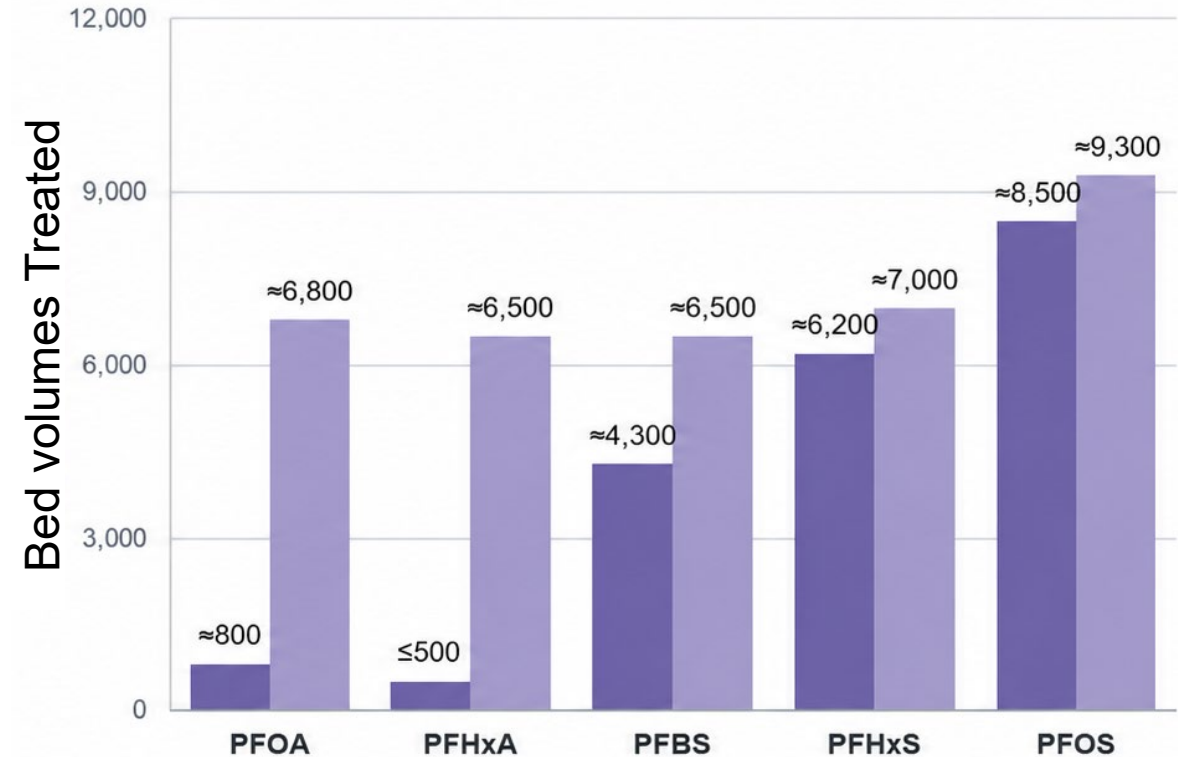
Resin A

■ 4 min EBCT ■ 8 min EBCT

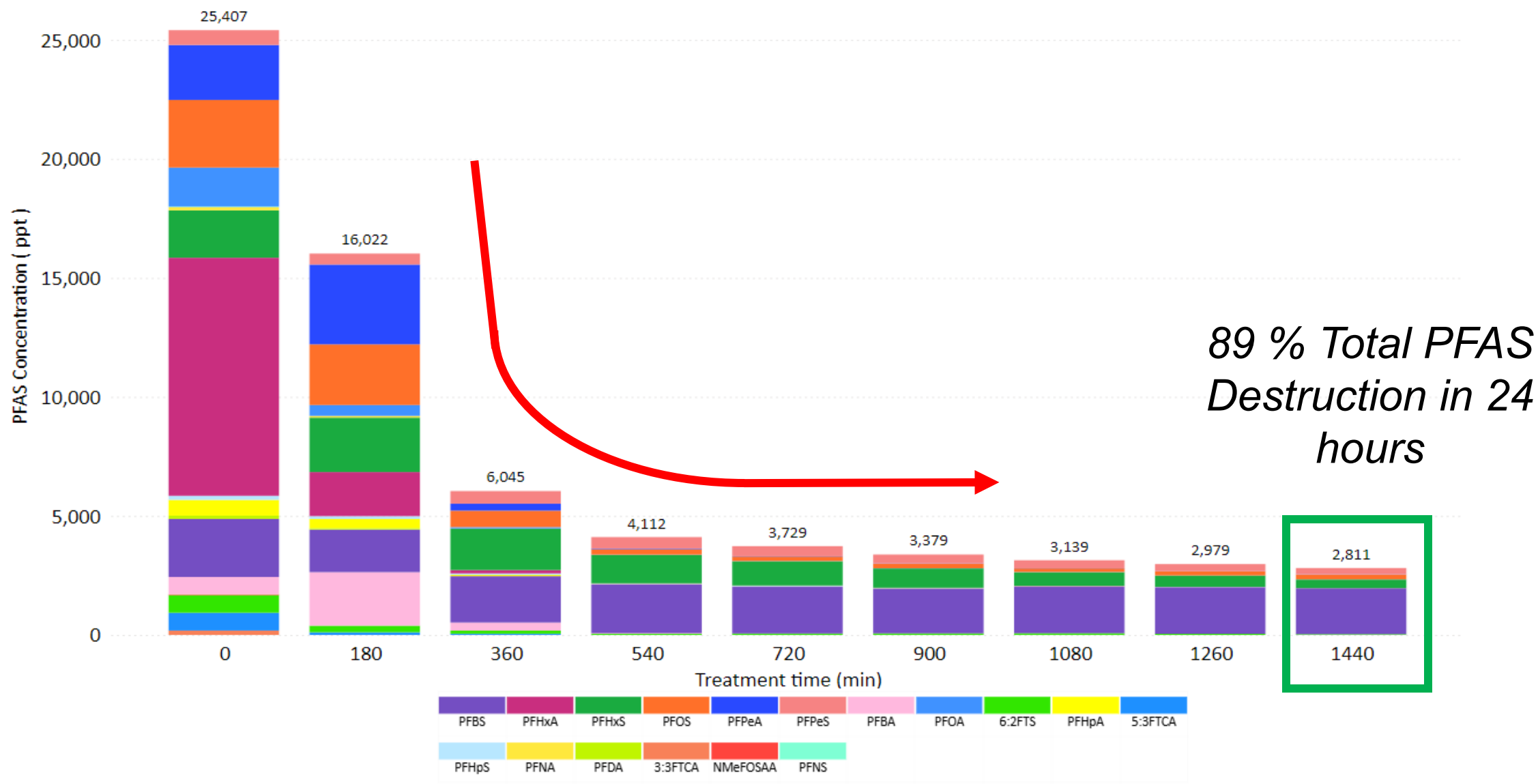


Resin D

■ 4 min EBCT ■ 8 min EBCT



Phase 1.3: Bench-Scale Destruction by Electro-Oxidation



Large-Scale Concept and Results

E2METRIX Units





Farah Ben
Salah

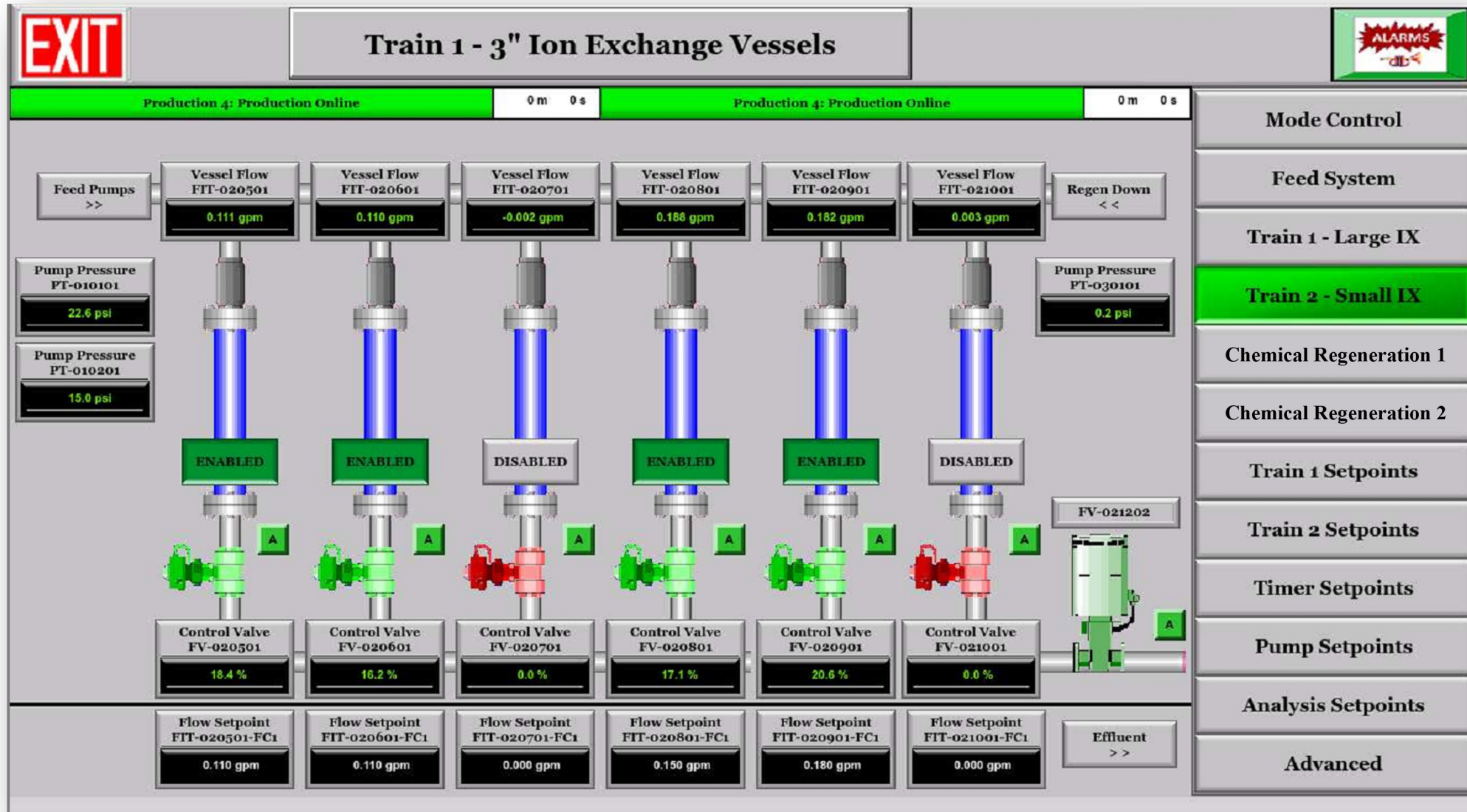
Ivan Garcia

Jacob
Hereford

Ion Exchange Pilot Unit

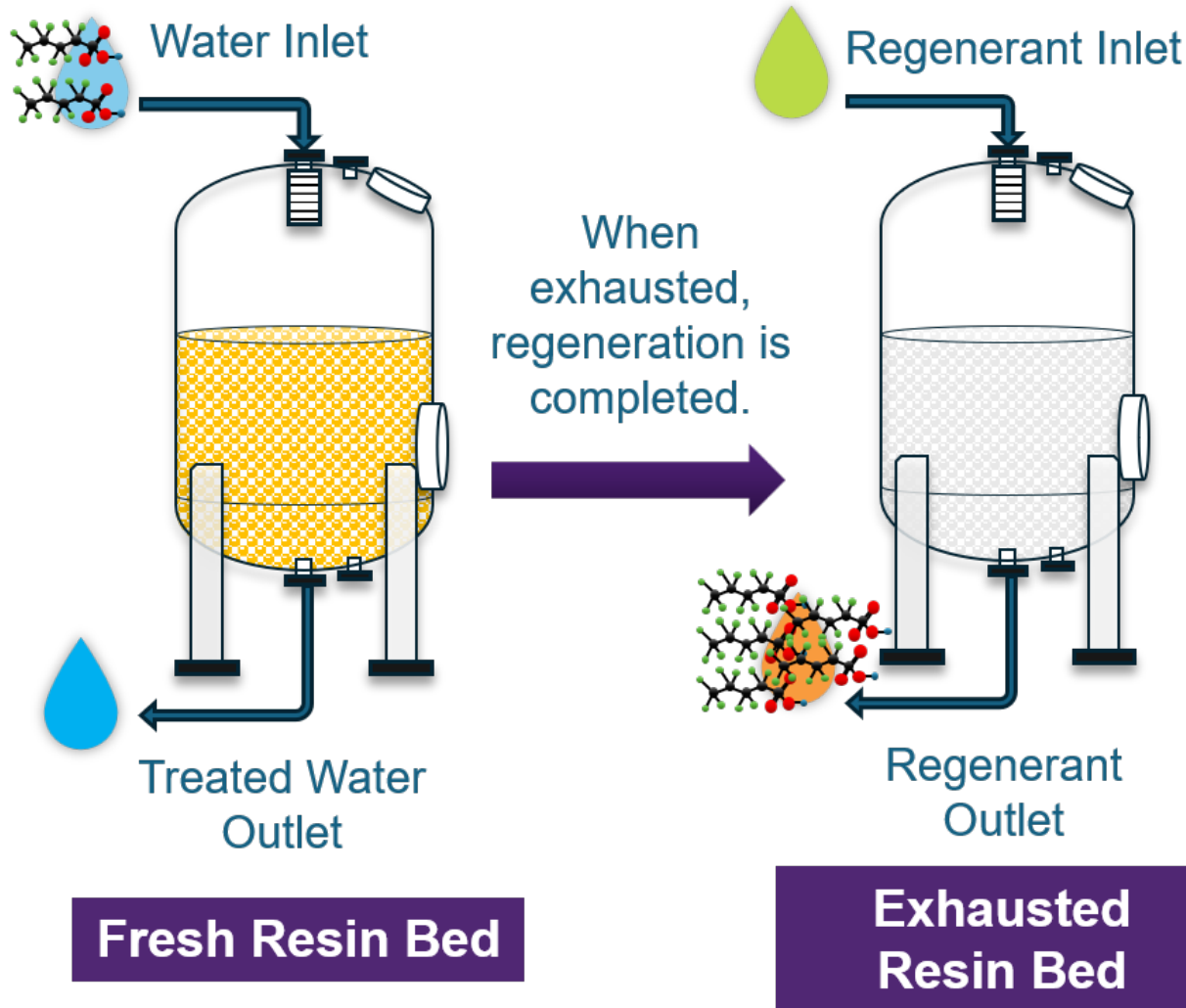


Ion Exchange Pilot Unit



Adsorption – Desorption

Regenerable Ion Exchange Resin



- Over continued operation, IX resin becomes saturated with exchanged ions i.e., PFAS compounds & TOC, leading to exhaustion and reduced removal efficiency.
- Traditionally, exhausted resins have been disposed by incineration/landfill, and new media is purchased and loaded.
- Regeneration presents a sustainable alternative to incineration. By pairing with a destruction technology and treating the chemical waste.
- The pilot was to assess regeneration using non-alcohol solvents with less PFAS selective resins.
- The chemical waste contains high concentrations of PFAS which are destroyed with E2METRIX's Obreak® Electro-Oxidation.

Resins Tested at Large Scale Pilot

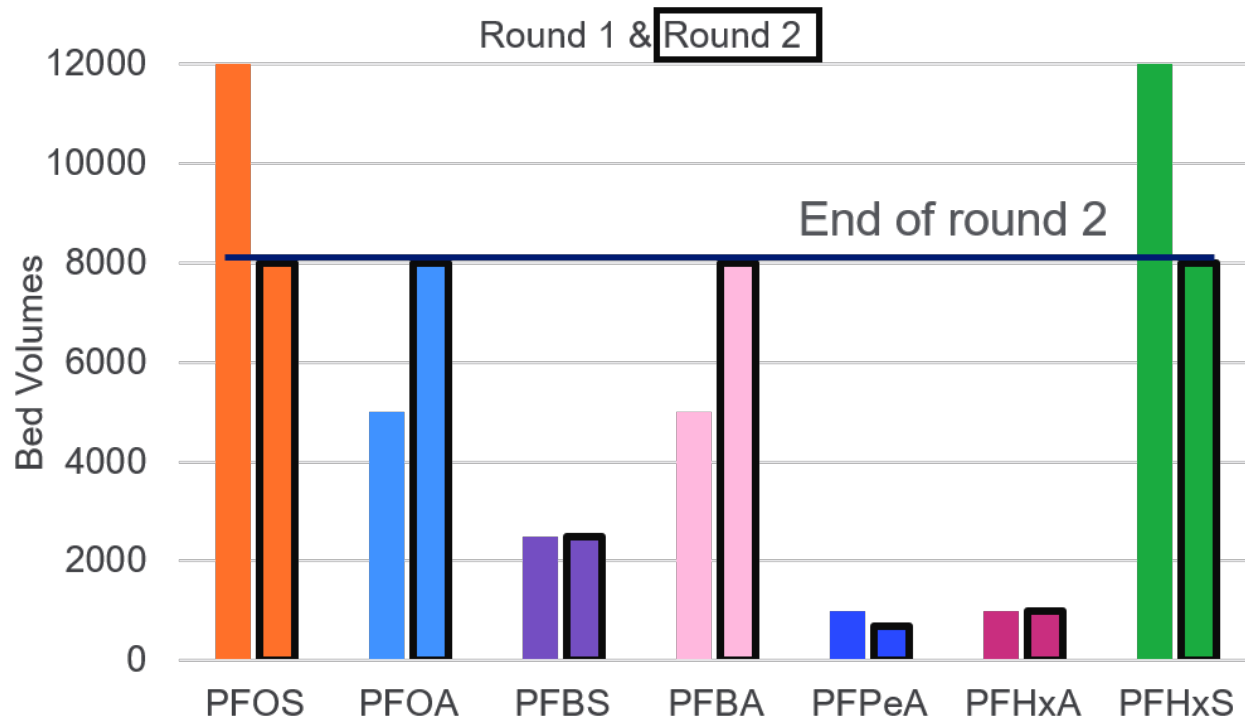
Column #	Column Di. (in.)	Resin	Pore Type	Configuration	EBCT (min)
1	3"	Resin G	Gel	Lag	5
2	3"	Resin D	MP	Lead	5
3	3"	Resin C	MP	Lead	5
4	3"	Resin A	MP	Lag	5
5	3"	Resin C	MP	Single-Pass	10
6	3"	Resin A	Gel	Single-Pass	10
7	8"	Resin C	MP	Single-Pass	5
8	8"	Resin C	MP	Single-Pass	5
9	8"	Resin D	MP	Single-Pass	5
10	8"	Resin D	MP	Single-Pass	5

Resin
Screening

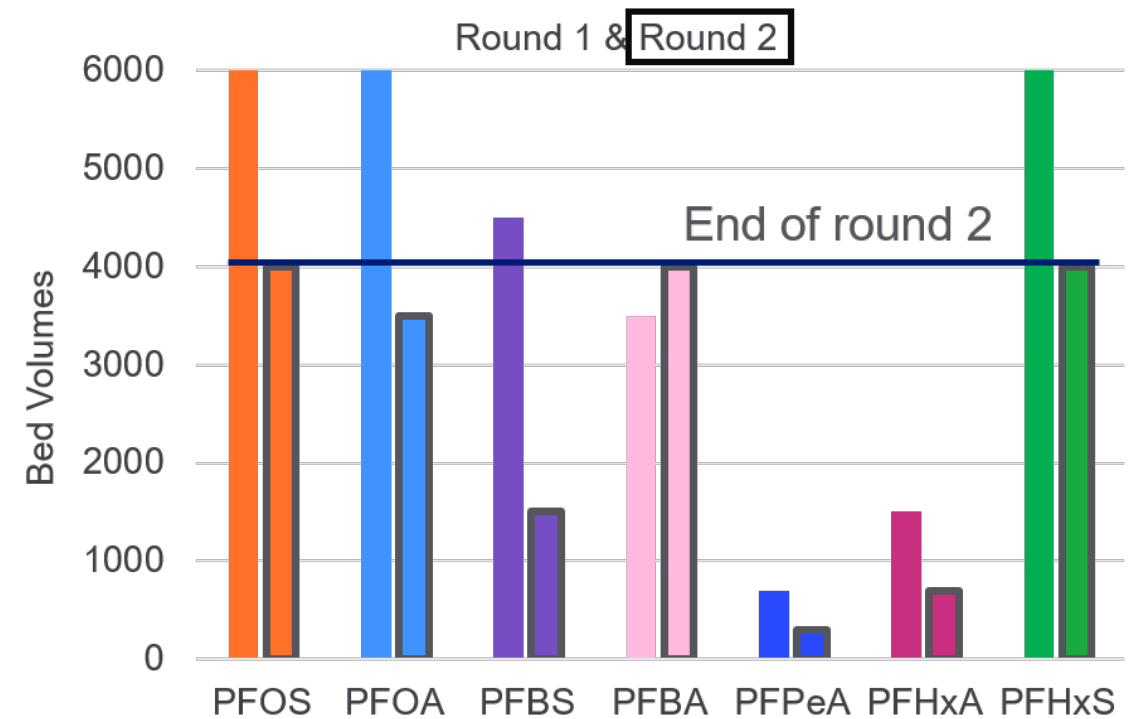
Regenerant
Solution

Bed Volumes to 50% PFAS Breakthrough

Resin C 5 min EBCT - C/Co = BV at 50%



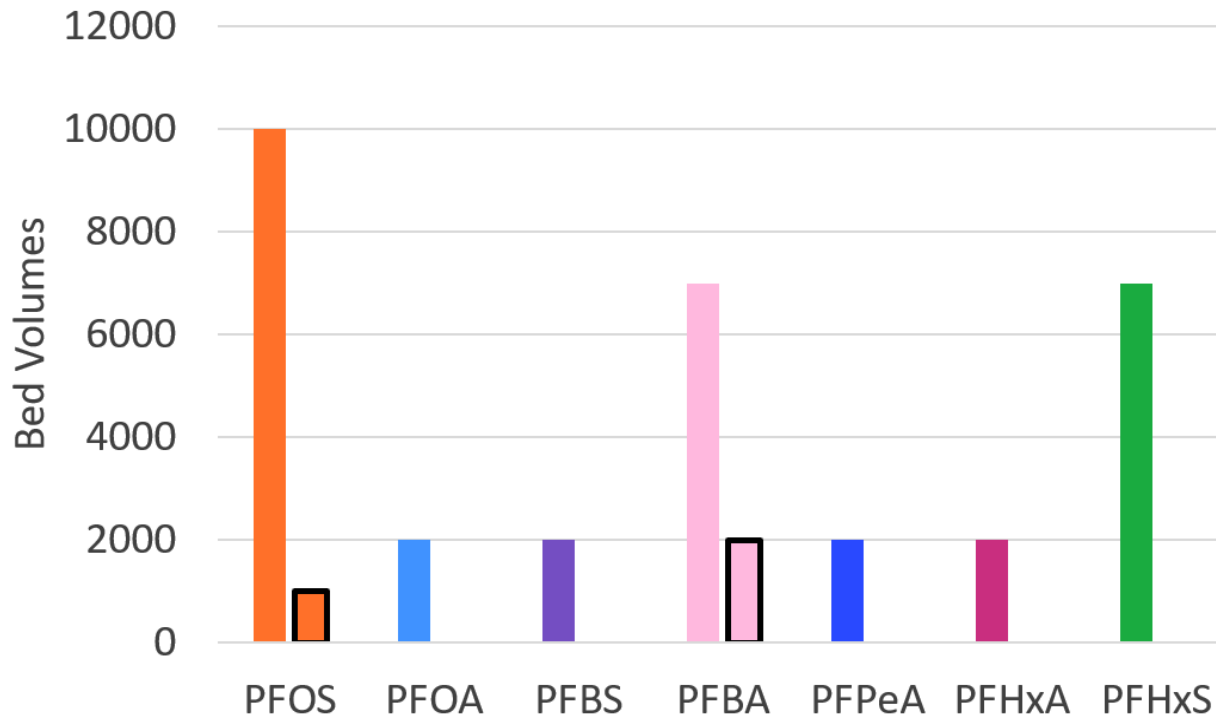
Resin C 10 min EBCT - C/Co = BV at 50%



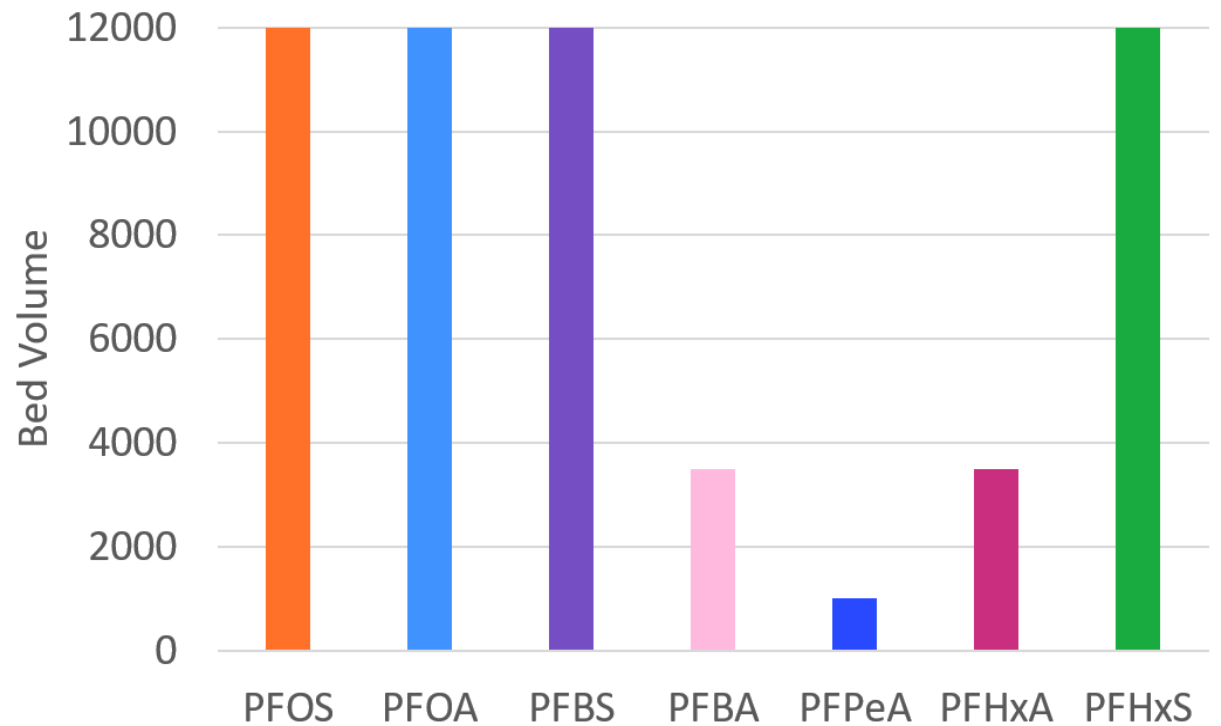
- Regeneration was performed between Round 1 and Round 2

Bed Volumes to 50% PFAS Breakthrough

Resin D 5 min EBCT - C/Co = BV at 50%



Resin A 10 min EBCT - C/Co = BV at 50%



**Single-Use
No regeneration**

Post GAC (Inlet to Columns) PFAS Concentrations

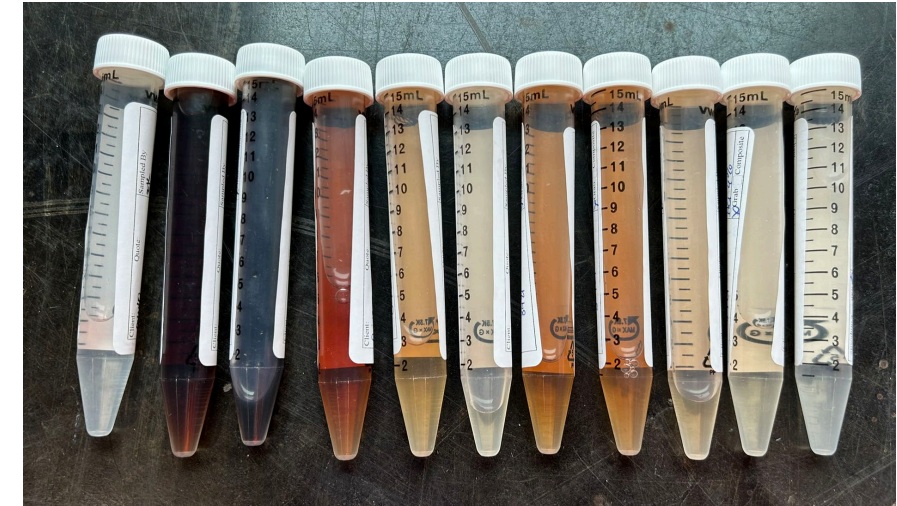
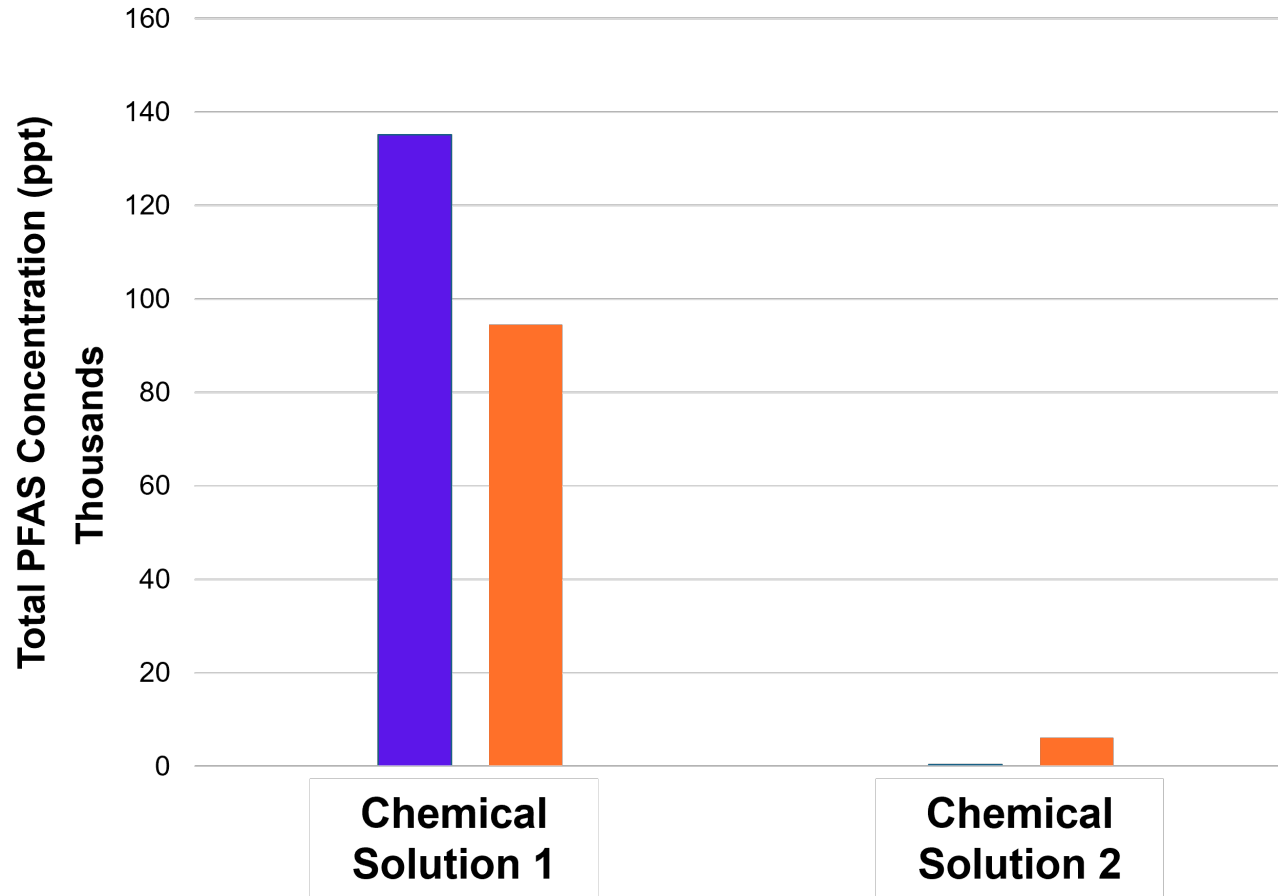


- EBCT = ~10 min
- GAC was installed for TOC reduction. This was exhausted very quickly (within 2 weeks).
- GAC was not replaced once exhausted as this would increase downtime and OPEX.

Parameter	Unit	Value
Total Dissolved Solids	mg/L	8600
Total Hardness	mg/L	170
TOC Pre GAC	mg/L	45-50
TOC Post GAC	mg/L	15-20

Ion Exchange Desorption

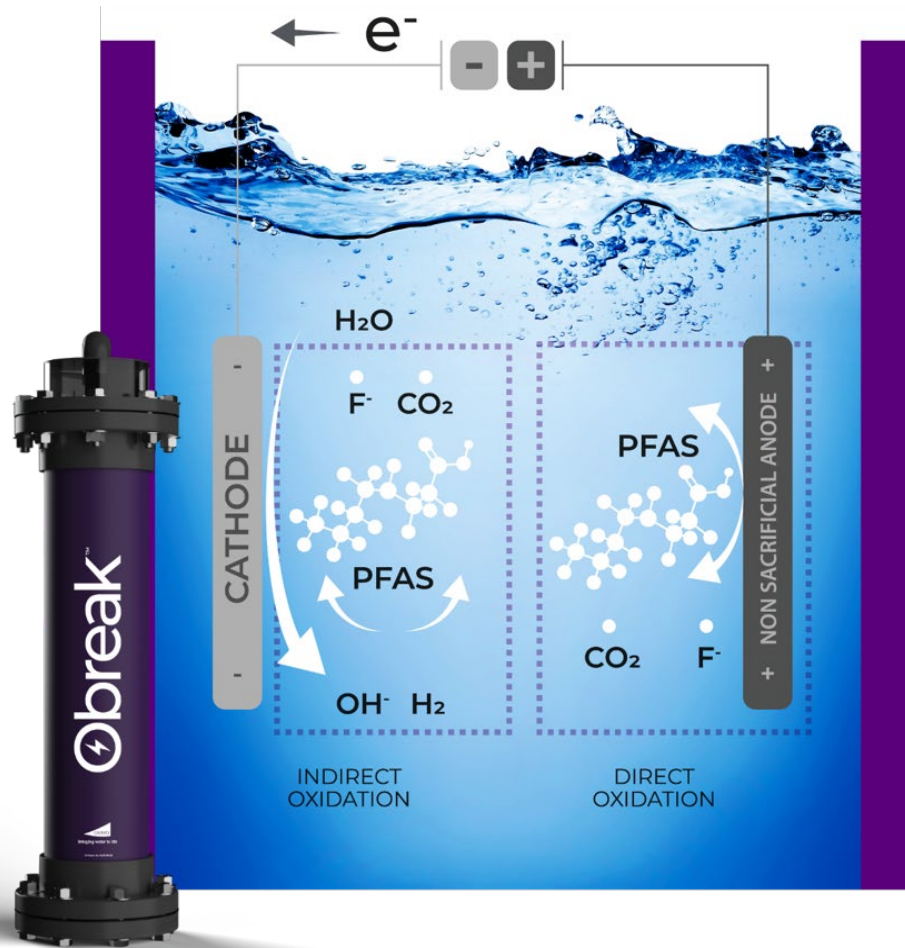
Resin C Regeneration Round 1 vs. Round 2



- Regen 1 - 28% of Total desorbed were long-chain PFAS
- Regen 2 – 52% of Total desorbed were long-chain PFAS
- 35% reduction in desorption between regeneration 1 and 2
- Consider additional steps to help improve long-chain PFAS desorption

Destruction Testing

How Electro-Oxidation Destroys PFAS



Electro-Oxidation

- Pass an electrical current through the electrodes (anode and cathode)
 - Non-sacrificial electrodes
- **Direct oxidation** happens at **surface of anode** that cleaves the C-F bond



- Indirect oxidation through other electro-chemically created oxidants also react with and break down PFAS in bulk liquid
- Operates at ambient temperatures and low pressures



Two Approaches to PFAS Destruction

LOW INTENSITY

minutes-to-hours

Electrochemical Oxidation

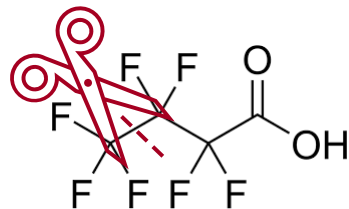
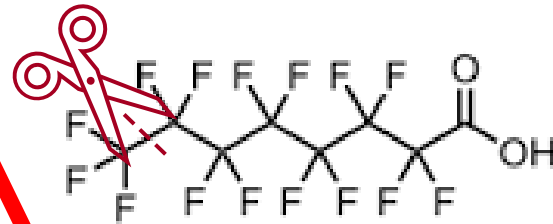
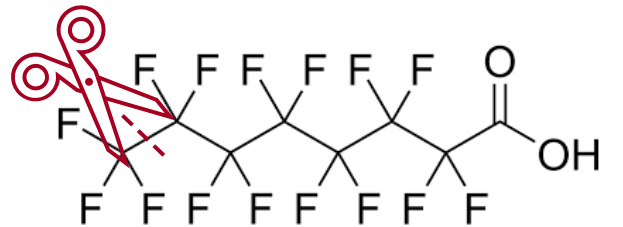
UV Reduction

Sonolysis

Plasma

Pyrolysis / gasification

ARP*



CO₂ and F⁻

STEPWISE

HIGH INTENSITY

seconds-minutes

SCWO

HALT

Incineration



ONE STEP

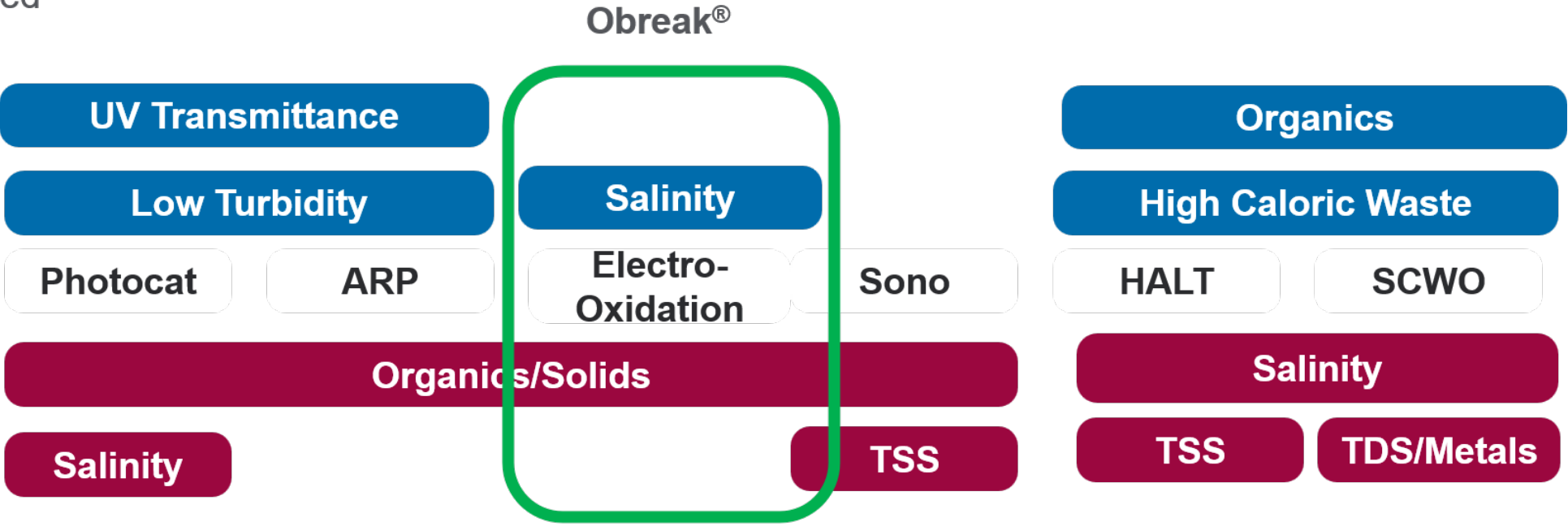
CO₂ and F⁻

Destruction Treatment Technologies

More Preferred



Less Preferred



Source: Survey by CDM Smith, 2024* Modified by OVIVO

Integrated Solution for Onsite Destruction

CONCENTRATE

Reverse Osmosis
Olift® Foam Fractionation
Regenerable Ion Exchange



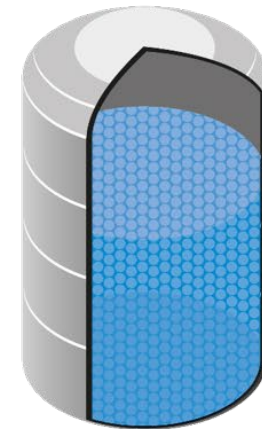
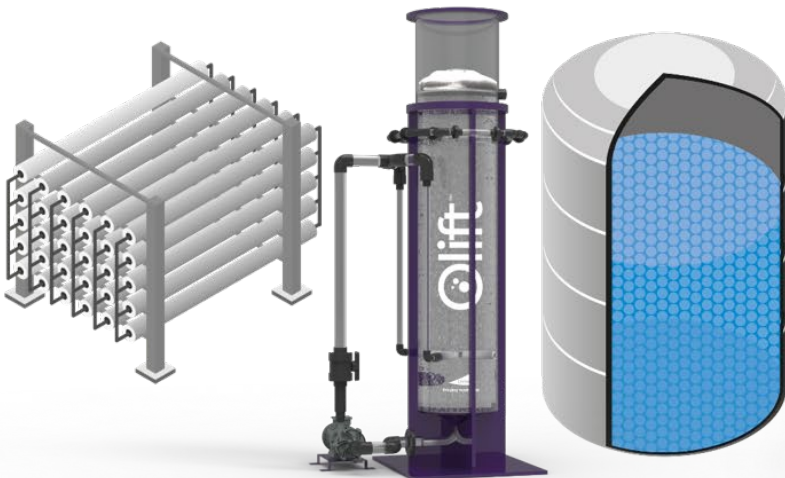
DESTROY

Obreak® Electro-Oxidation



POLISH

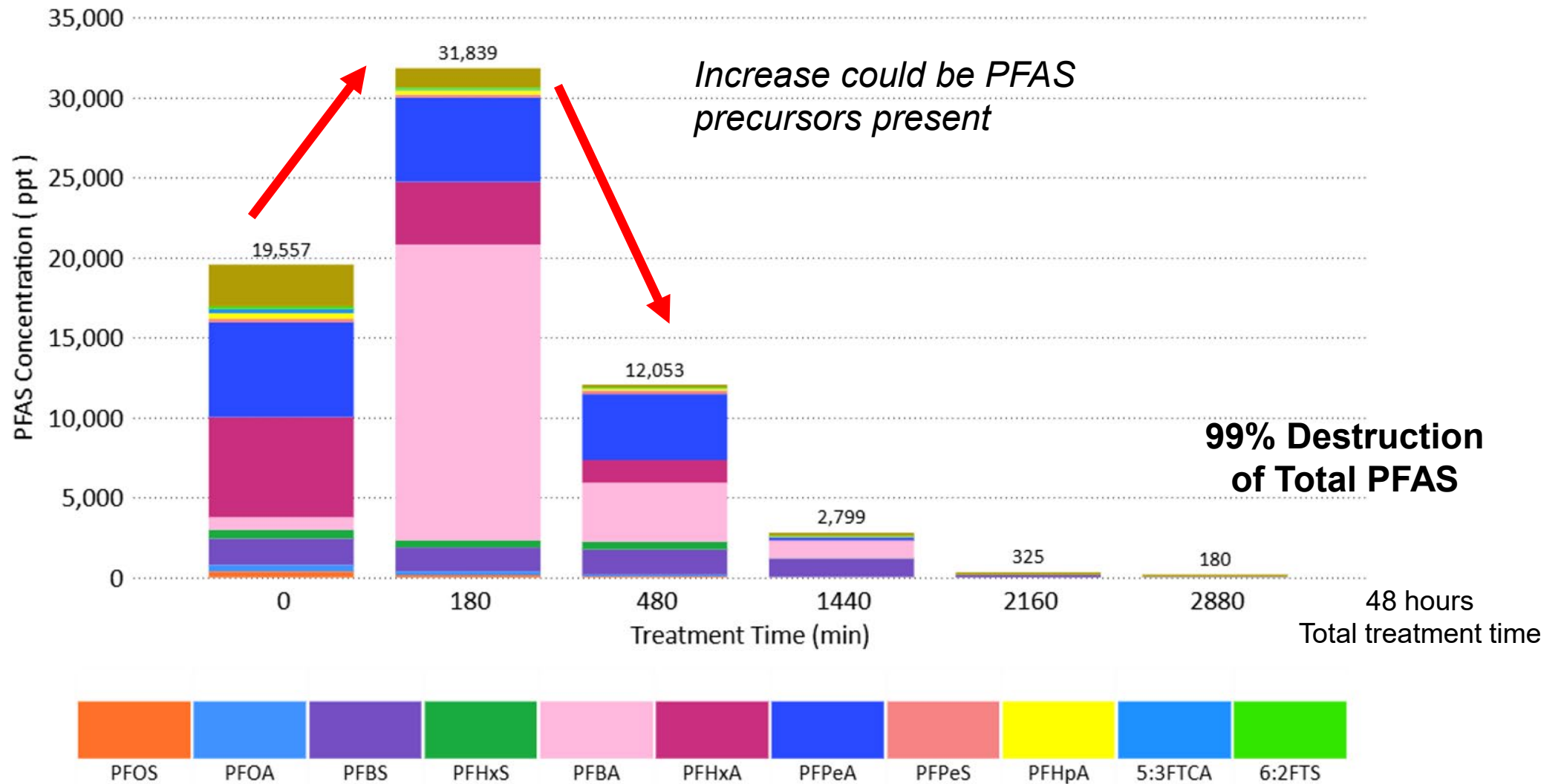
GAC
Ion Exchange



Obreak® Electro-Oxidation Full Scale System



Destruction Results-Total PFAS

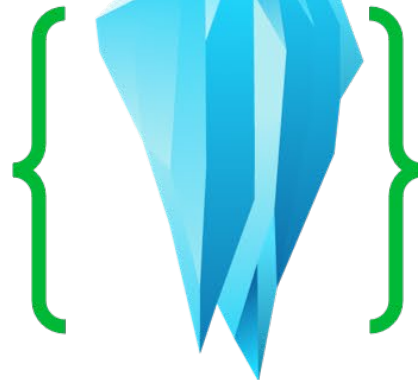


Total Oxidizable Precursor Assay (TOP Assay)

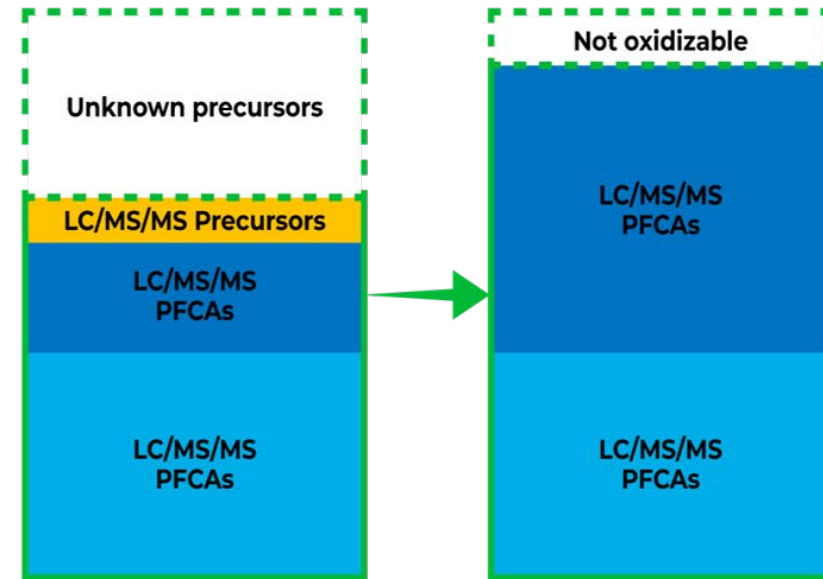
TOP Assay is a measurement of oxidizable PFAS precursors. Useful tool to understand the “**actual**” presence of PFAS.



PRE



POST

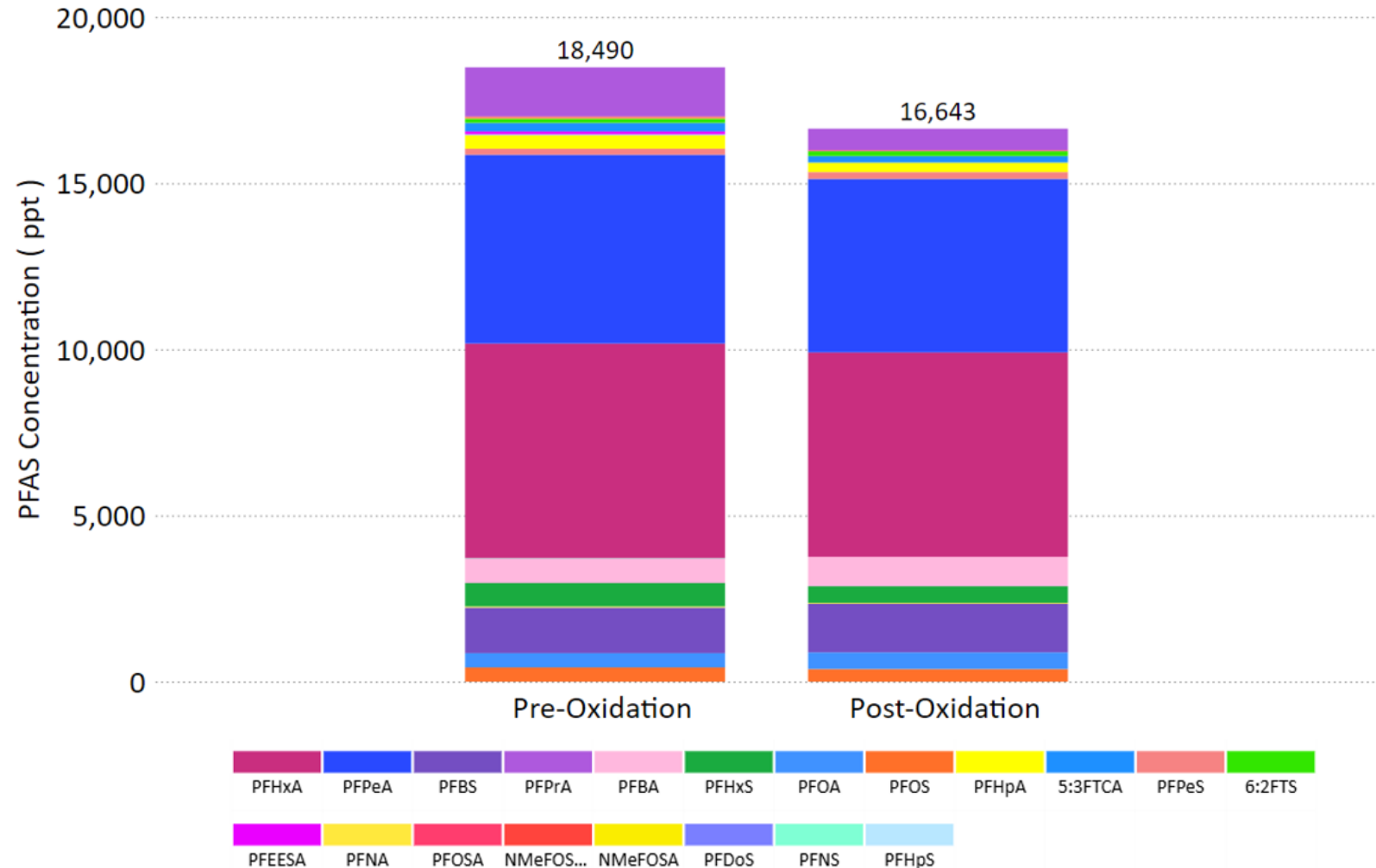


PRE

POST

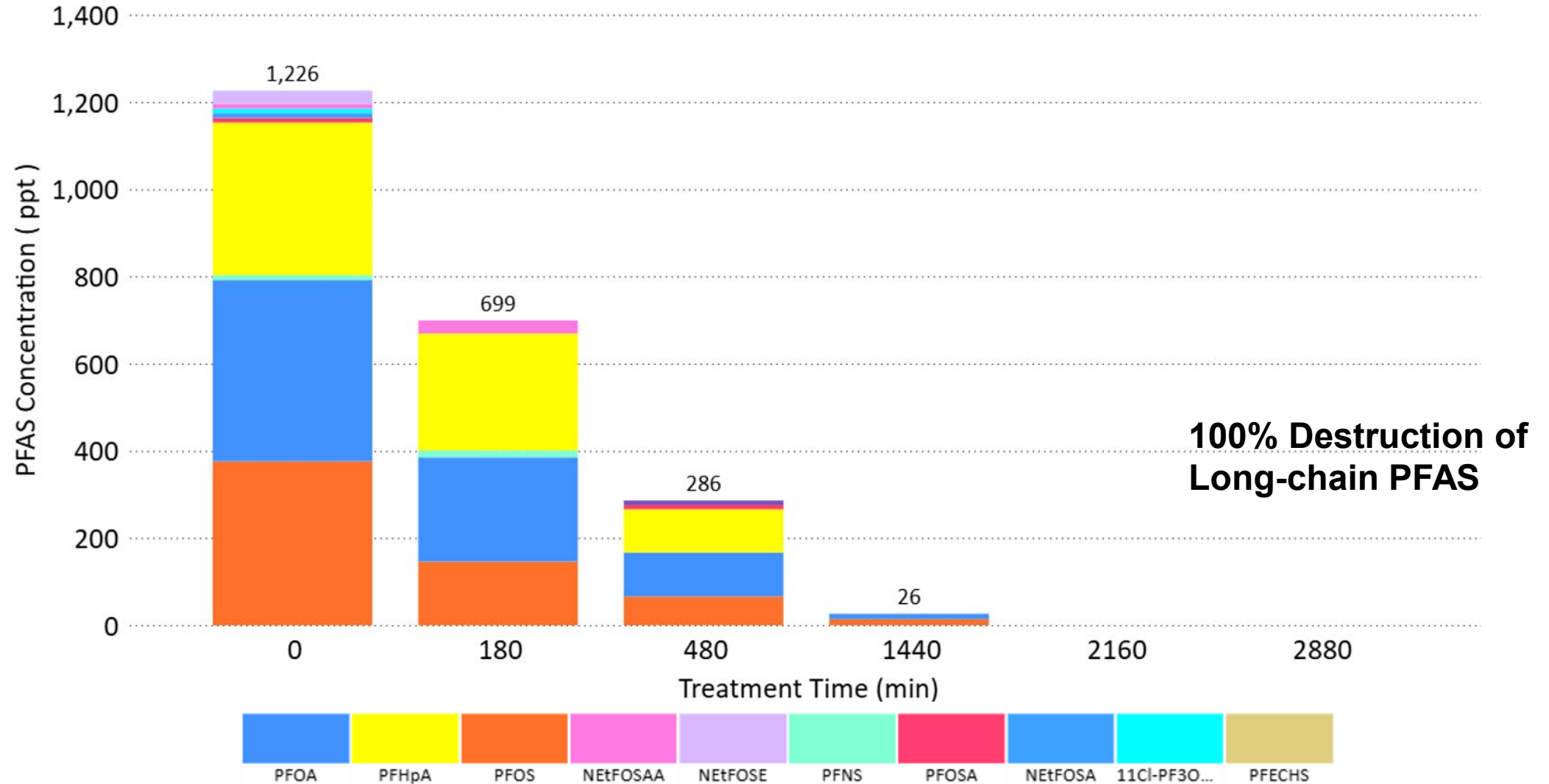
TOP Assay – Regenerant Solution

Regenerant Solution - Untreated

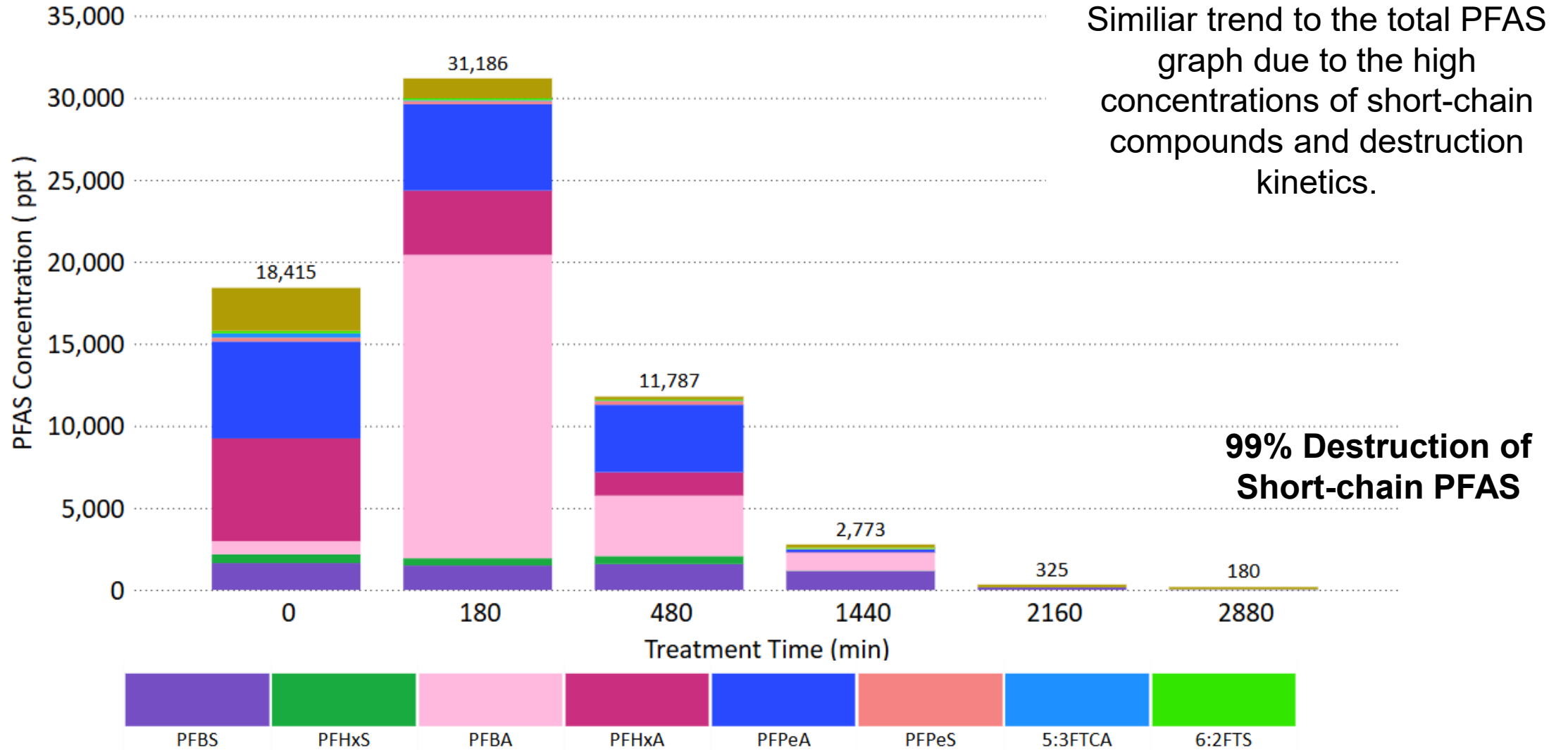


- Did not see precursors from TOP Assay of regenerant solution.
- Could be interference from the matrix itself.
- Continued on-going testing to confirm the presence of precursors.

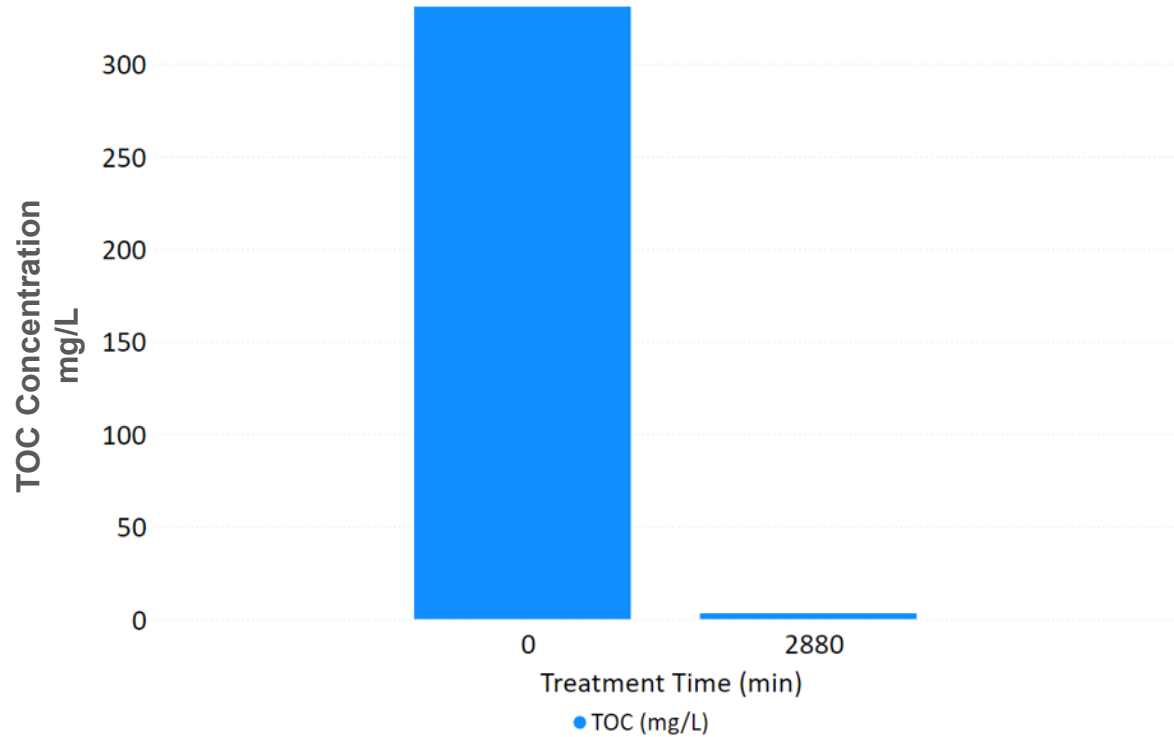
Destruction Results – Long-chain



Destruction Results – Short-chain



Destruction Results – TOC & Byproducts

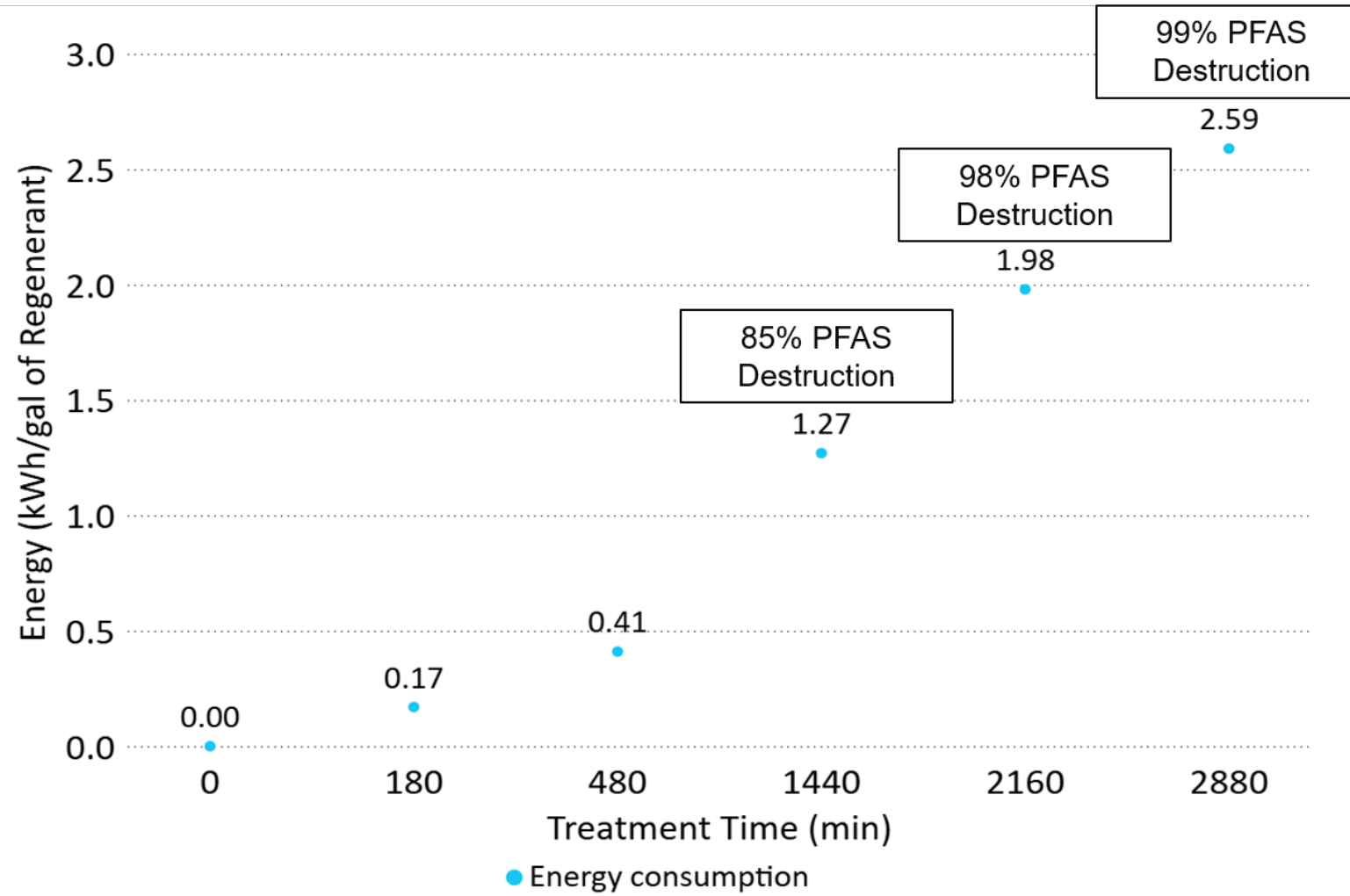


Treatment Time (min)	0	2880
TOC (mg/L)	331	3
Perchlorate (mg/L)	1	3,200
Chloride (mg/L)	21,000	7,300



It is possible to dose approved chemicals to reduce perchlorate formation

Destruction Results – Energy



Selecting an efficient treatment time includes balancing destruction with energy usage.

Lessons Learned

- Heavy competition with TOC
 - Less selective resins chosen that are potentially more regenerable without the use of alcohol solutions.
- Long Analytical TAT
 - Difficult to make operational decisions quickly
- Biofouling – green growth in the tubing and cartridge filters.
 - Added UV to reduce biofouling
- Plugging / air bubbles in columns = more troubleshooting



Conclusions & Next Steps

- PFAS in regenerant solution can be destroyed by EO effectively, best performance with Resin C.
- Regeneration of IX with an inorganic regenerant solution is possible but more refinement is needed for improved desorption of long-chain PFAS compounds.
 - Current media life is ~4-6 weeks which is quick compared to a cleaner matrix like groundwater.
- Next steps include:
 - Compare total mass balance from Regen and Single Use Columns to ensure regen process is economical.
 - Calculate theoretical cost to use EO technology with RO Concentrate.
 - Consider trialing the Foam Fractionation process and comparing with EO calculations.
 - Complete final data analysis and develop the final report to USBR.
- Stay tuned for this report and future journal publications!

Thank You!

Dr. Meeta Pannu
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Product Manager
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Stay informed

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f i n @ d X v



Questions?

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