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PNWS





Sammamish Plateau Water®

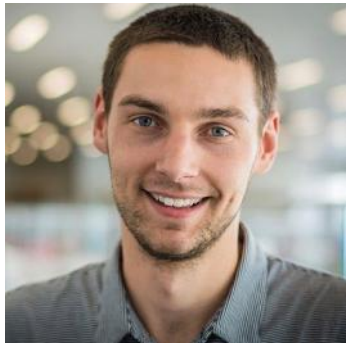
KENNEWICK WASHINGTON

Rapid Results for Long-Term Success: Identifying PFAS Adsorbents to Treat WA Groundwater Sources

May 6, 2026 | American Water Works Association Pacific Northwest Section Conference | Tacoma, WA

Acknowledgements

Today's Presenters:



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KENNEWICK WASHINGTON

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- Al Vetrovs
- Grace Crowe
- Yarrow Polacek

Agenda


Utility Background and PFAS Concentrations


RSSCT Methodology


RSSCT Results


Cost Analysis


Design Considerations

Sammamish Plateau Water



Well 2 Existing Facility



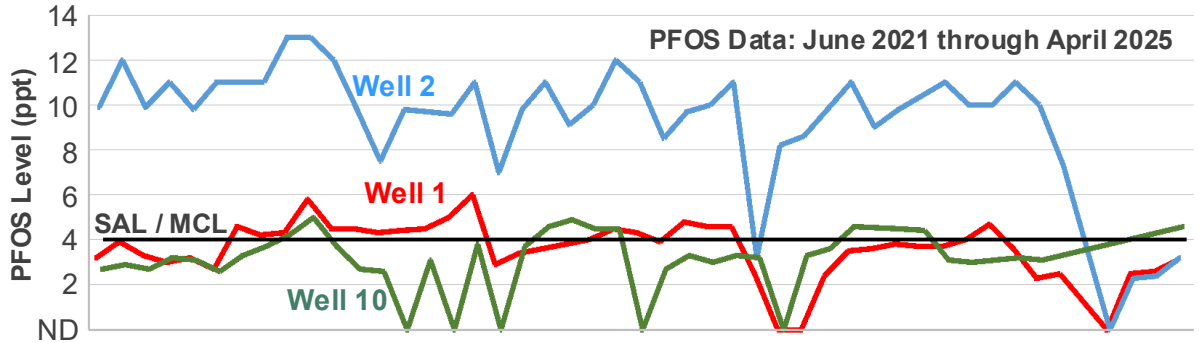
Design two PFAS treatment facilities to treat water from Wells 1, 2, and 10 to reduce PFAS concentrations below Federal MCLs and Washington SALs

Monitoring & Regulatory Status

- PFAS Regs Reminder:
  - **PFOA (4 ppt), PFOS (4 ppt), PFHxS (10 ppt)**
  - **WA "Aligned" SALs were effective Jan 2026**
  - **Federal MCLs have not cleared OMB; Monitoring requirements start April 2027 and MCLs enforceable in April 2029**

- Sammamish Wells 2, 4, 10 Monitoring Results of Interest

	PFOS	PFOA	PFHxS
SALs & MCLs:	4 ppt	4 ppt	10 ppt
Well 10	ND to 5 ppt	ND	3 to 10 ppt
Well 2	4 to 13 ppt	ND to 5 ppt	6 to 22 ppt
Well 1	ND to 6 ppt	ND to 2 ppt	3 to 11 ppt



https://doh.wa.gov/community-and-environment/drinking-water/contaminants/pfas-drinking-water

Washington State Department of HEALTH

State Action Levels, MCLs, and Trigger Levels

PFAS	SAL Effective 1/15/26
PFOA	4.0 ppt
PFOS	4.0 ppt
PFHxS	10 ppt
PFNA	10 ppt
PFBS	--
HFPO-DA	10 ppt
Hazard Index**	1 unitless ratio



PFAS Regulatory Thresholds

Compound	Trigger Level (1/2 MCL)	MCL	PQL[1]
	Level (in parts per trillion, unless otherwise noted)		
PFOA	2.0[2]	4.0	4.0
PFOS	2.0[2]	4.0	4.0
PFHxS	5	10	3.0
HFPO-DA	5	10	5.0
PFNA	5	10	4.0
PFBS	N/A	N/A	3.0
Hazard Index[3]	0.5 (unitless)	1 (unitless)	N/A

https://www.epa.gov/system/files/documents/2024-12/pfas-initialmonitoring-qrg-dec24.pdf

Sammamish RSSCT Methodology

RSSCT Water Sampling & Preparation



- Water Collection
  - **Wells 1, 2, and 10**
  - **Well 2 post-treatment for Fe/Mn Oxidation & Filtration**
  - **2-Stage 10x2.5-in polypropylene filters (5-µm Pureplus and 1-µm Aquaboon)**
  - **55-gal polyethylene drums**

- Water Delivery / Test Setup
  - **Confluence Lab, Shilshole Bay**
  - **Added NaOCl for 1 mg/L residual**
  - **Dechlor (Potassium Metabisulfite)**
  - **4 Rounds of Testing**
    - *Well 2*
    - *Well 10*
    - *Well 2+10 50:50 blend*
    - *Well 1 (use 'best performing' GAC)*
  - **PFAS Spike (Manhattan College) for PFOA/PFOS of 10-20 ng/L to increase analytical granularity****



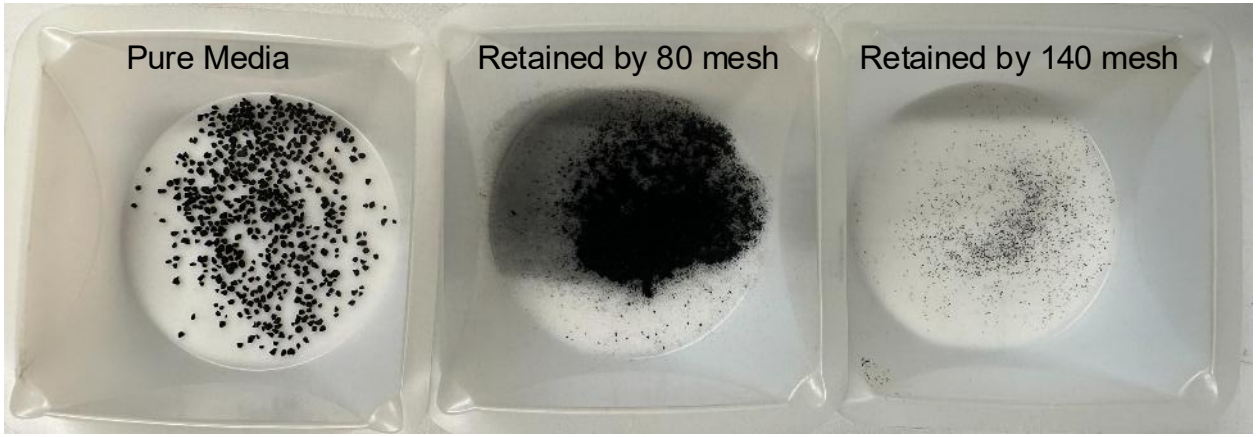
** Micropollutant **adsorption** is **independent** of **concentration** in presence of organics (Knappe et al. 1998, Corwin & Summers 2012)

RSSCT for Adsorbent Media Testing

- Small-scale Testing
  - **Scalable to expected full scale media longevity**
  - **Based on operational parameters (i.e., empty bed contact time [EBCT] and adsorbent media particle size)**
- Media Types
  - **Calgon Carbon F400**
  - **Arq CarbPure 1240**
- Media Preparation
  - **Raw media effective size from 0.5 to 1.0 mm**
  - **Ground by hand, stainless steel conical burr mill**
  - **Sieved using 80 mesh (170 µm) and 140 mesh (105 µm)**
  - **Material retained by 140 mesh used in RSSCT (geometric mean media size = 134 µm)**







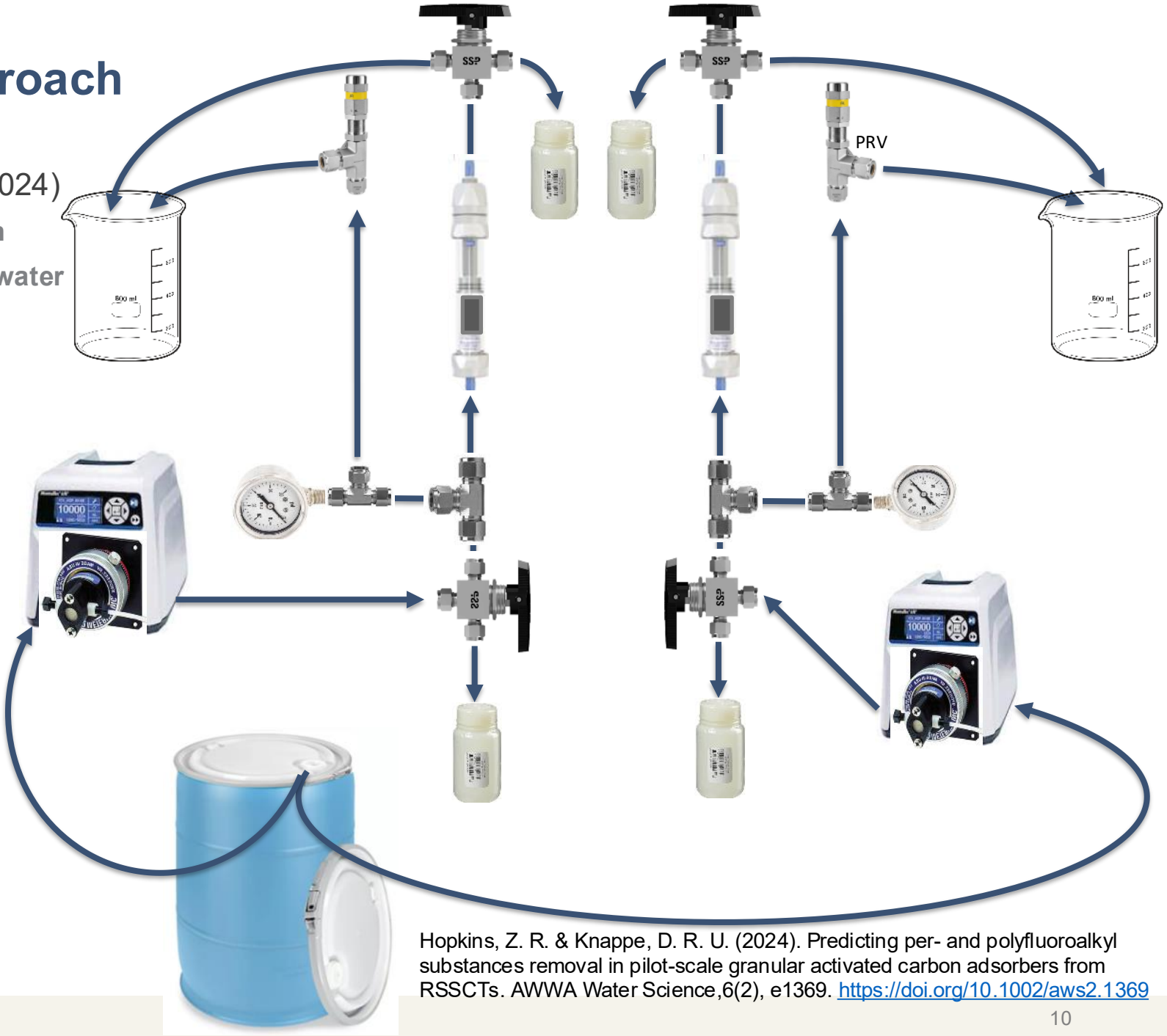




RSSCT Apparatus and Approach

- X = 0.25 RSSCT (Hopkins and Knappe, 2024)
  - 6.6-mm x 100-mm chromatography column
  - 25-mm GAC bed depth, 0.06 µS ultra pure water
  - 3.6 mL/min, 1.3 gal/day, x2 columns/media
  - Allowed 3,000 to 4,000 bed volumes/day
- Test Duration (Days) & EBCTs
  - Well 2: 14 day, 10-min EBCT, x2 media
  - Well 2+10: 14-day, 10-min EBCT, x2
  - **Results informed an EBCT change**
  - Well 10: 14 day, 8-min EBCT, x2
  - **Results informed a duration change**
  - Well 1: 22 day, 10-min EBCT, x1
  - 7 conditions
  - 54 testing days





Hopkins, Z. R. & Knappe, D. R. U. (2024). Predicting per- and polyfluoroalkyl substances removal in pilot-scale granular activated carbon adsorbers from RSSCTs. AWWA Water Science,6(2), e1369. https://doi.org/10.1002/aws2.1369

RSSCT Water Quality & Sampling Conditions

- Raw Water Quality
  - **Arsenic: ND to 4 µg/L (a design/operations impact)**
  - **TOC: ND to 0.31 mg/L (never detected GAC breakthrough)**
  - **Treatment didn't change Nitrate + Nitrite-N (0.2 to 1.4 mg/L), chloride (5 to 10 mg/L), or sulfate (7 to 15 mg/L)**
- Sampling
  - **Raw water PFAS (barrel) checked on day 0 & end of test**
  - **Each PFAS sample bottle held ~300 bed volumes (~1 hr)**
  - **PFAS labs all reported to method detection limits (MDLs) (Eurofins Laboratories in Pomona, CA). For example:**
    - *PFOA Reporting Limit (RL) = 2.0 ng/L*
    - *PFOA MDL used for these tests = 0.38 ng/L*





Test No.	Well No.	Days Collecting PFAS Samples
1	12	0 2 4 5 6 7 8 9 10 11 12 14
2	2 + 10	0 2 4 5 6 8 10 11 12 14
3	10	0 7 8 10 11 12 13 14
4	1	0 10 13 15 17 20 22

Testing Analyzed Adsorption Characteristics of (Figures on Next Slides):

Compound & Chain Length	PFAS Type
PFOA, 8	Perfluoroalkyl carboxylic acid (PFCA)
PFOS, 8	Perfluoroalkyl sulfonic acid (PFSA)

Compound & Chain Length	PFAS Type
PFBS, 4	PFSAs
PFPeS, 5	
PFHxS, 6	

Compound & Chain length	PFAS Type
PFBA, 4	PFCAs
PFPeA, 5	
PFHxA, 6	
PFHpA, 7	

Sammamish RSSCT Results

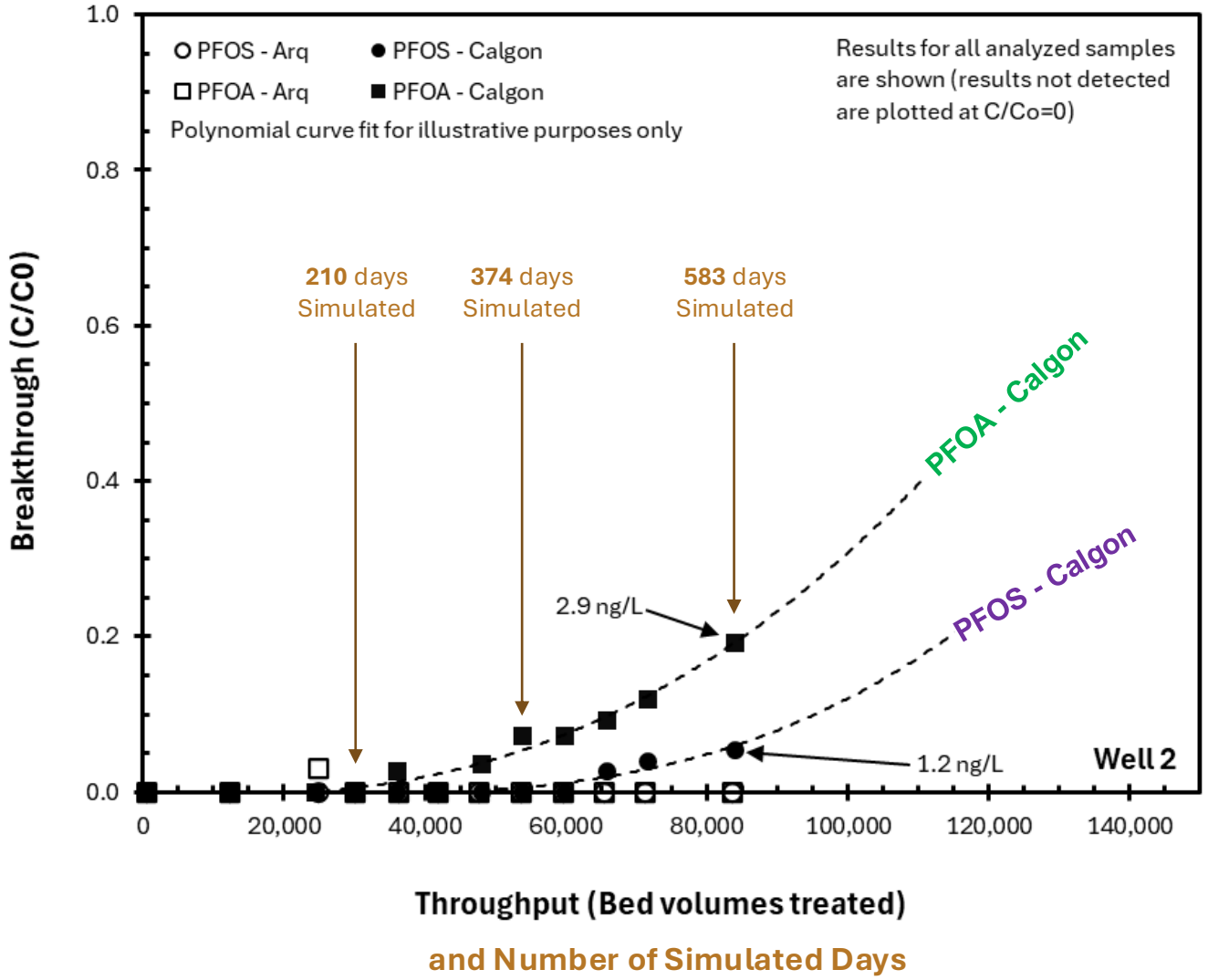
RSSCT Results: Well 2

- Breakthrough curves (C/Co)
- All detections used in data plots
- Testing over 14 days
  - **10 min EBCT, ~83,500 Bed Volumes**
- Calgon F400 at Test End, 583 days
  - **PFOS = 1.2 ng/L**
  - **PFOA = 2.9 ng/L**

Below MCLs

- Arq 1240 at Test End, 580 days
  - **PFOS not detected**
  - **PFOA not detected ('blip' on day 4)**

Below MCLs



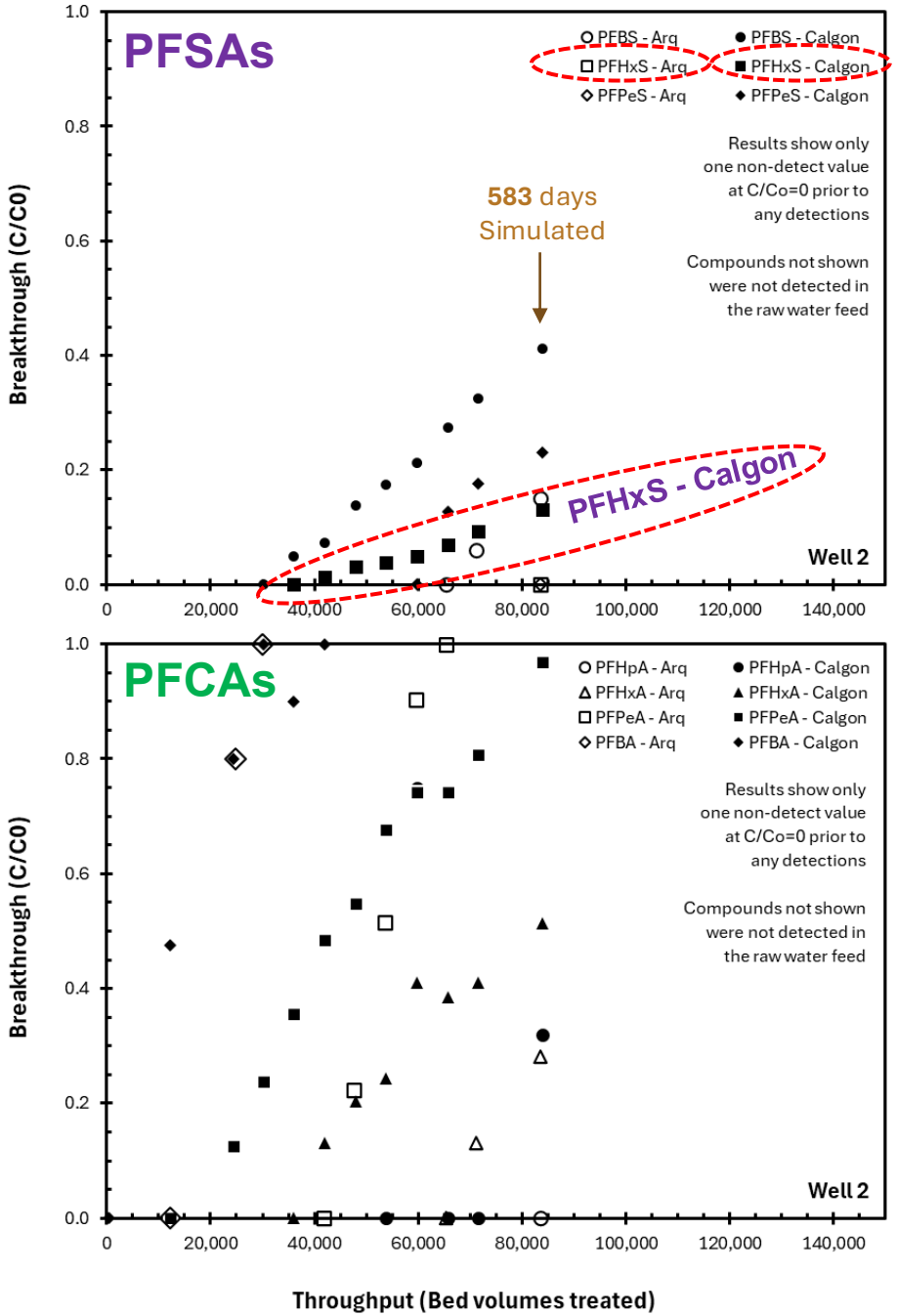
RSSCT Results: Well 2, Continued

- Breakthrough curves (C/Co)
- All detections used in data plots
- Testing over 14 days
  - **10 min EBCT, ~83,500 Bed Volumes**
- Calgon F400 at Test End, 583 days
  - **PFOS = 1.2 ng/L**
  - **PFOA = 2.9 ng/L**
  - **PFHxS = 3.4 ng/L**
  - **Spiked PFSAs, PFCAs**

Below MCLs

- Arq 1240 at Test End, 580 days
  - **PFOS not detected**
  - **PFOA not detected ('blip' on day 4)**
  - **PFHxS not detected**
  - **Spiked PFSAs, PFCAs**

Below MCLs



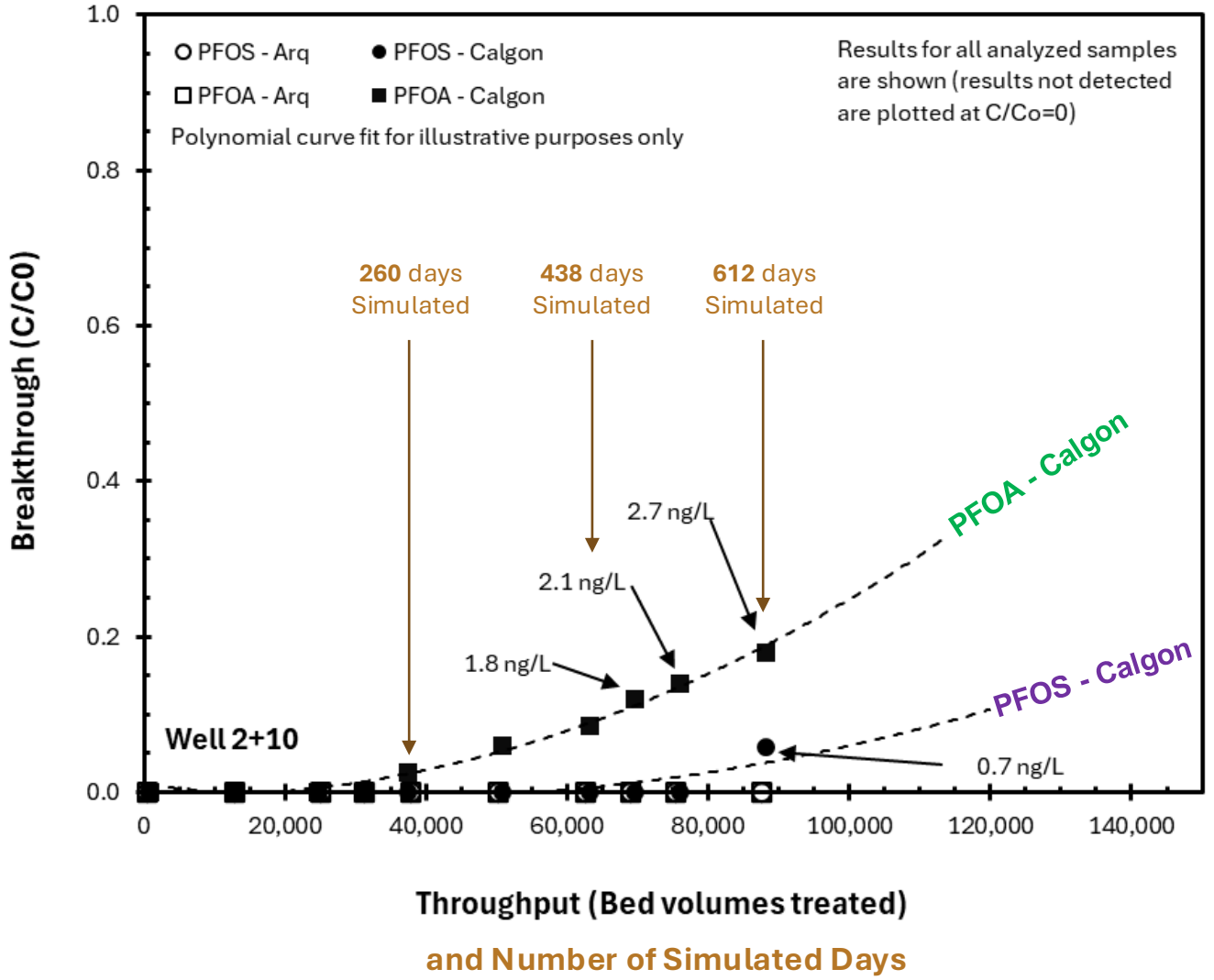
RSSCT Results: Well 2+10, 50:50 Blend

- Testing over 14 days
  - **10 min EBCT, ~88,100 Bed Volumes**
- Calgon F400 at Test End, 612 days
  - **PFOS = 0.7 ng/L**
  - **PFOA = 2.7 ng/L**

Below MCLs

- Arq 1240 at Test End, 607 days
  - **PFOS not detected**
  - **PFOA not detected**

Below MCLs



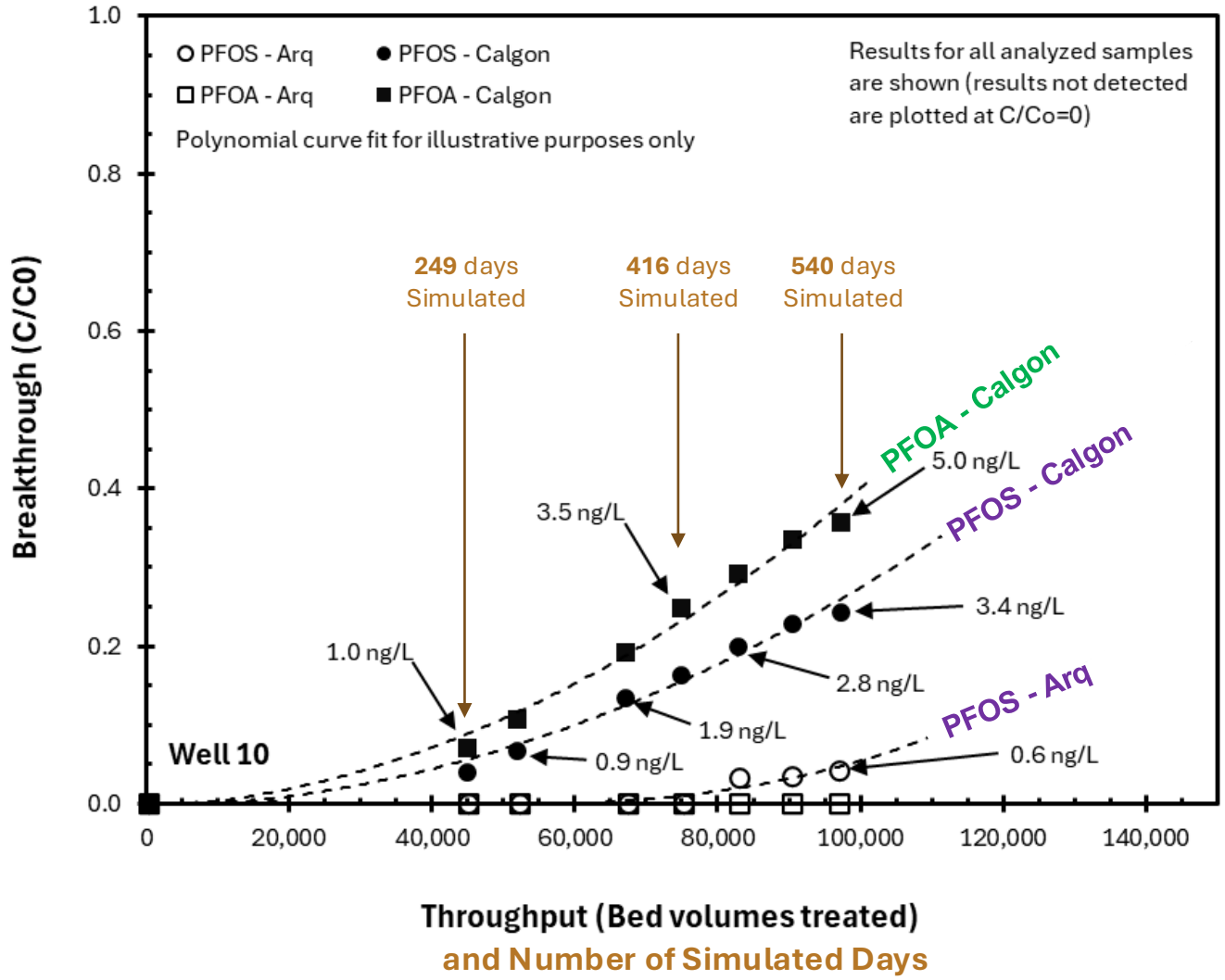
RSSCT Results: Well 10

- Testing over 14 days
  - **8 min EBCT, ~97,500 Bed Volumes**
  - **Faster PFAS passage at sub-optimal EBCT**
- Calgon F400 at Test End, 540 days
  - **PFOS = 3.4 ng/L**
  - **PFOA = 5.0 ng/L**

Below MCLs

- Arq 1240 at Test End, 539 days
  - **PFOS = 0.6 ng/L**
  - **PFOA not detected**

Below MCLs

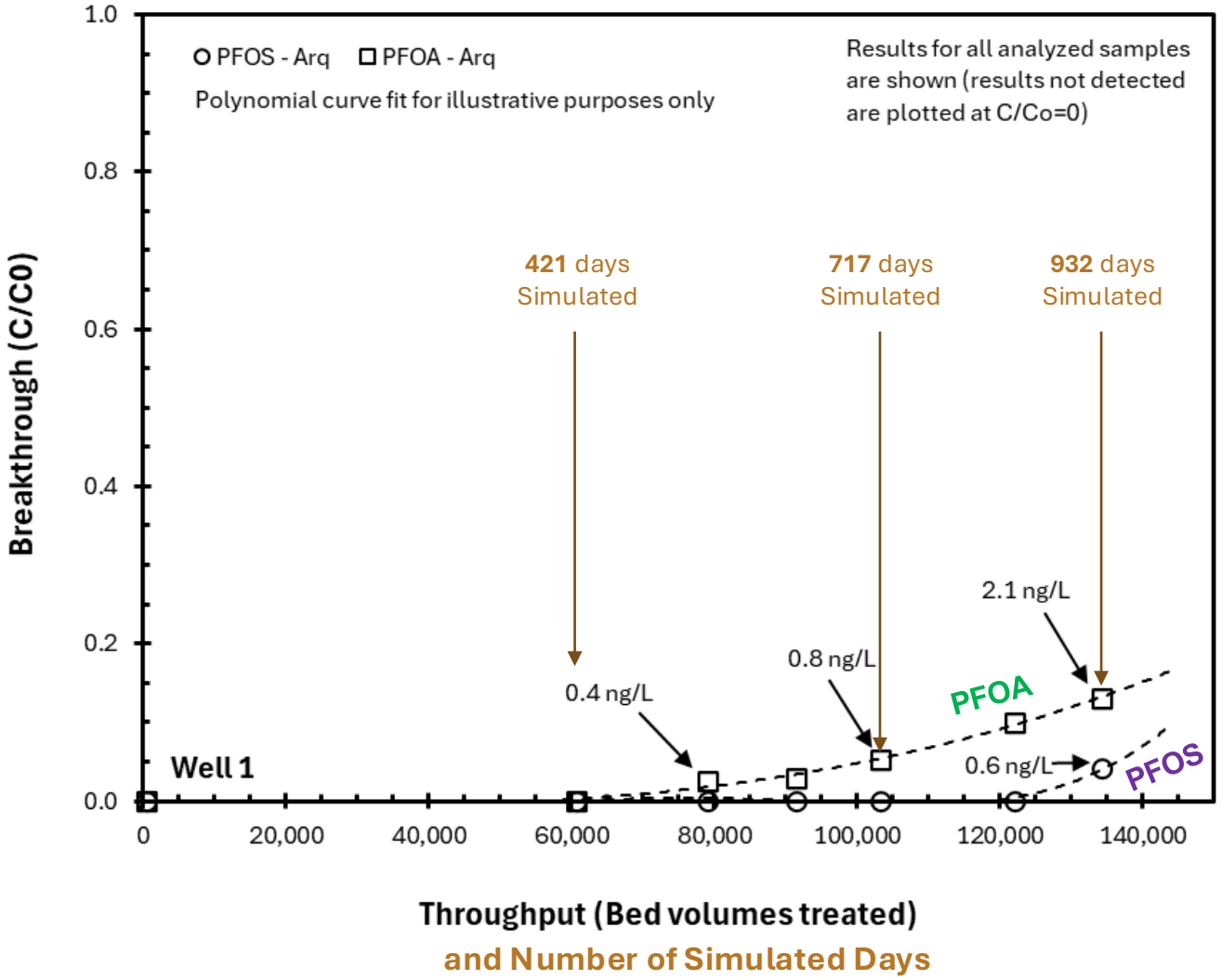


RSSCT Results: Well 1

- Testing over 22 days – Arq media only
  - **10 min EBCT, ~134,000 Bed Volumes**
  - **Design EBCT, longer operating time**

- Arq 1240 at Test End, 932 days
  - **PFOS = 0.6 ng/L**
  - **PFOA = 2.1 ng/L**

Below MCLs



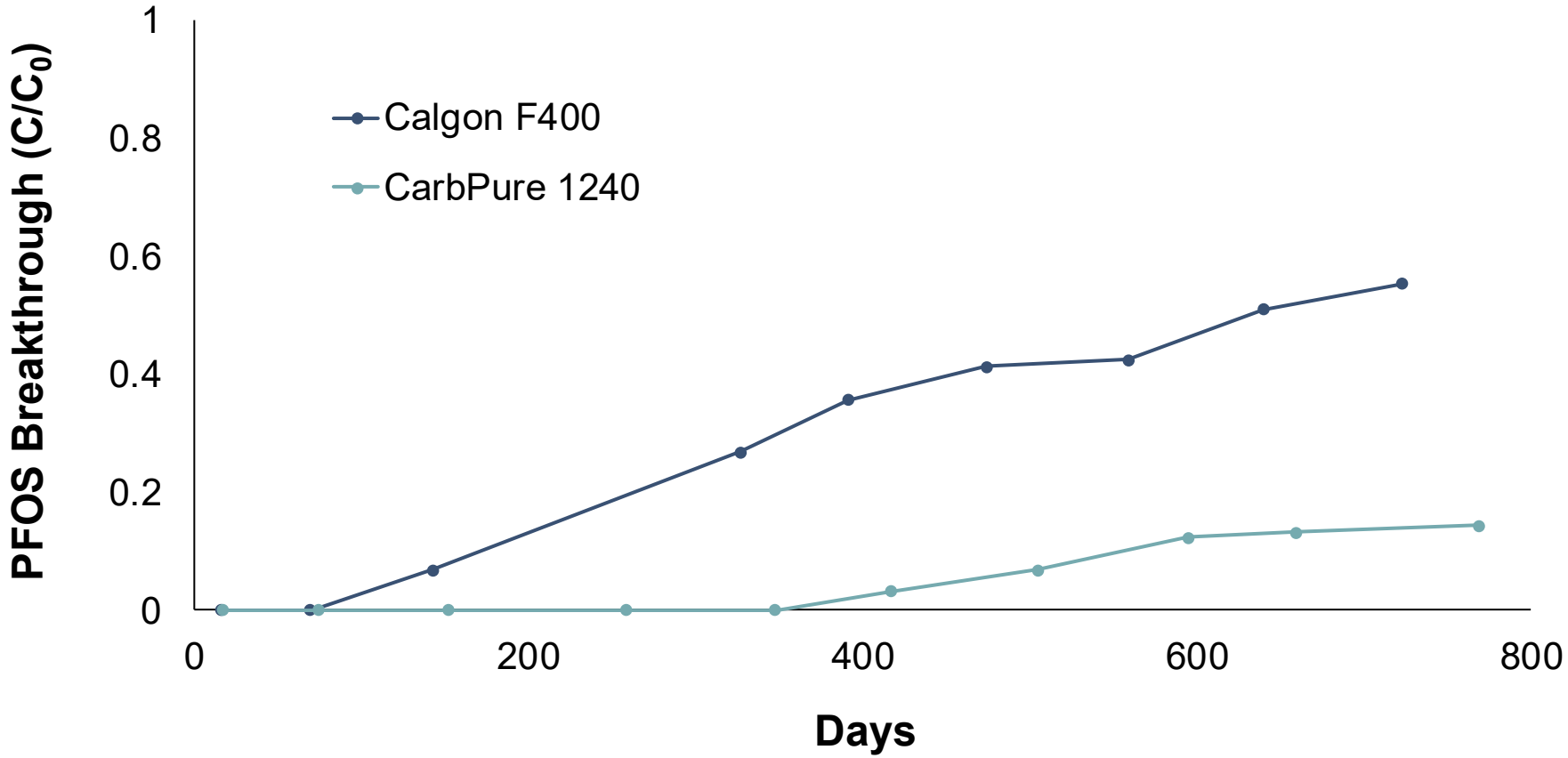
City of Kennewick



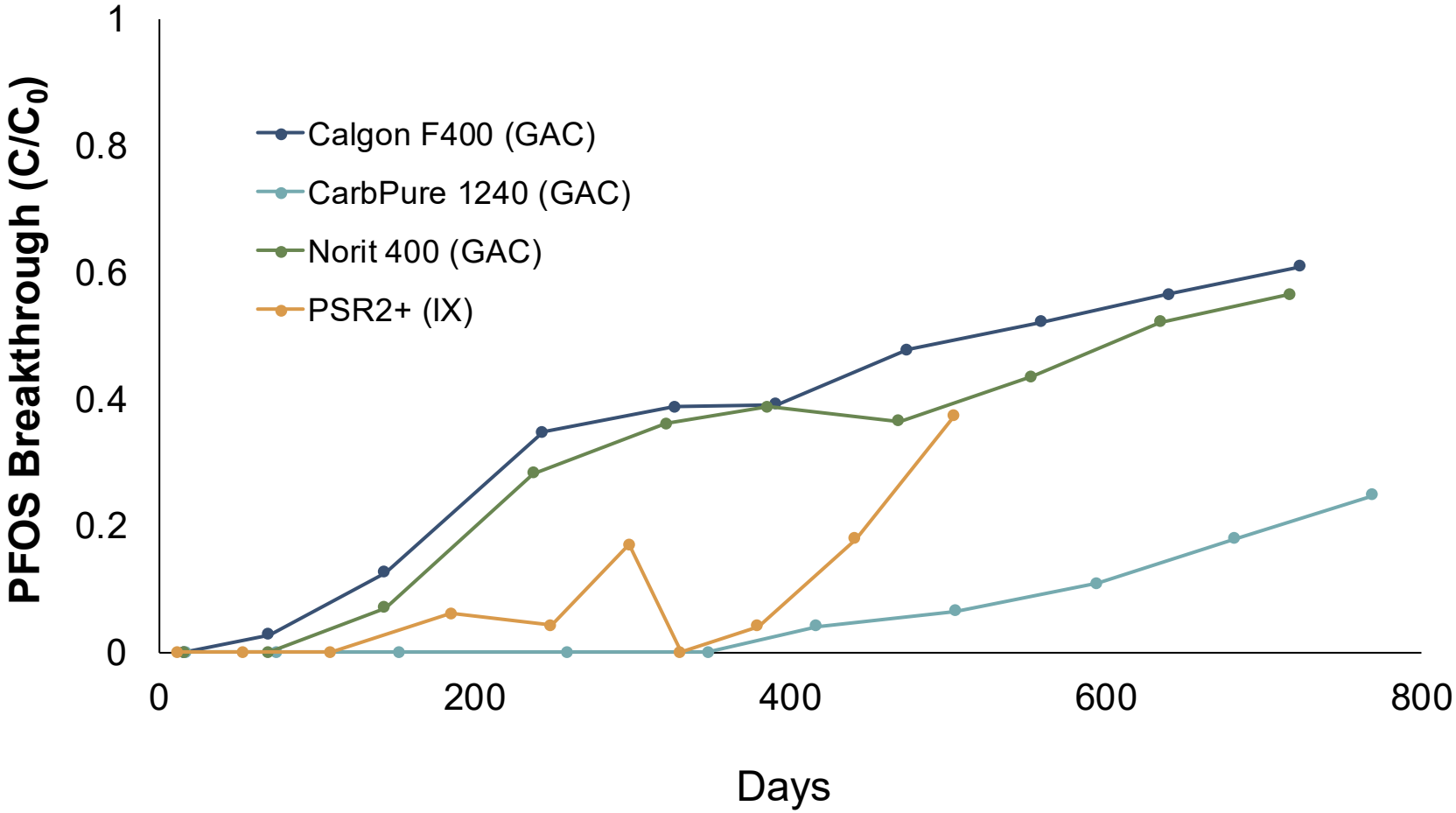
RSSCT Results for the City of Kennewick

Design PFAS treatment facility to treat water from RC4 and RC5 to reduce PFAS concentrations below the Federal MCLs

RC 5 RSSCT Results



RC 4/5 Blend RSSCT Results

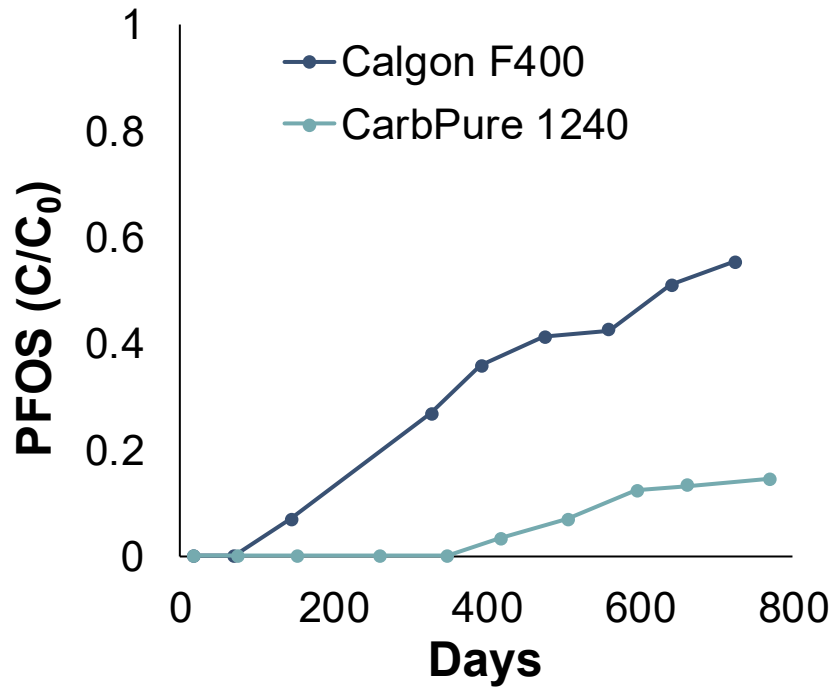


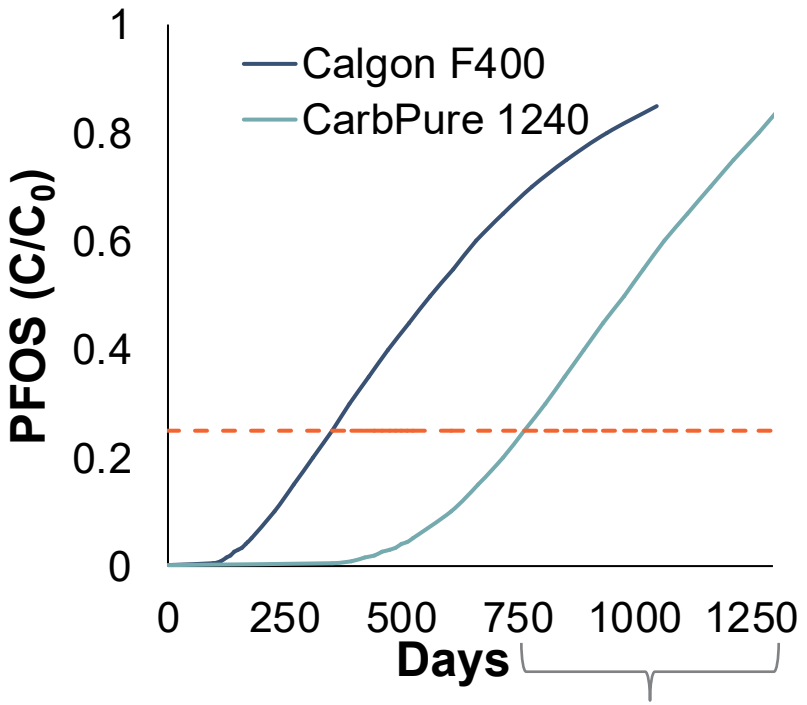
Application of Fixed Bed Adsorption Models to Project Breakthrough

Incomplete breakthrough observed in RSSCT leads to inability to project changeout costs

Application of pore surface diffusion model (PSDM) to fit early breakthrough and infer higher changeout thresholds

Opportunities to further optimize GAC changeout strategies with continuous data series



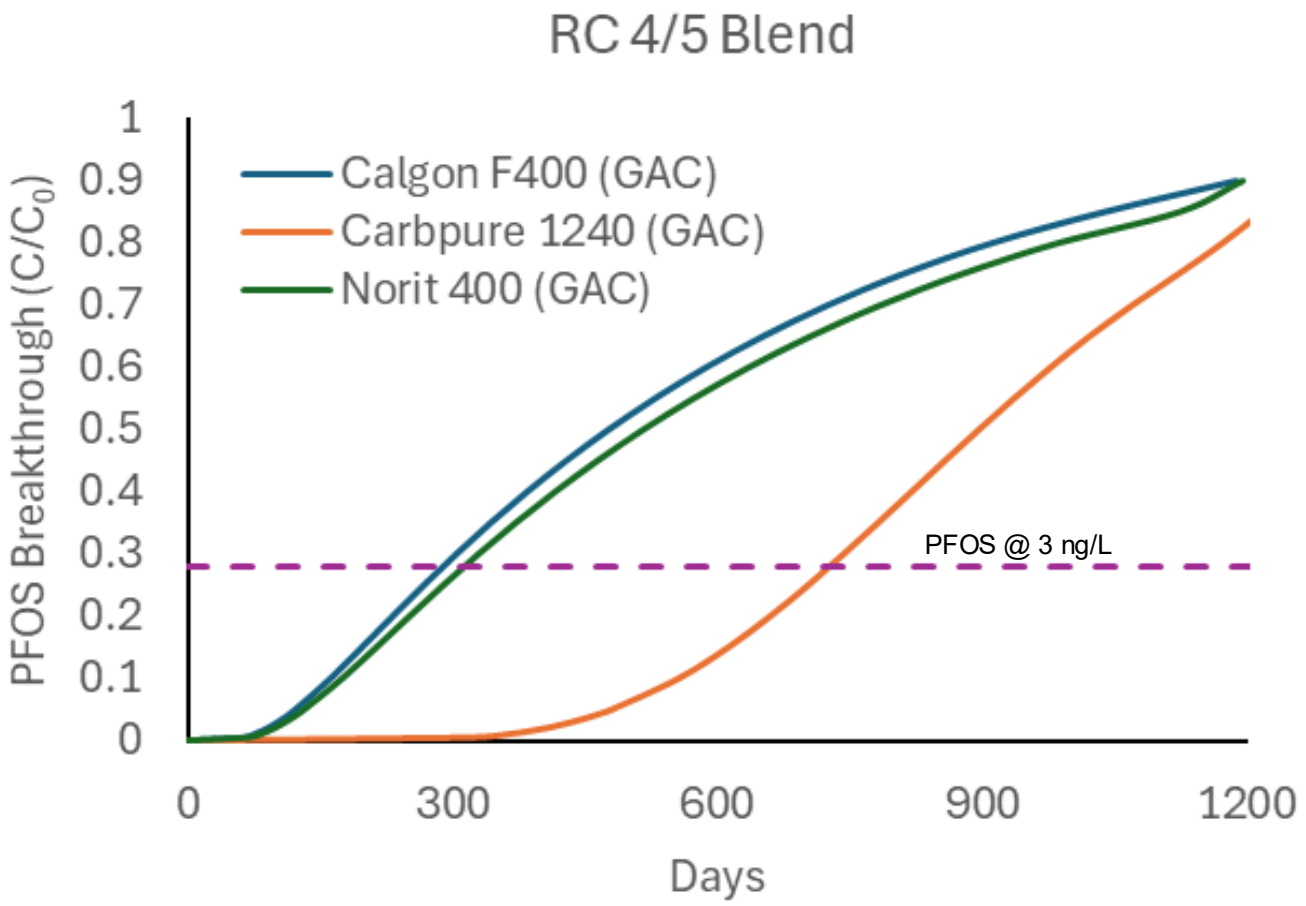


Extended performance projections

PHASTER

RC 4/5 Blend Projected Breakthrough Curves - Kennewick

Application of Pore Surface Diffusion Model (PSDM)

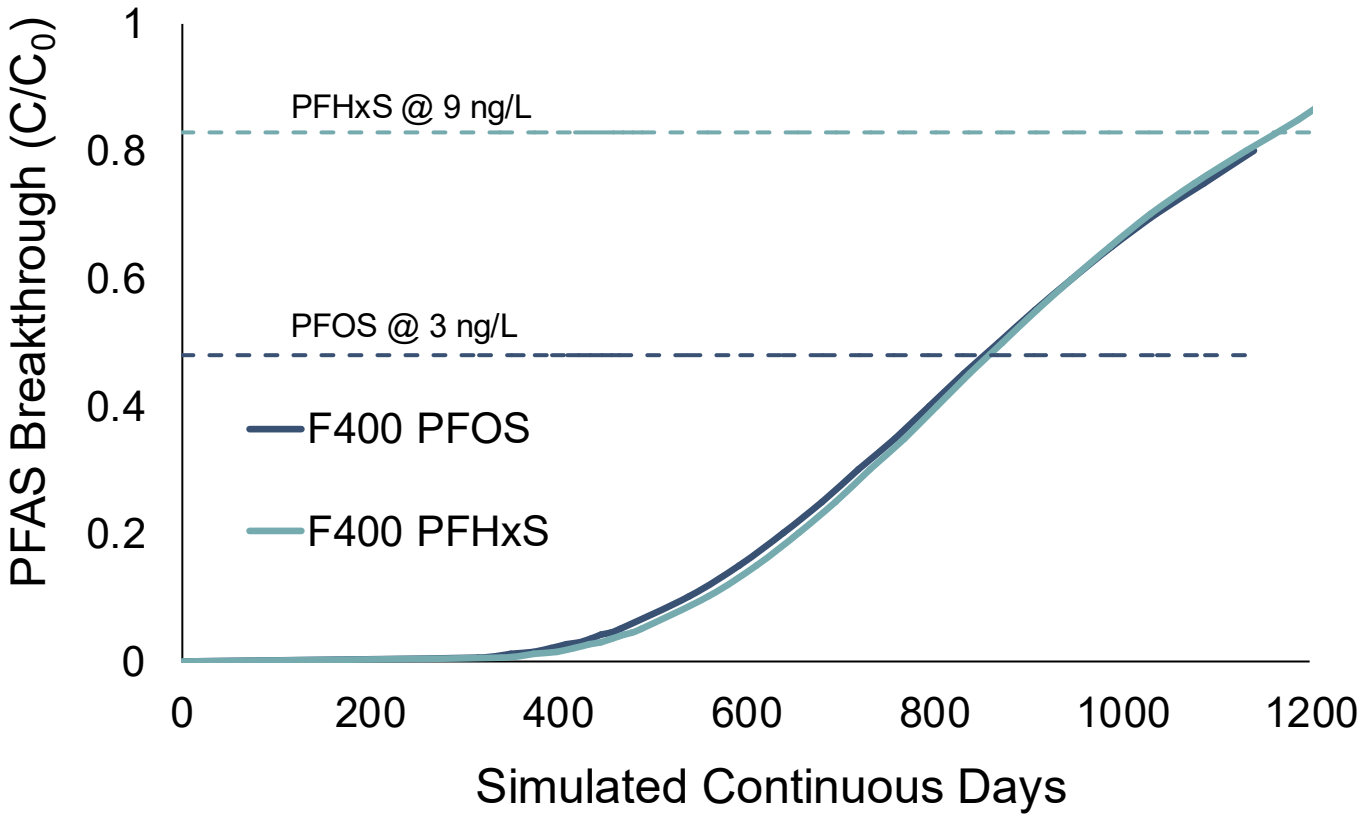


Adsorbent Media	Predicted Changeout Frequency
Calgon F400 (GAC)	285 days
CarbPure 1240 (GAC)	720 days
Norit 400 (GAC)	310 days

PFOA influent concentrations are below MCL

Slide assumes average PFOS concentrations from available data

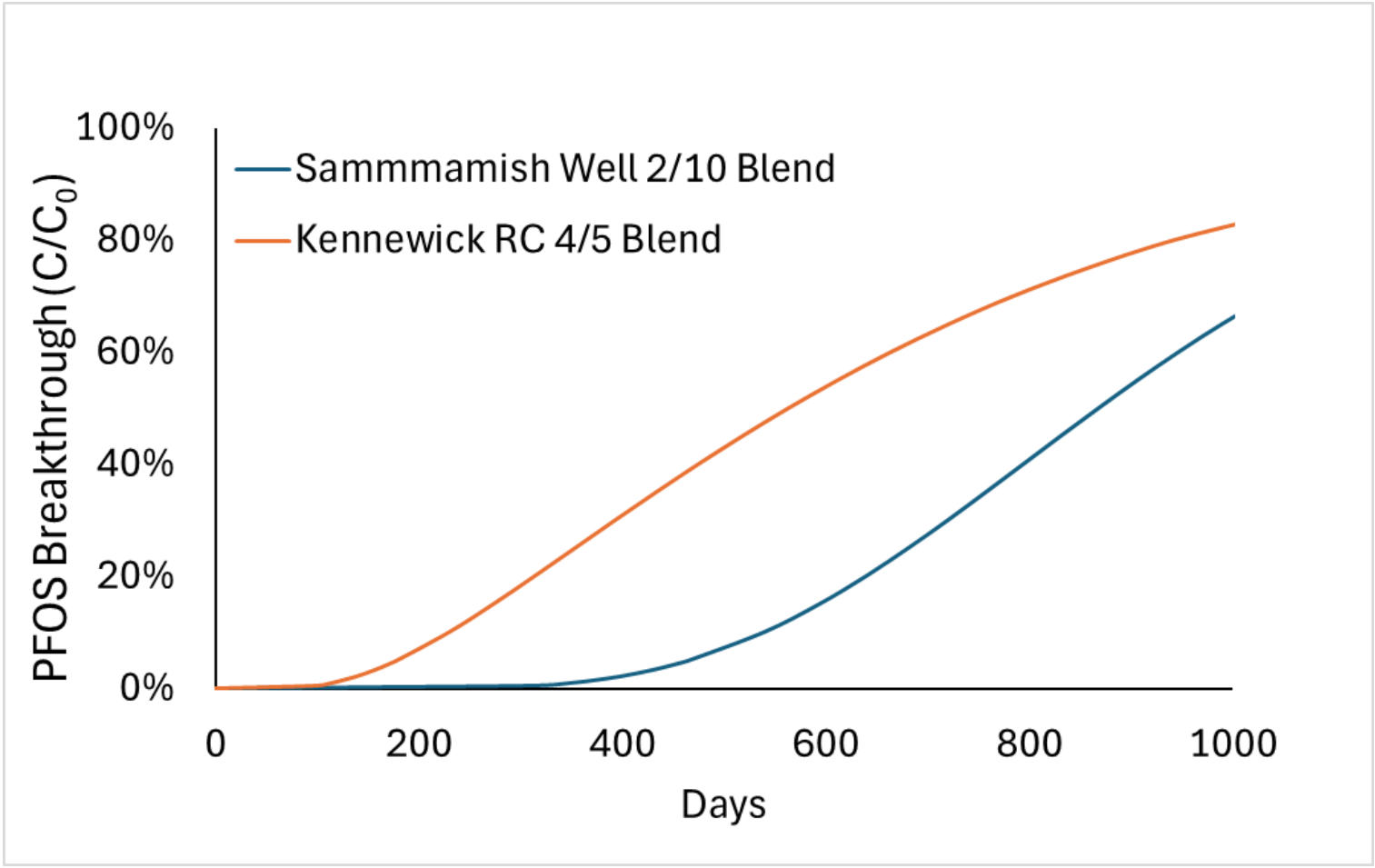
Well 2 & 10 Projected Breakthrough Curves



Adsorbent Media	Dictating PFAS	Changeout Frequency
Calgon F400	**PFOS**	**850 days**
Calgon F400	PFHxS	1150 days

Large differences in treatment longevity based on water type.

Calgon F400 Breakthrough Results



Similar RSSCT design with respect to EBCT and x=0.25 design

Differences in background water quality:

TOC

1 mg/L (Kennewick) vs 0.3 mg/L (Sammamish)

Evaluation of Changeout Costs

Predicted Media Changeout Costs

Parameter	Sammamish	Kennewick
Facility Size (MGD)	1.4	10
Avg. Number of Operational Days/yr	151	365
Changeout Frequency (days)	850-1,100	285-720
Number of Operational Years before Changeout	~5.6	~1.3
Assumed Number of Operational Yrs before Changeout	*5[a]*	~1.3
Cost at Time of Changeout – Virgin ($)	***$89,000***	***$1,250,000***
Cost at Time of Changeout – Reactivated ($)	***$61,000***	***$930,000***
[A] assumed 5 yr changeout threshold for operability		
Sammamish much smaller GAC application (1 pair of 12x40 vessels vs 7 pairs)		

Predicted Annual Media Changeout Costs

Parameter	Sammamish Well 2-10 Blend	Kennewick RC 4/5 Blend
Media Type	GAC	GAC
Pressure Vessel Pairs	1	7
EBCT (min)	10	10
Changeout Interval (days)	850-1,100	285-720
Annual Media Cost w Virgin Media ($/yr)	$18,000 - $22,000[a]	$379,000 - $786,000[a]
Annual Media Cost w Reactivated Media ($/yr)	$13,000 - $21,000[b]	$412,000 - $591,000[b]

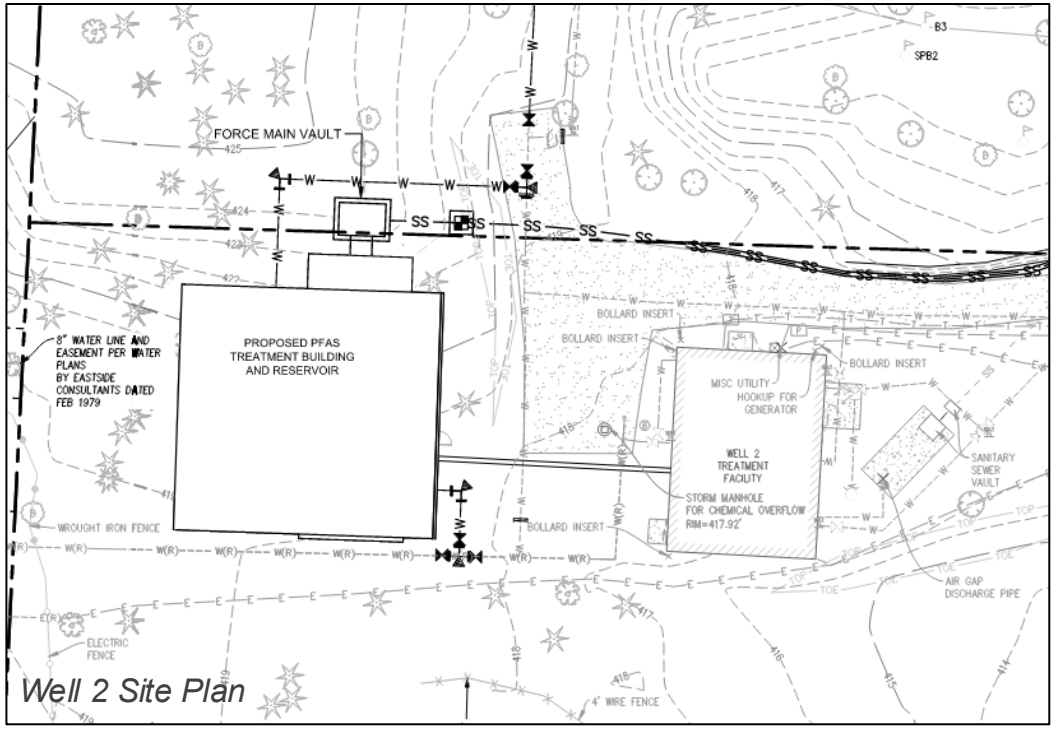
a: Virgin Media Unit Cost ($66-80/ft^3)
b: Reactivated Media Unit Cost ($38-90/ft^3)

Differences in treatment size, changeout interval, seasonal operation, and media selection may *widely* impact annual GAC costs!

Design Considerations

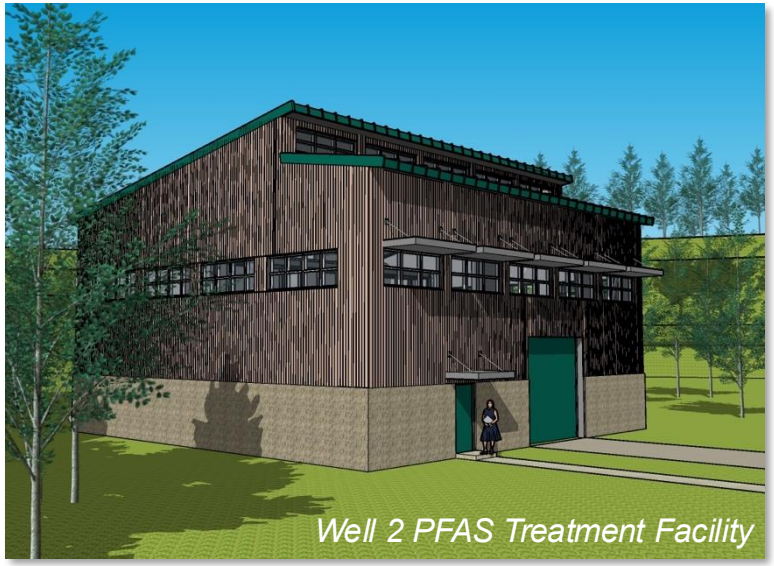
Sammamish Plateau Water® Design Considerations

- Seasonal Operations
  - **Shutdown Procedures – Draining**
  - **Startup Procedures – Disinfection and Flushing**
- Residuals Handling
  - **Backwashing Procedures**
  - **Start-up Forward Flushing for Arsenic Reduction**
- Spacing and Site Constraints
  - **LOTS of trees!**
  - **Residuals Storage Tank - above versus below grade?**



Well 2 Site Plan

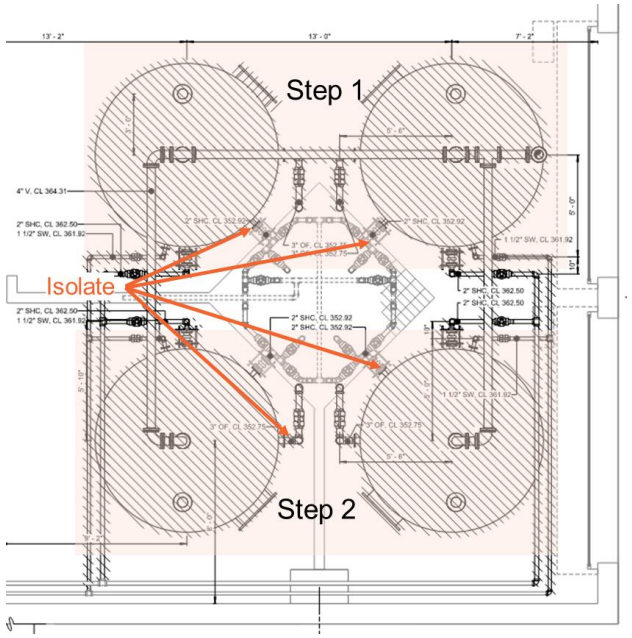



Well 2 PFAS Treatment Facility

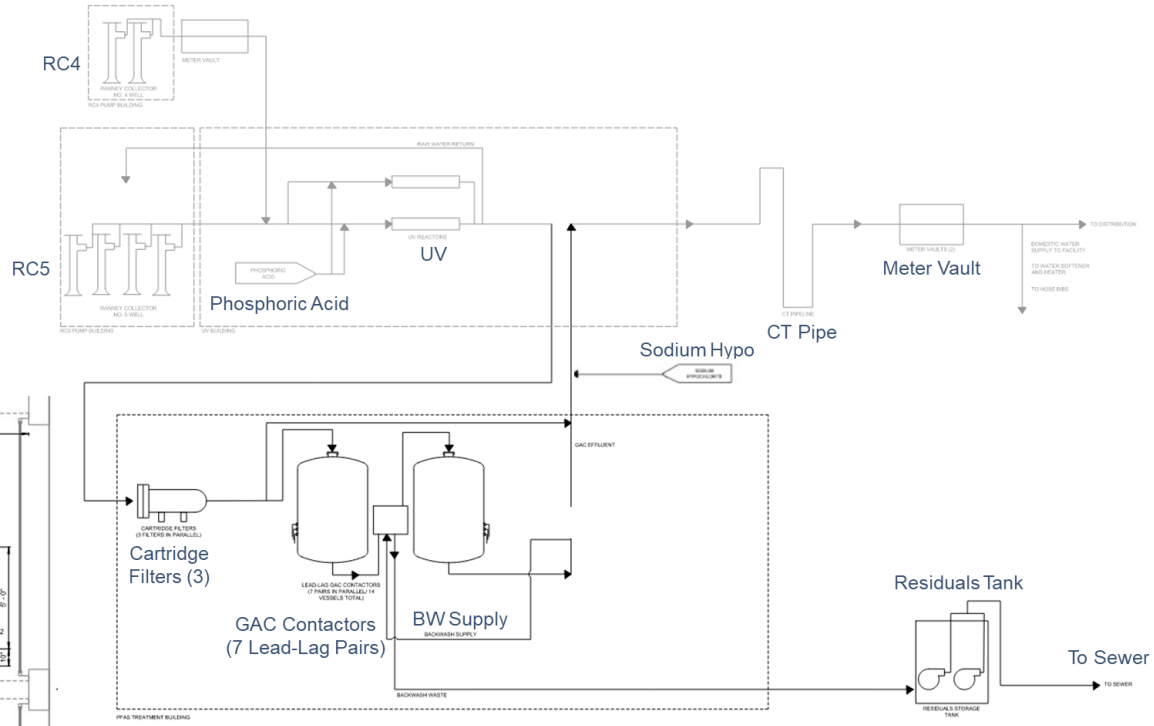
Design Considerations

- Hydraulic Evaluation of Existing Pump Capacity
- MOPO for chemical and new GAC tie-ins

- Backwashing Procedures
  - Start-up Forward Flushing for As Reduction



MOPO Considerations



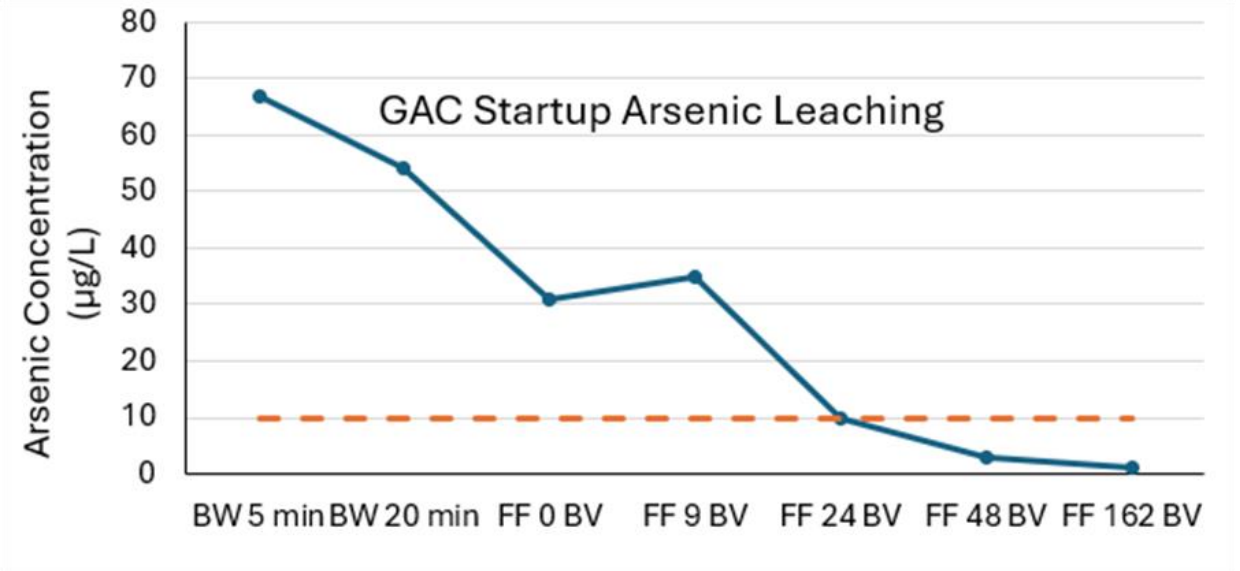
Proposed PFD

GAC Residuals Management

Leaching and Spent GAC

- Startup residuals management required for fines removal and metals leaching
  - **Metals leaching from GAC startup variable based on GAC sourcing**
  - **~60 BVs of forward flush to waste**
  - **A variety of procedures applicable to reduce flushing volumes at the expense of flushing time/cost.**
- Intermittent backwash waste generated from operational backwashing
  - **~36,000 Gallons – likely not to drive EQ tank sizing**

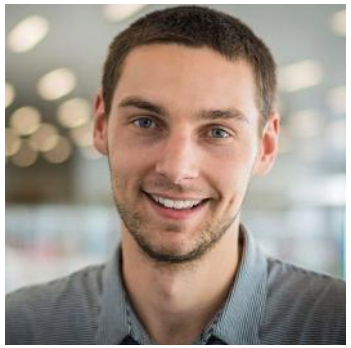
GAC Reactivation preferred spent GAC management option. Custom municipal reactivation may be available.



GAC As Leaching from other piloting efforts

Questions?

Thank you!!



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Sammamish Plateau Water®

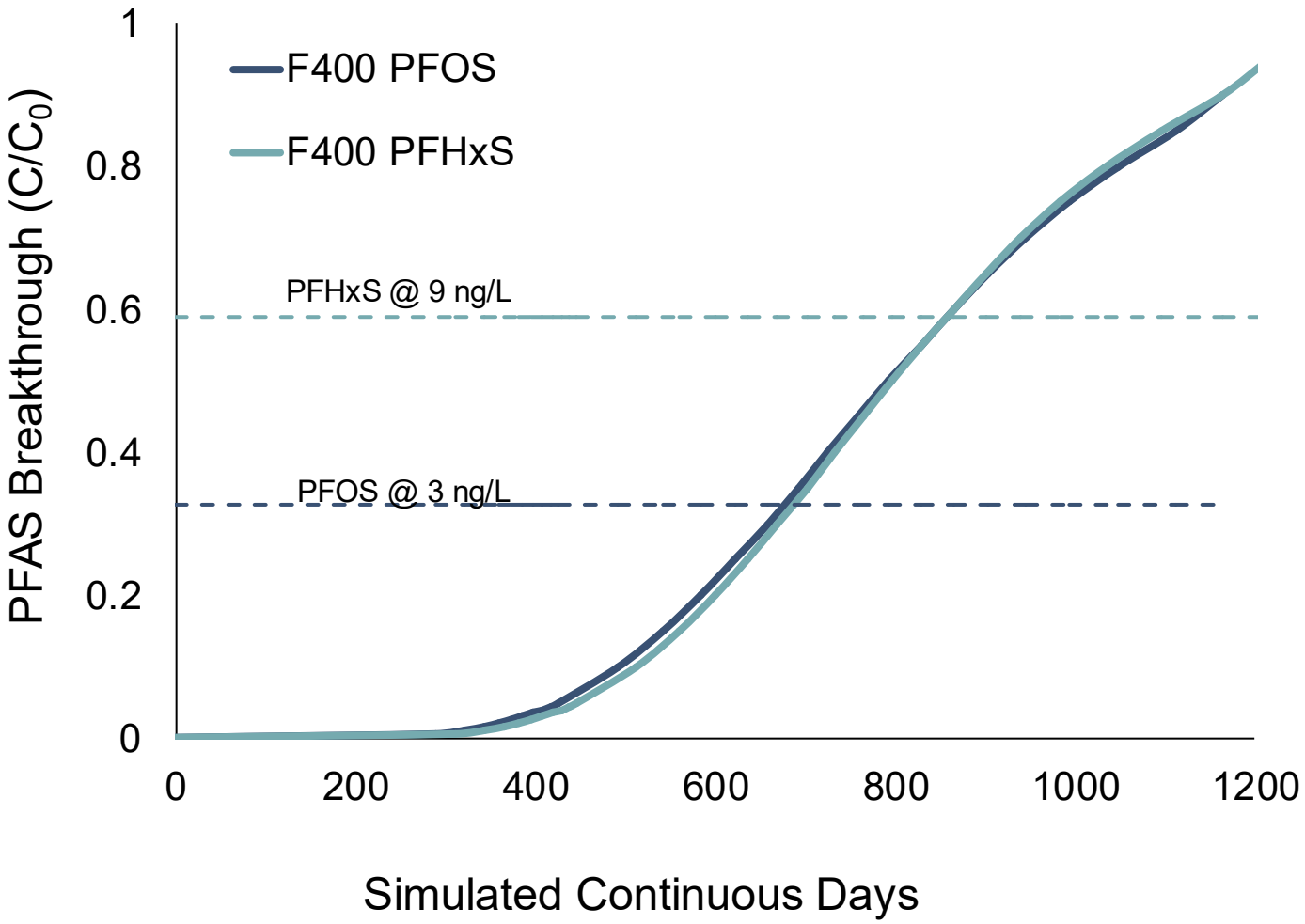
KENNEWICK WASHINGTON

Rapid Results for Long-Term Success: Identifying PFAS Adsorbents to Treat WA Groundwater Sources

May 6, 2026 | American Water Works Association Pacific Northwest Section Conference | Tacoma, WA

EXTRA

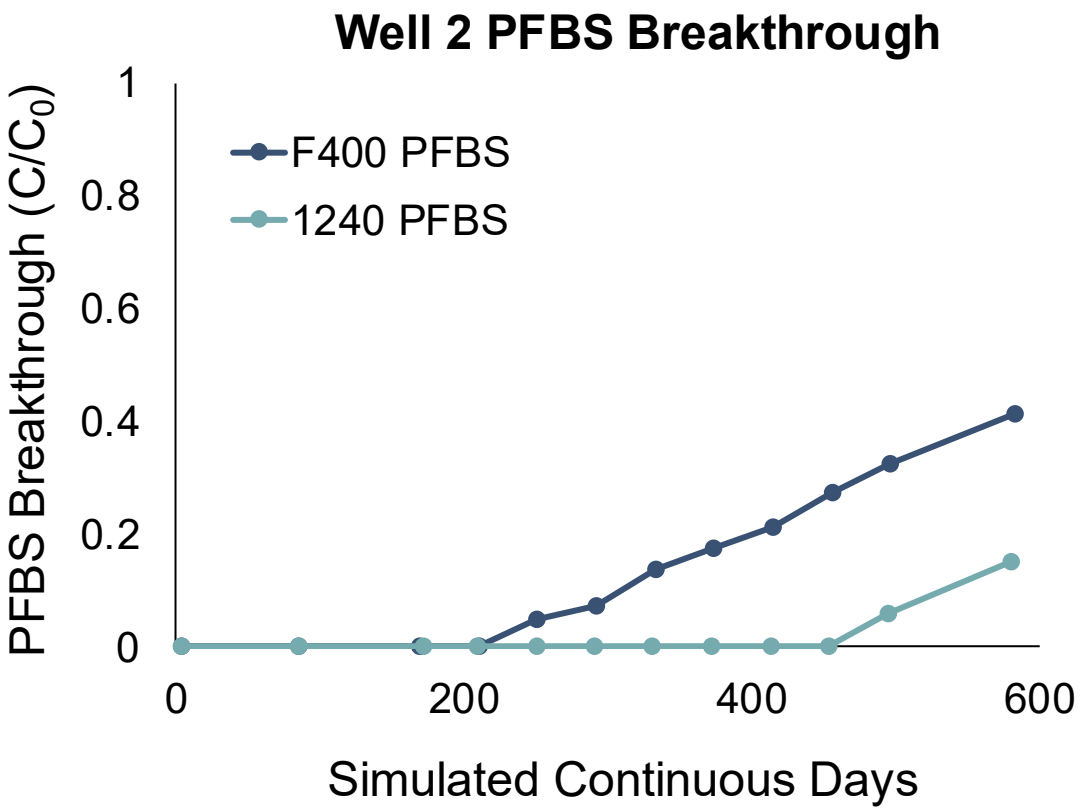
Well 2 Projected Breakthrough Curves

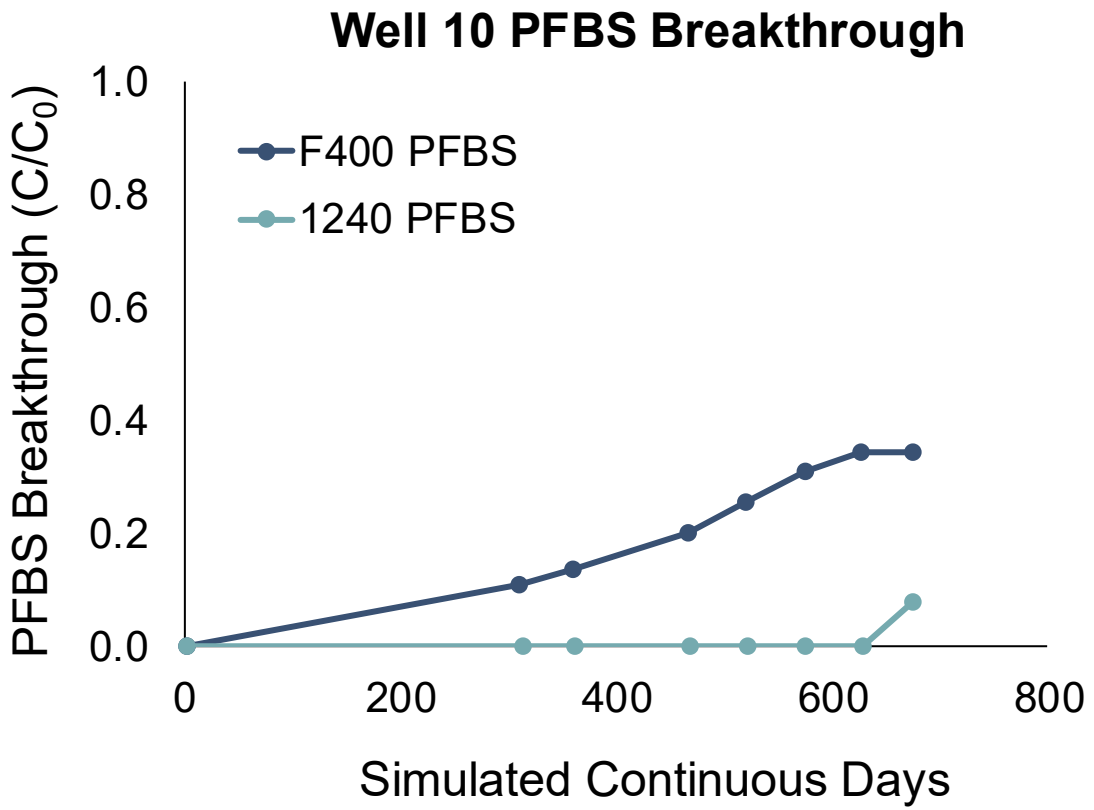


Adsorbent Media	Dictating PFAS	Changeout Frequency
Calgon F400	**PFOS**	**675 days**
Calgon F400	PFHxS	860 days
Arq 1240*	**PFOS**	**925 days**
Arq 1240*	PFHxS	1110 days

* Arq 1240 changeout frequencies were based on the difference between the first detection of PFBS for Calgon F400 and Arq 1240, resulting in a conservative estimate of Arq 1240 lasting 250 days longer than Calgon F400 for PFOS and PFHxS.

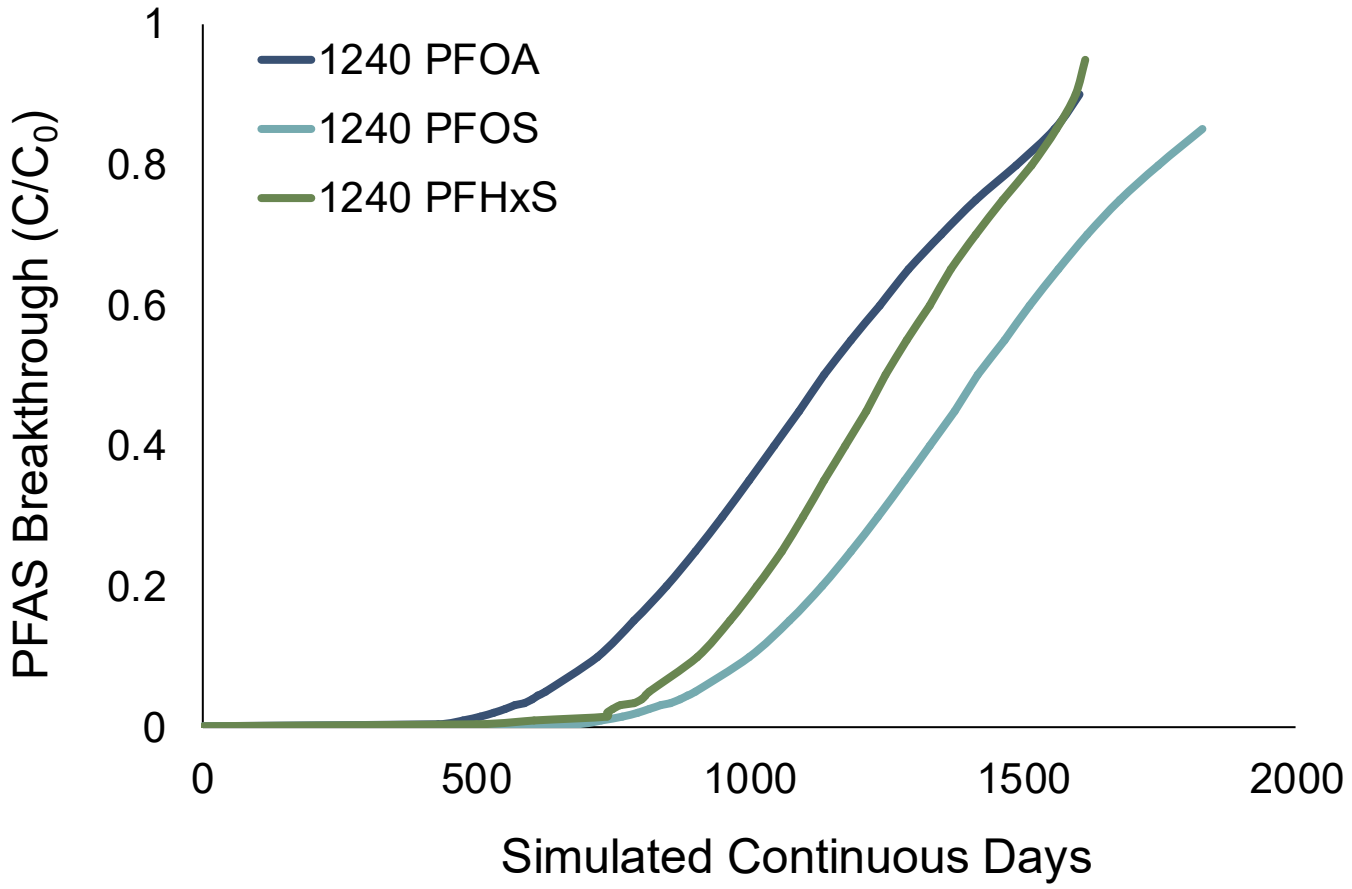
Validation of Extrapolation for Arq 1240 Projected Media Changeout Frequency





* Arq 1240 GAC media experienced no PFOS or PFHxS detections throughout the duration of the RSSCT for Well 2 and Well 2/10 blend. Changeout frequency for this media was based on the time difference between the first detected PFBS sample for each media. The first detection of PFBS for Arq 1240 occurred 250-350 days after the first observed detection compared to Calgon for well 2 and well 10 RSSCTs, respectively. Therefore, changeout frequency for Arq 1240 was assumed to be 250 days after Calgon for PFOS and PFHxS.

Well 1 Projected Breakthrough Curves



- **The average influent concentration of all PFAS are below their respective MCLs for Well 1**
- Therefore, a changeout frequency is not mentioned