PFAS-Laden Spent Media Destruction Using Supercritical Water Oxidation Technology

B6. Comparing Ex Situ Destruction Technologies

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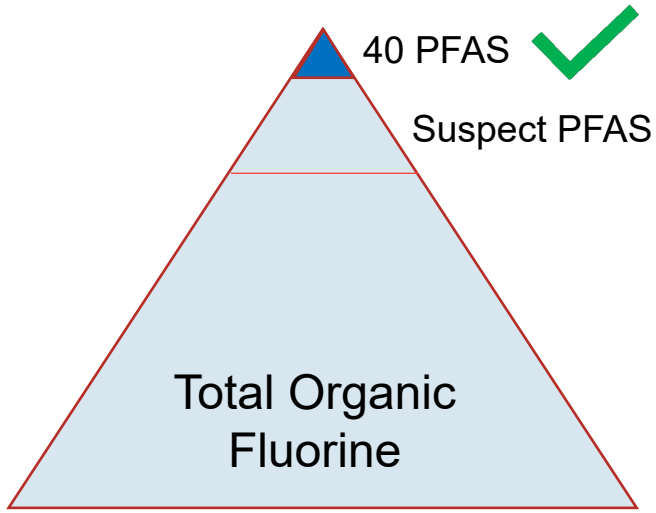
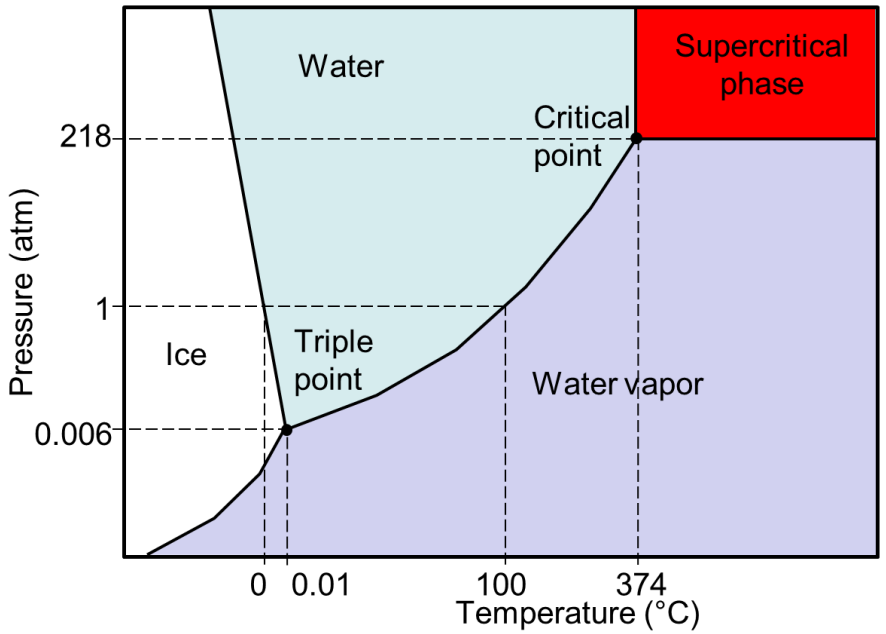
Spent PFAS-Laden Media Destruction Study Plan

- Develop a new approach to effectively, safely and economically destroy PFAS-laden spent media on site without off-site disposal or incineration
- Prove the concept that supercritical water oxidation (SCWO) technology is feasible
- Identify knowledge/data gaps and prepare for scale-up applications
  - Performance evaluation using Draft EPA Method 1633 for 40 PFAS



Technology Background



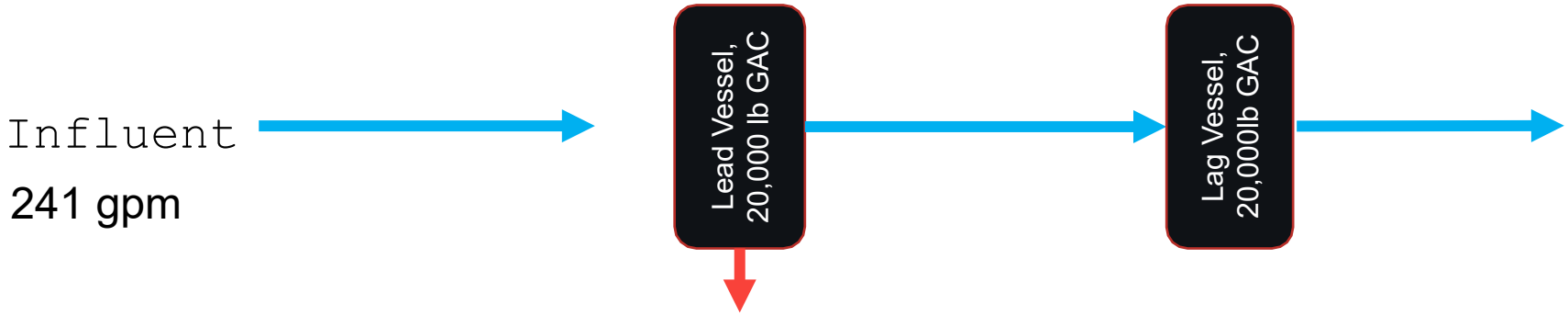
$$\textbf{PFAS} + O_2\ (\text{air}) \xrightarrow{>374\ ^\circ C,\ \sim 240\ \text{bars}} CO_2 + \mathbf{F^-} + \mathbf{CaF_2} + \text{heat} + H_2O$$

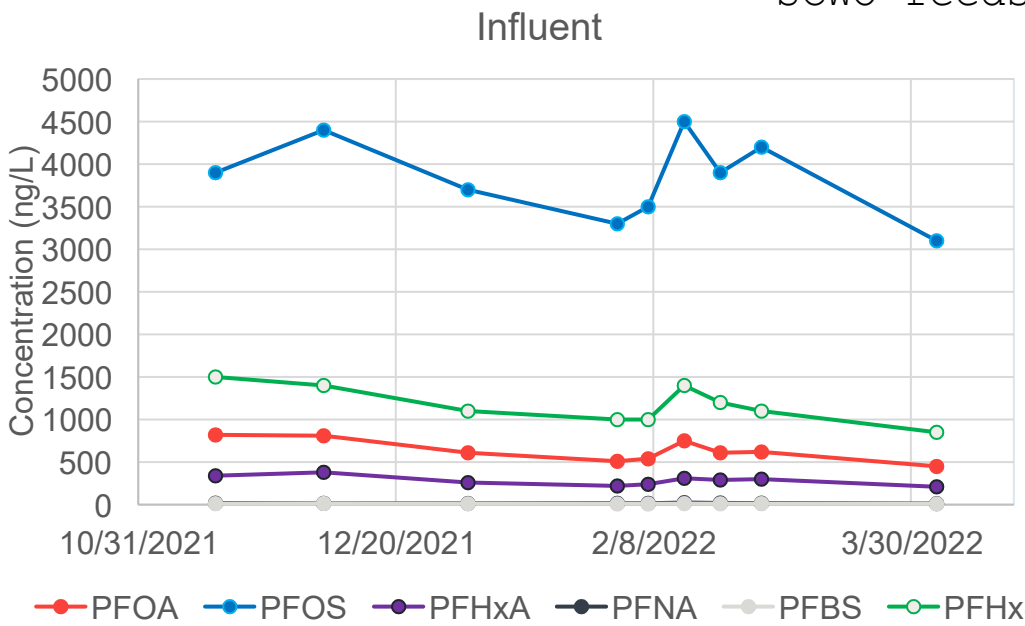
- Water >374°C and pressure of 221.1 bar is considered “supercritical”
- Under these conditions, certain chemical oxidation processes are accelerated
- Treatability studies successfully destroyed PFAS in AFFF and other concentrates
- Pilot and full-scale system available
  - 374Water AirSCWO™
  - General Atomics iSCWO™
  - Battelle Annihilator™

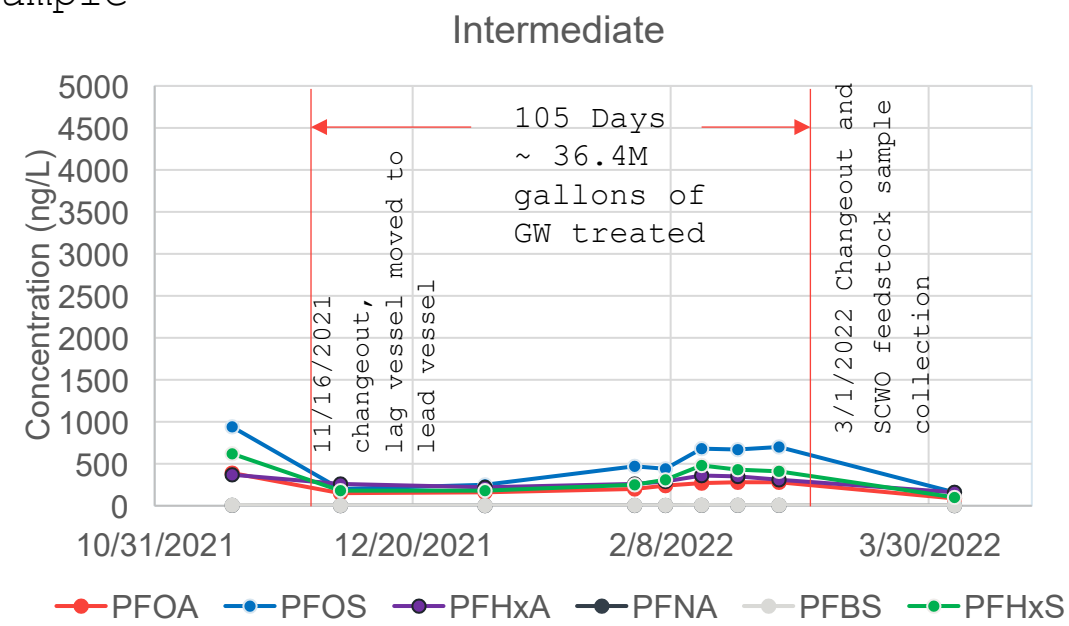
SCWO Feedstock Sample Collection

- **Spent GAC** sample (FT-02) from a full-scale groundwater treatment system
- **Spent AIX** sample (Mission Street) from a full-scale groundwater treatment system
- **Spent AIX** sample (Miramar) from a mobile wastewater treatment system
- Estimated PFAS mass loading on the spent media based on the PFAS treatment system operation and monitoring data
- SCWO treatment using 374Water AirSCWO-1 system

FT-02 Spent GAC Sample
Full-scale PFAS treatment system operated since April 2015

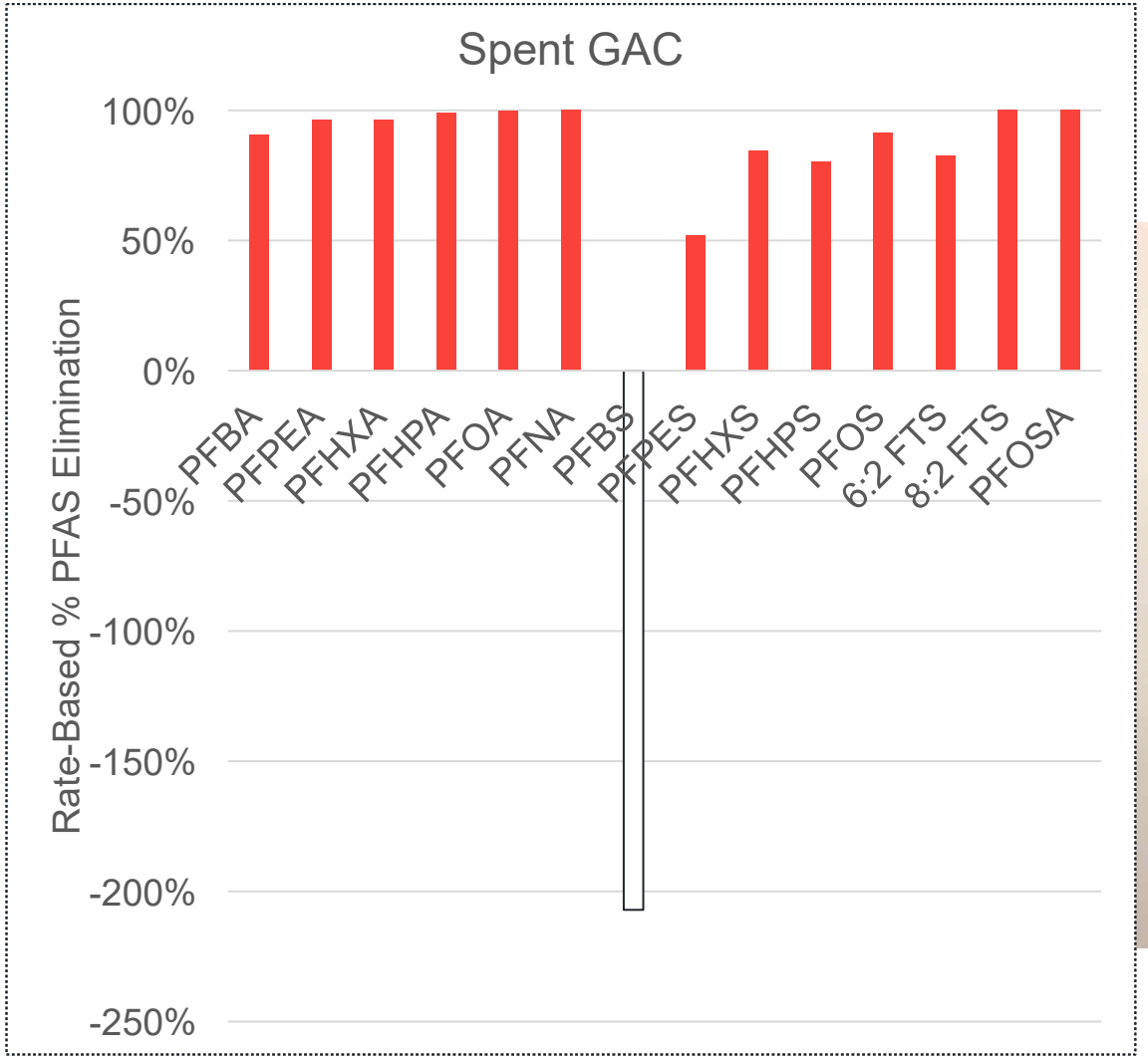


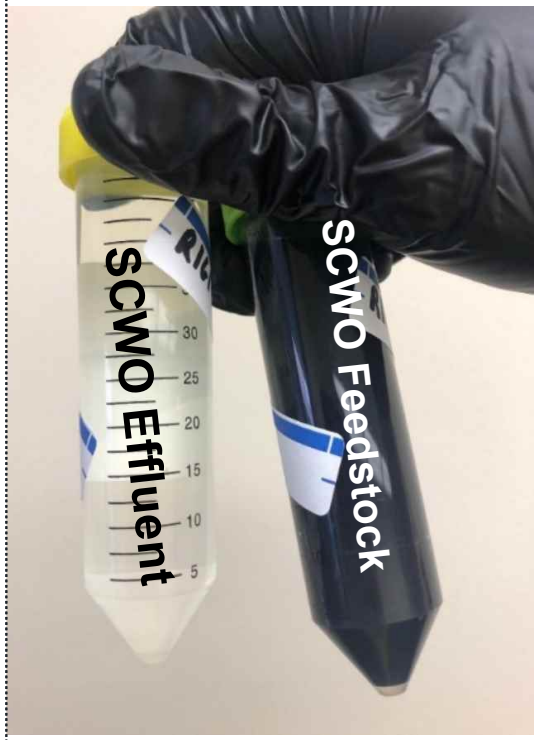




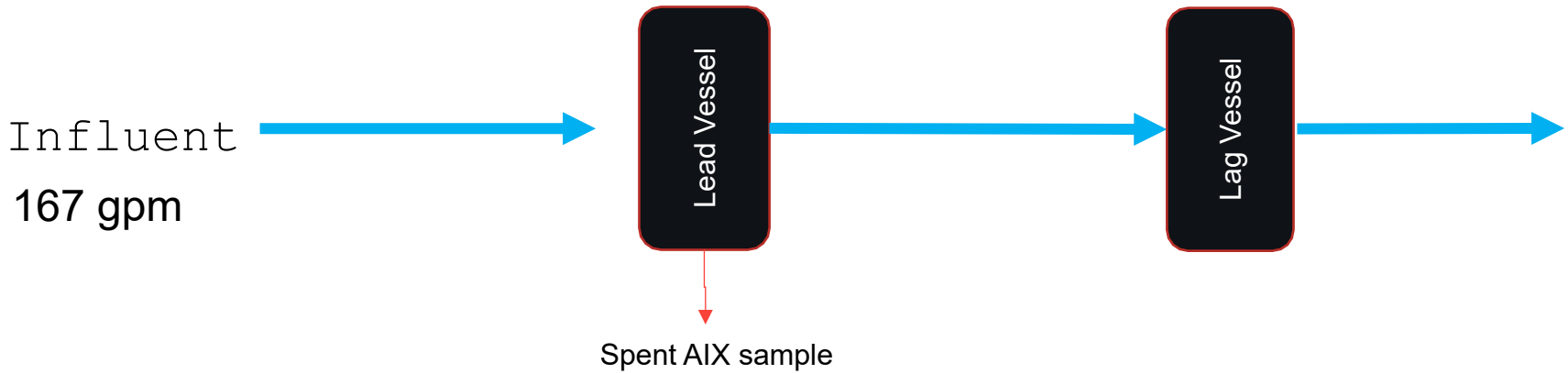
SCWO Treatment Results

FT-02 Spent GAC	Feedstock (Measured)	Effluent
	ng/kg	ng/L, ppt
PFBA	15,035.78	42.6
PFPEA	25,196.78	25.7
PFHXA	33,506.26	28.7
PFHPA	3,364.94	1.14
PFOA	**13,059.03**	**1.1**
PFNA	288.82	ND
PFBS	689.62	41.3
PFPES	514.4	5.09
PFHXS	17,737.03	50.9
PFHPS	928.44	4.62
PFOS	**83,935.60**	**243**
6:2 FTS	12,611.81	98.7
8:2 FTS	4,321.11	ND
PFOSA	3,164.58	5.07
Total PFCA	90,451.61	99.24
Total PFSA	103,805.09	344.91
Precursors	20,097.50	103.77
Short chain (C<6)	41,436.58	114.69
Total	214,354.20	547.92





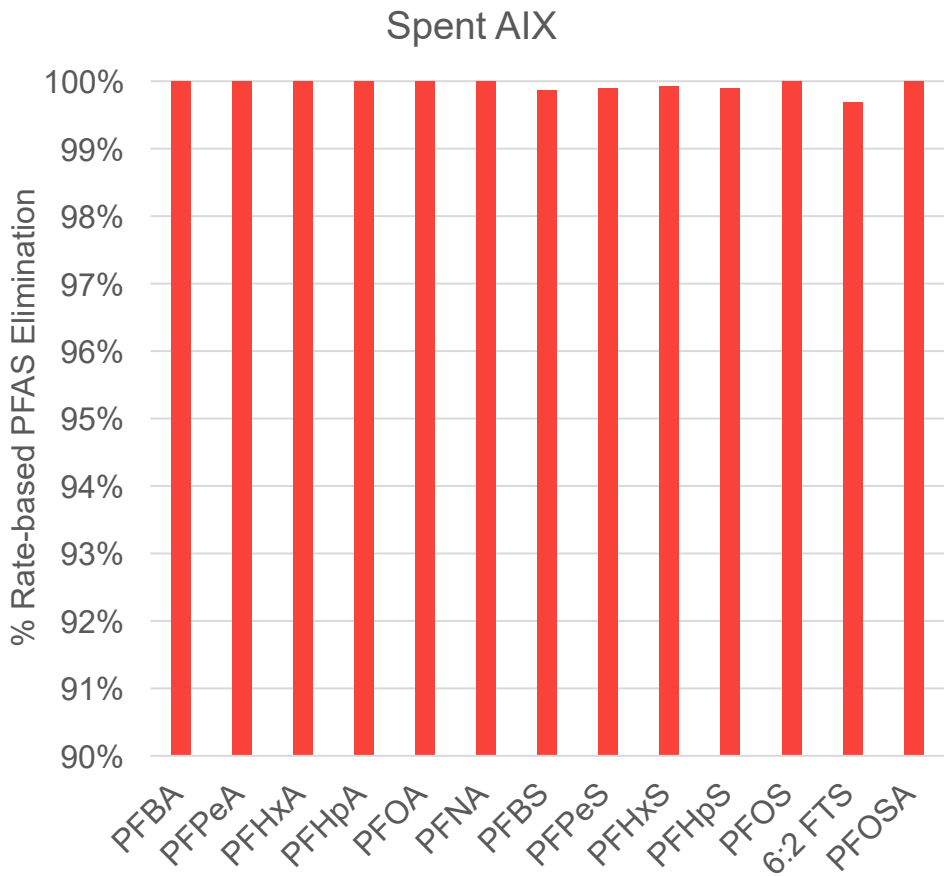
Mission Street Spent AIX Sample



- AIX resin treatment system has been operated since December to treat extracted groundwater for PFOS and PFOA
- The spent AIX is drained and disposed of
- The spent AIX sample for SCWO study was collected from the lead vessel after 264 days of lead vessel operation (i.e., treatment of 63.4 M gallons of influent groundwater)

SCWO Treatment Results

Mission Street Spent AIX	Feedstock	Effluent
	ng/kg	ng/L, ppt
PFBA	2,645.65	ND
PFPeA	17,841.45	ND
PFHxA	87,831.90	1.04
PFHpA	31,155.68	ND
PFOA	**120,057.31**	**ND**
PFNA	686.53	ND
PFBS	27,153.77	0.47
PFPeS	36,743.08	0.5
PFHxS	555,873.93	6.45
PFHpS	50,687.68	0.71
PFOS	**421,776.50**	**62.7**
6:2 FTS	33,256.92	1.39
PFOSA*	182.426	3.74
Total PFCA	260,218.52	1.04
Total PFSA	1,092,234.96	70.83
Precursors	33,256.92	5.13
Short chain (C<6)	84,383.95	0.97
Total	1,385,892.83	77



Miramar Spent AIX Sample

- Total PFAS influent concentrations exceeding **8 mg/L**
- Treatment train : organoclay (pre-treatment), GAC (primary treatment), and AIX (polishing treatment).
- COCs: PFAS, metals, TPH, VOC
- Two independent treatment trains of the same configuration
- Maximum operational flow rate of 10 gpm, and total EBCT of 50 minutes
- AIX treated approximately 0.36 M gallons of PFAS-contaminated wastewater

SCWO Treatment Results

Miramar Spent AIX	Feedstock	Effluent
	ng/kg	ng/L, ppt
PFBA	85,907.81	7.82
PFPEA	102,163.69	4.74
PFHXA	33,979.30	7.08
PFHPA	1,641.58	1.01
PFOA	**7,515.52**	**1.82**
PFBS	41,279.40	9.55
PFPES	4,724.37	10.8
PFHXS	33,659.45	198
PFHPS	8,056.44	39.5
PFOS	**491,251.18**	**501**
PFNS	180.53	ND
6:2 FTS	77,441.20	ND
8:2 FTS	3,875.82	ND
PFOSA	3,492.94	14.7
Total PFCA	231,207.90	22.47
Total PFSA	579,151.37	758.85
Precursors	84,809.96	14.70
Short chain (C<6)	234,075.27	32.91
Total	895,169.23	796.02

Extractable PFAS from Spent Media using Draft Method 1633

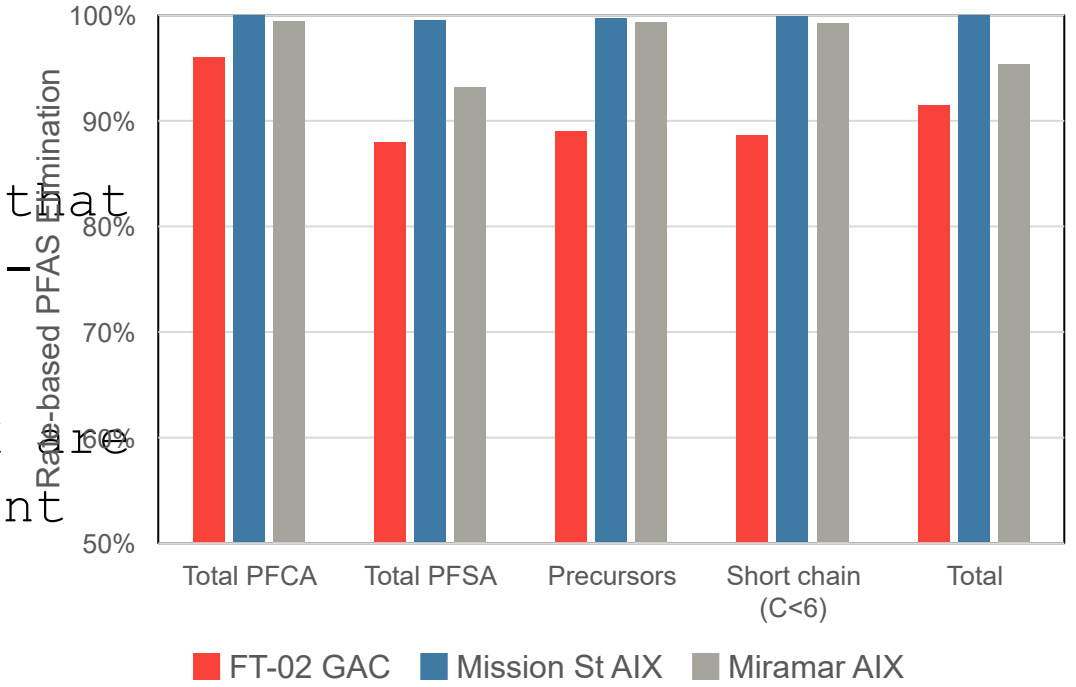
- Low PFAS recovery from spent GAC and AIX
- PFAS elimination %, DRE and fluorine mass balance are not reliable

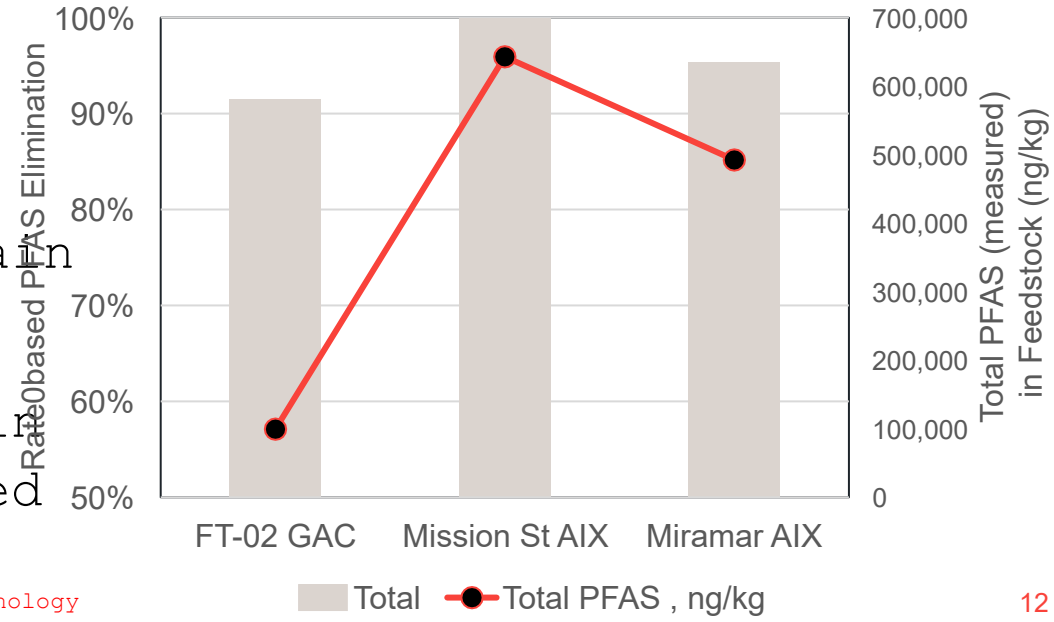
Mass loading	Calculated in spent GAC	EPA 1633 measured
PFOA, ng/kg	11,045,123	13,059
PFOS, ng/kg	59,622,929	83,936

Mass loading	Calculated in spent AIX	EPA 1633 measured
PFOA, ng/kg	1,658,988,799	120,057
PFOS, ng/kg	13,863,759,680	421,776

Summary

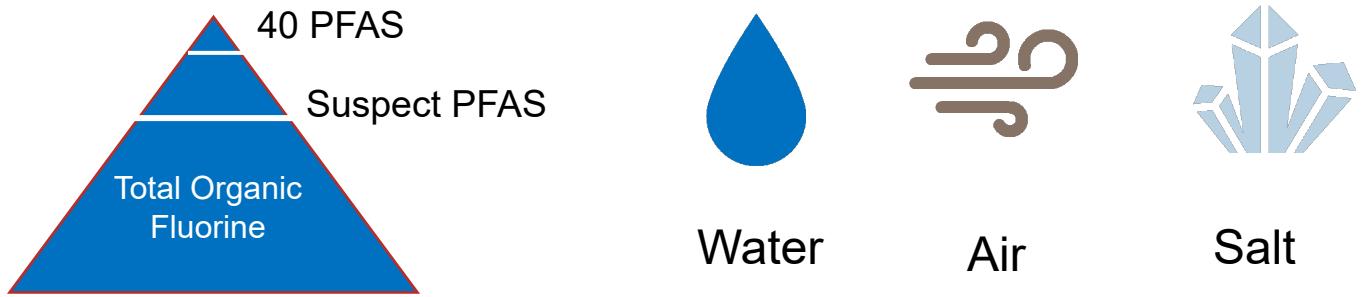
- The study proves the concept that SCWO can decompose spent PFAS-laden GAC and AIX
- PFAS in the spent GAC and AIX are eliminated after SCWO treatment
- Rate-based PFAS elimination effectiveness
  - Spent AIX > spent GAC
  - PFCAs > PFSAs
  - Long-chain PFAS > short chain PFAS
- Measured PFAS concentrations in feedstock may be underestimated



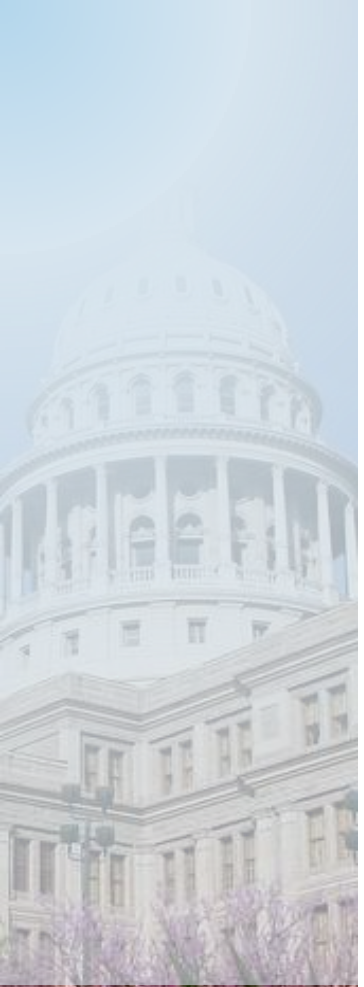


Next Step

- Advancing understanding of SCWO for Solid Waste Treatment
  - *PFAS destruction*
  - *F mass balance*
  - *Factors governing PFAS destruction*
    - Calorific value
    - SCWO reaction time
    - Sorbent media structures
    - Energy consumption
- On-site demonstration using AirSCWO-6
- Life cycle assessment
- Develop robust performance monitoring program



Two Pilot- Scale Demonstrations Using AirSCWO-6



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374WATER

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Thank You

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