PFAS Remediation: Application of water treatment technologies

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Acknowledgements

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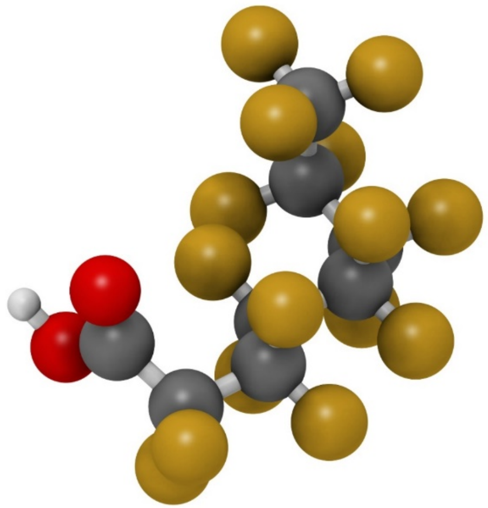
- Duluth
- Grand Rapids
- Hibbing
- Minneapolis
- Remote (CO, ME)
- Salt Lake City
- Technology supplier/partner: Clean Harbors

Outline

- Introduction to PFAS and PFAS treatment technologies
- Two case studies
  1. Industrial stormwater treatment
  2. Manufacturing process water treatment
- Direction and challenges of PFAS water treatment

PFAS Properties

- **manufactured chemicals** that are used in products that resist heat, oil, stains, and water
  - used in **coating** and **waterproofing** processes, **fire suppression,** and to reduce surface tension
- resistant to biodegradation
- destroyed at high temperatures
- semi-volatile
- miscible in water
- slight affinity for organic carbon



Per- and polyfluoroalkyl substances

(PFAS)

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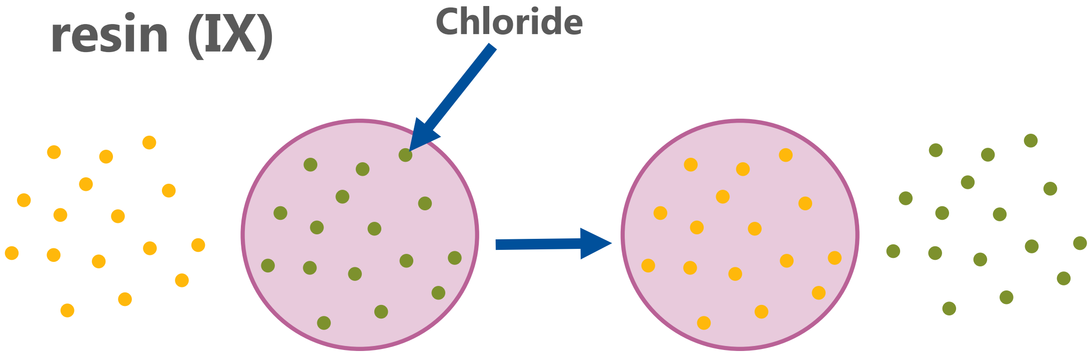
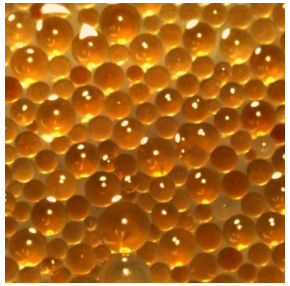
Widely-demonstrated PFAS water treatment technologies

Granular activated carbon (GAC)

12x40 reagglomerated bituminous coal

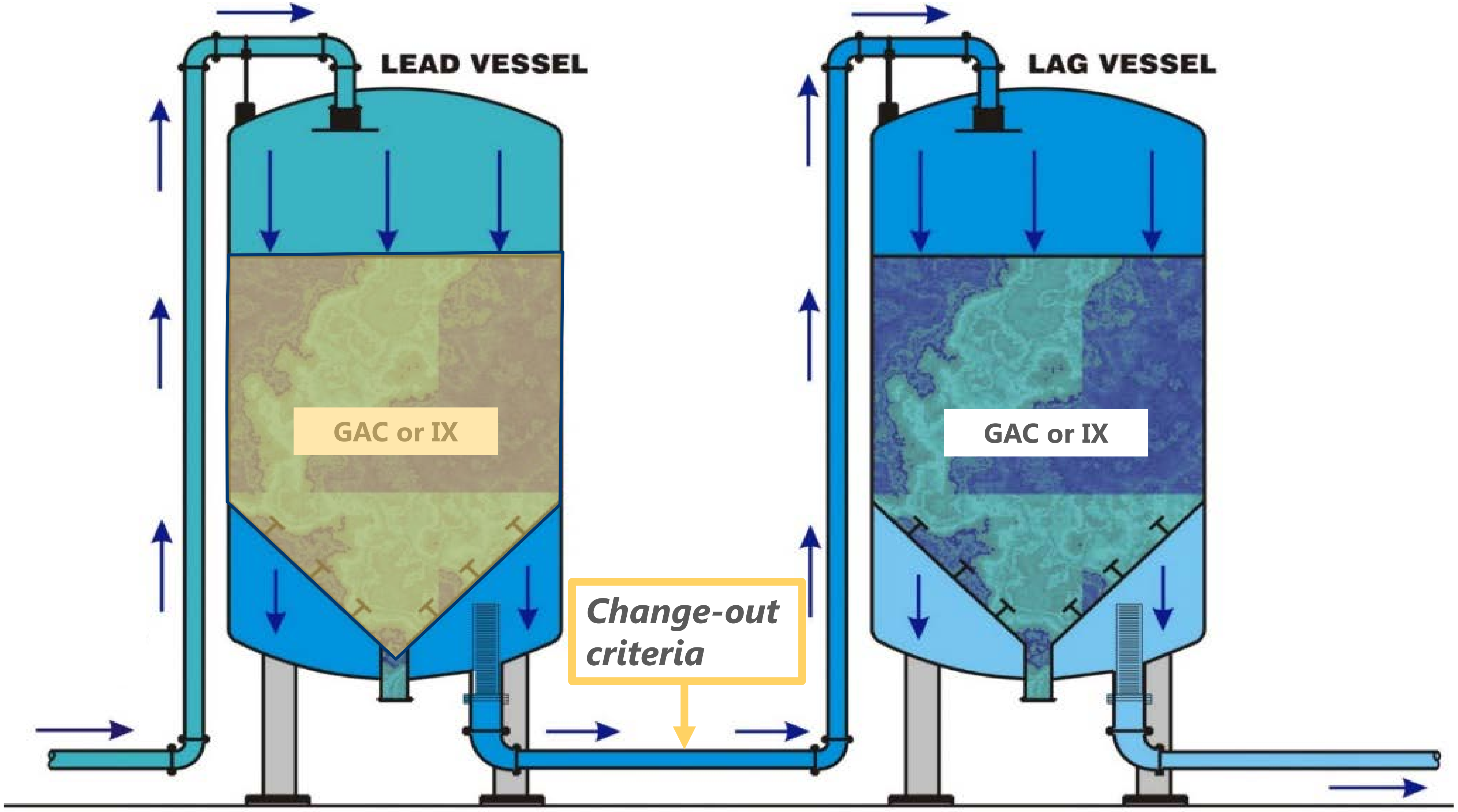
Ion exchange resin (IX)





Most are quaternary amine functional groups (re-purposed perchlorate/strong base anion exchange resins)

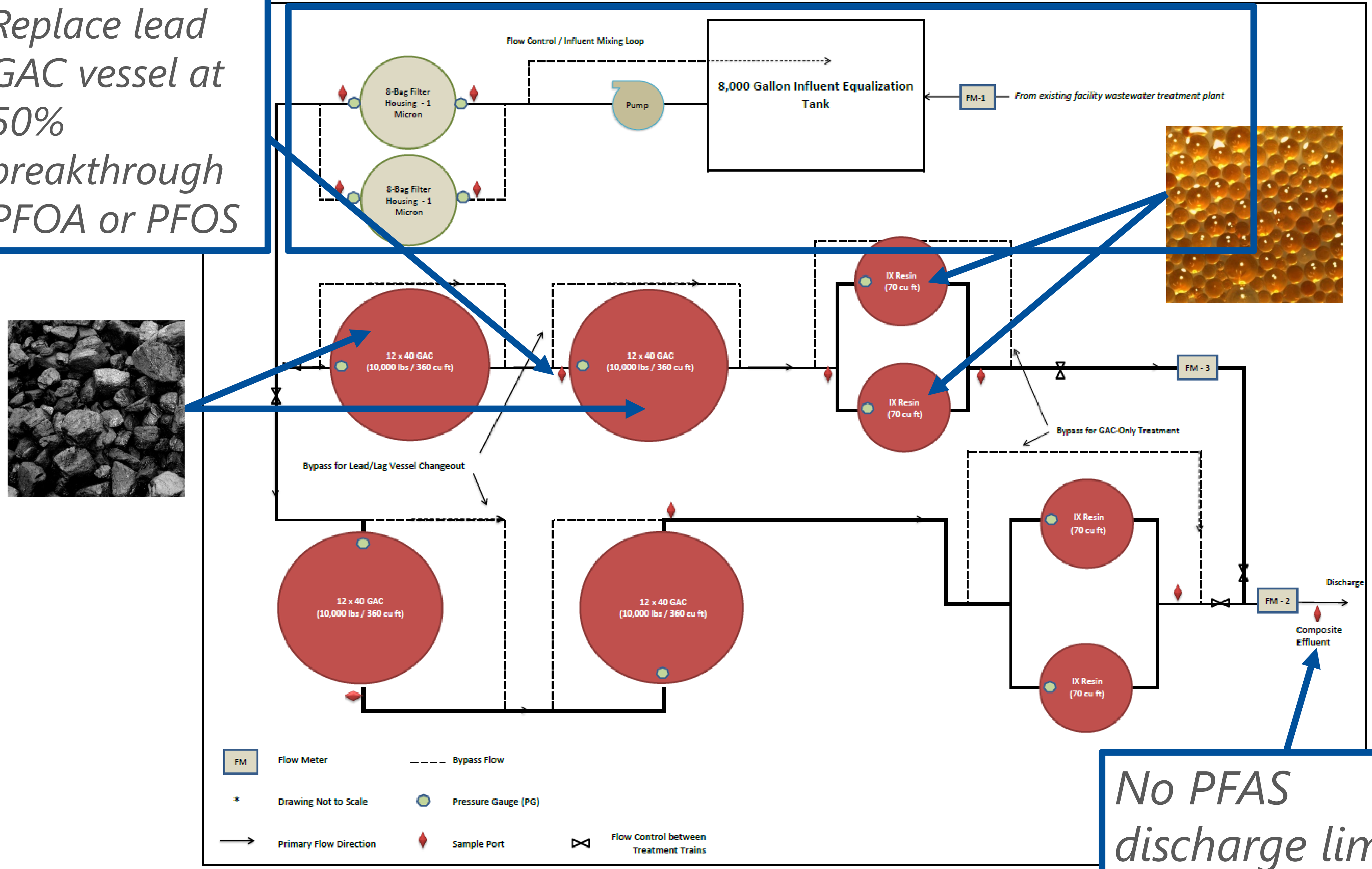
Typical PFAS water treatment



PFAS water treatment system example 1

- **Client type:** industrial
- **Water source:** stormwater, onsite ponds, process water
- **Objective:** treat PFAS-impacted water post-fire for discharge to surface water

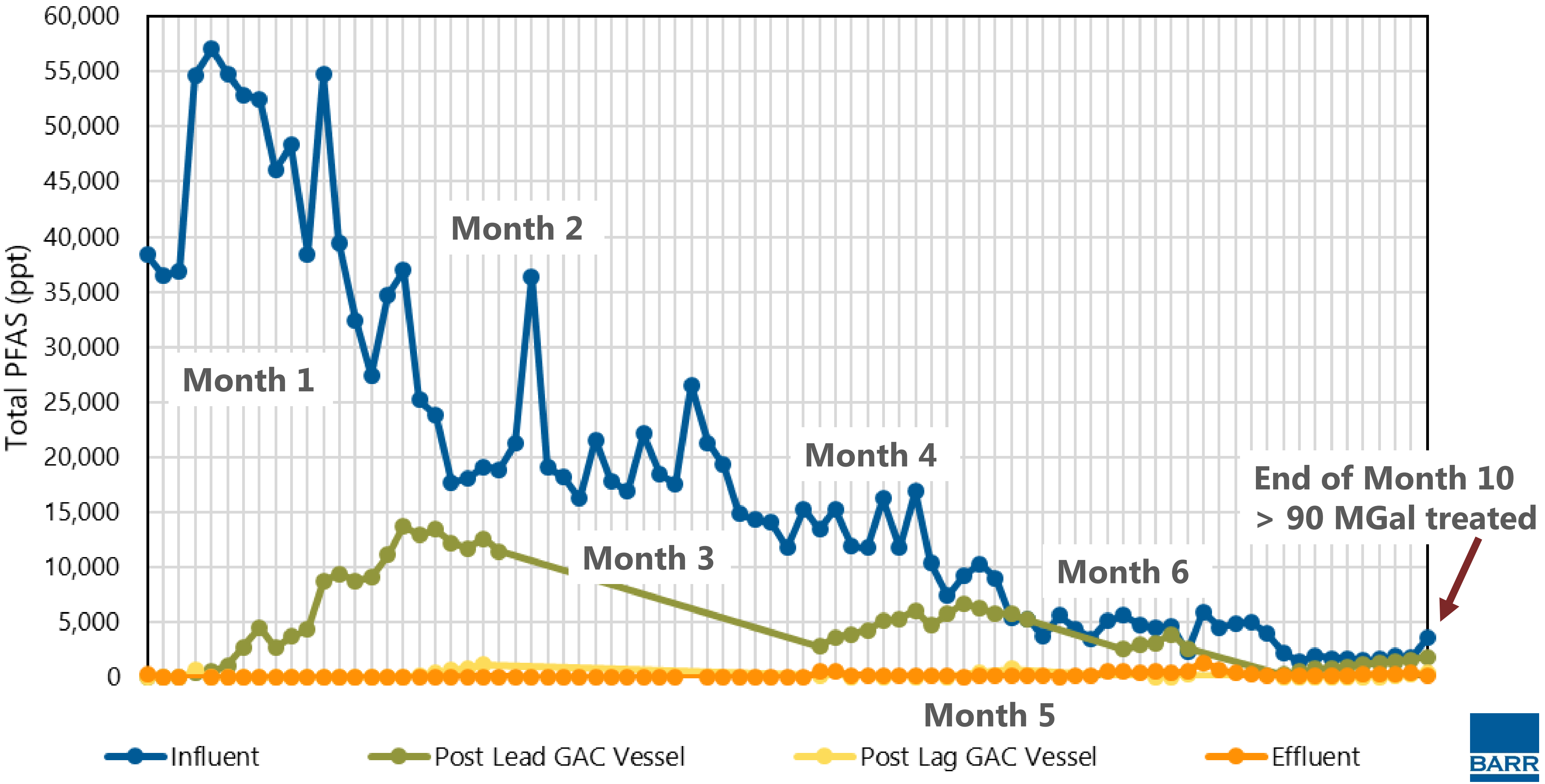
Replace lead GAC vessel at 50% breakthrough PFOA or PFOS



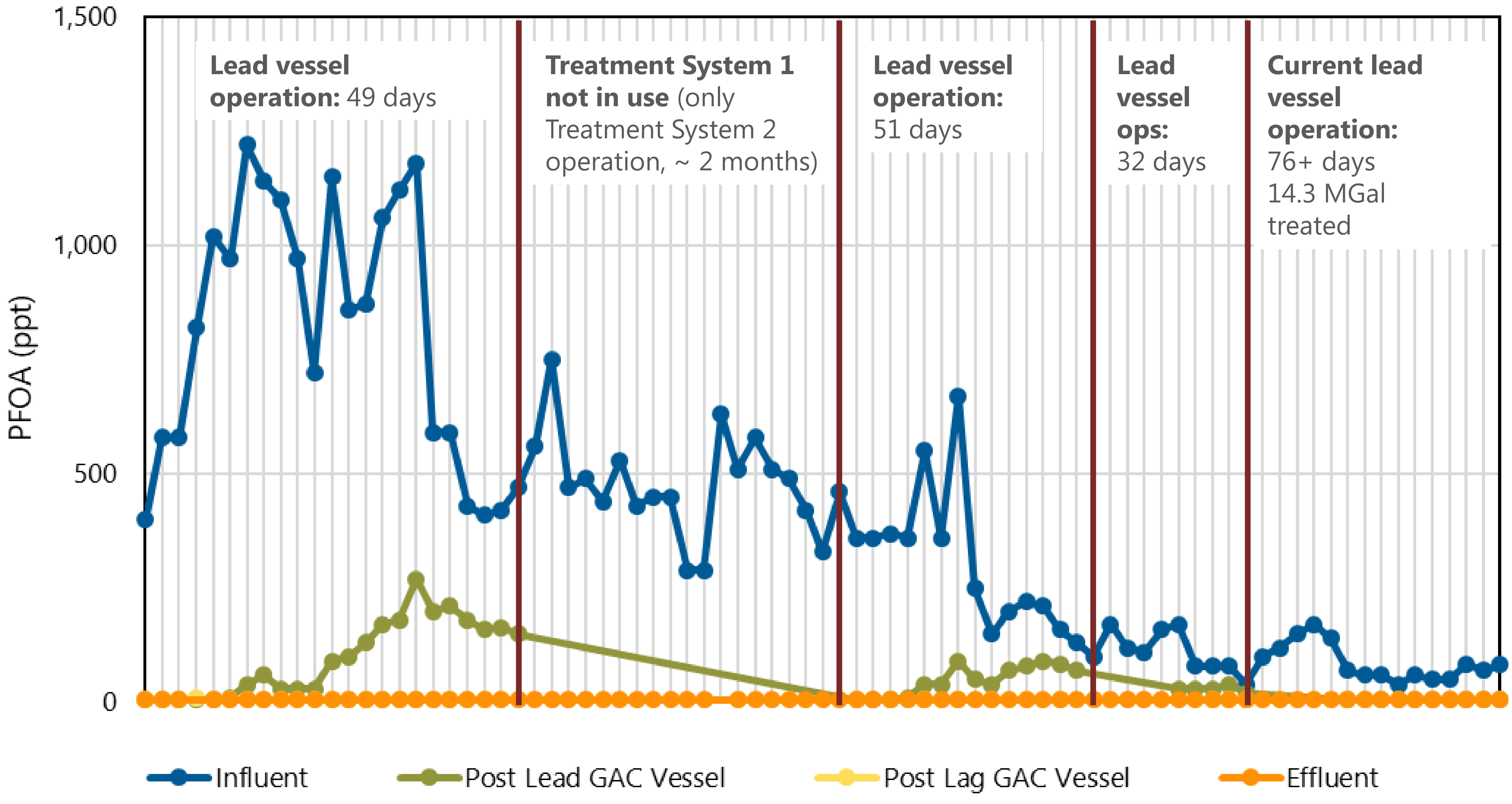
No PFAS discharge limits

PFAS water treatment system 1

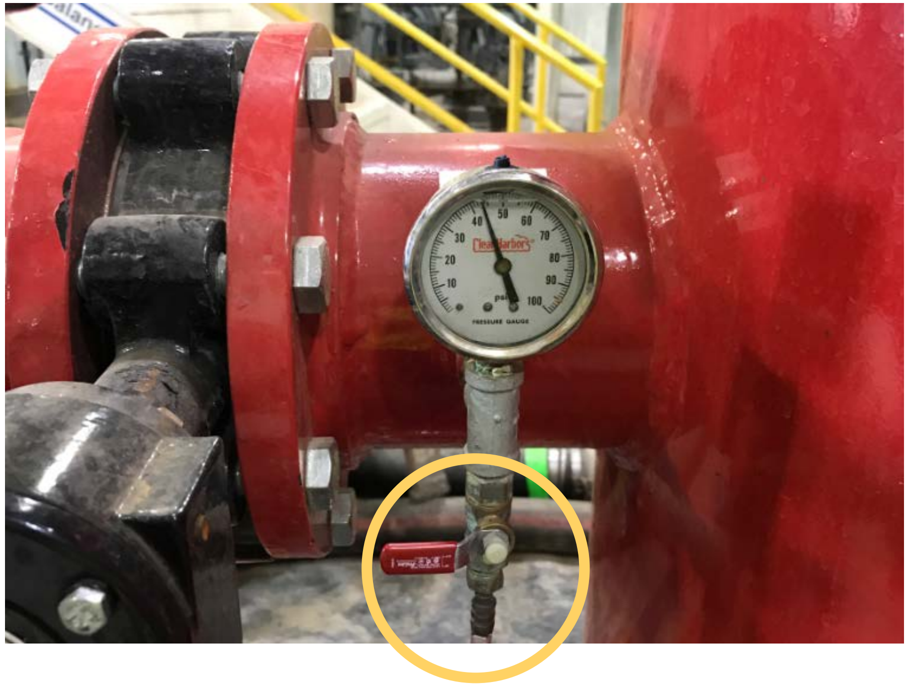
Total PFAS breakthrough and PFAS mass removal



PFOA breakthrough and lead vessel change out



Lessons learned



- Absence of PFAS limits during design
- GAC usage rate
- Management of PFAS breakthrough (esp. short chains)

PFAS water treatment system example 2

- **Client type:** industrial, manufacturing
- **Water source:** process wastewater
- **Objective:** treat PFAS-impacted wastewater for discharge to sanitary sewer

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Process Objectives

Wastewater characteristics

- Process wastewater
- Foamy
- Slightly acidic (~pH 6)
- Elevated concentration of fine particles
- Intermittent elevated iron
- High total organic carbon, biological oxygen demand

Key technical objectives

- Key objective is to remove PFAS
- Prepare water for granular activated carbon treatment
  - Remove fine particles and iron
  - Remove total organic carbon
- Continue to meet current effluent limits
- Minimize residual volume

Treatment process development: **solids removal**

Bench

Physical

-Filtration

-Centrifugation

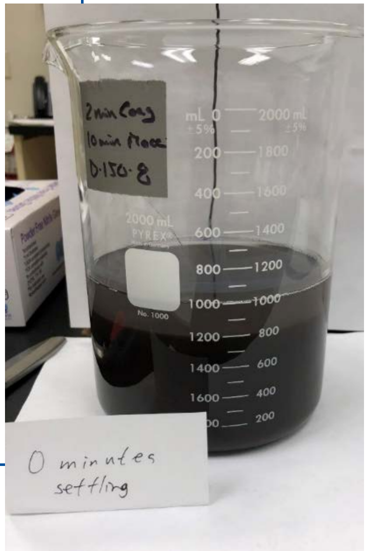
-Heating

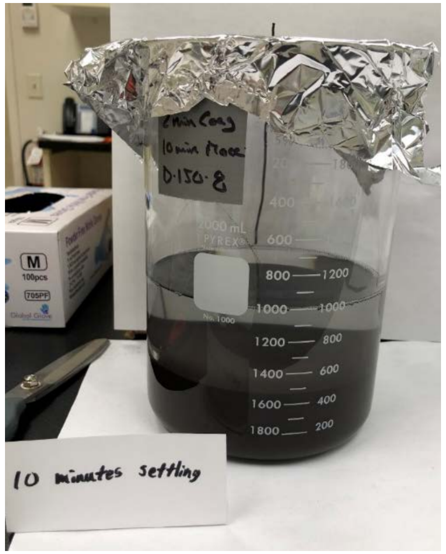
Biological

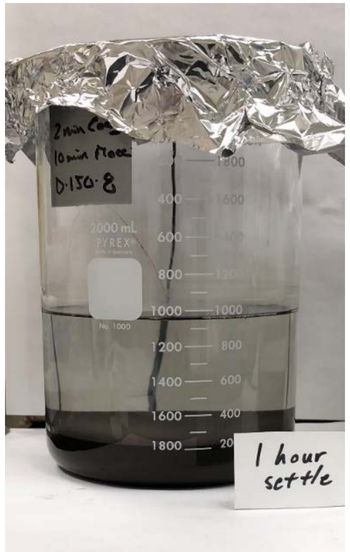
Chemical

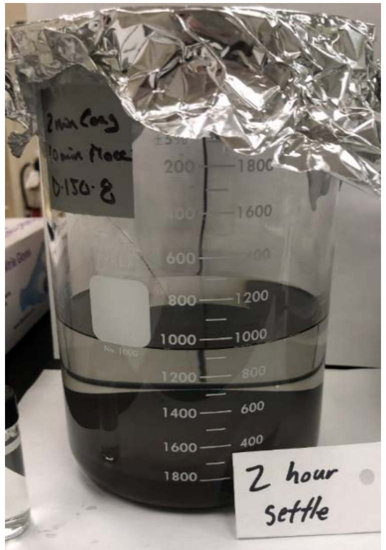
-pH adjustment

-Coagulation/flocculation









Treatment process development: **scale-up**

Bench

Physical

-Filtration

-Centrifugation

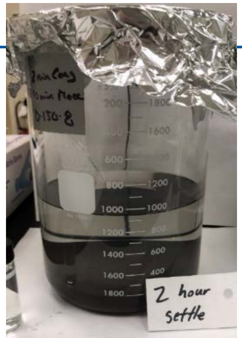
-Heating

Biological

Chemical

-pH adjustment

-Coagulation/flocculation



Column

Media testing and selection

-GAC

-IX

-Combinations

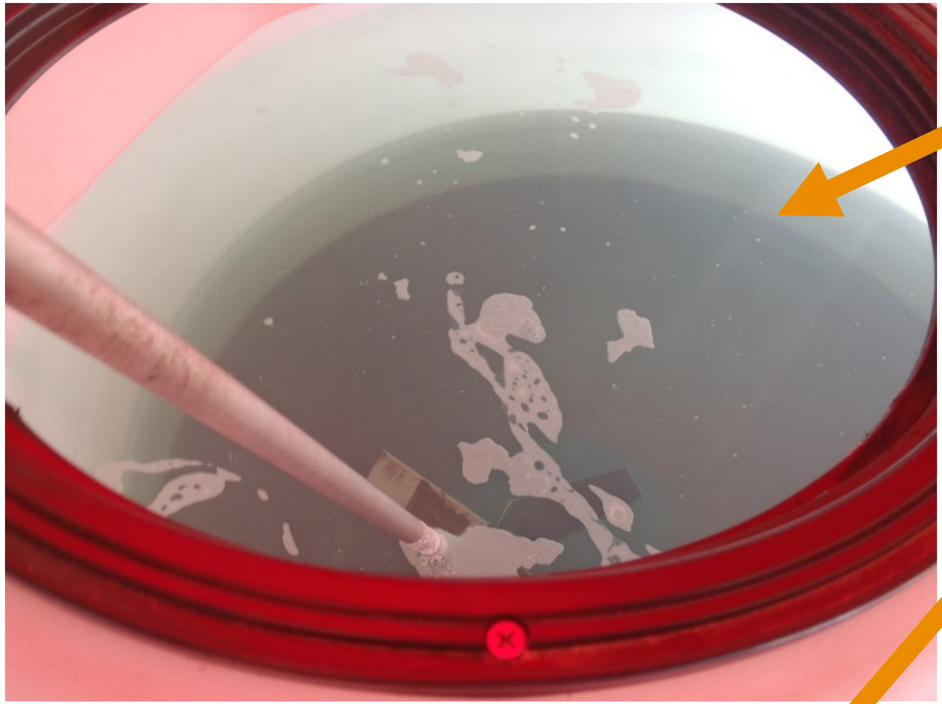
Pilot

Scale-up

Validate performance

Assess feed water variability

Pilot testing

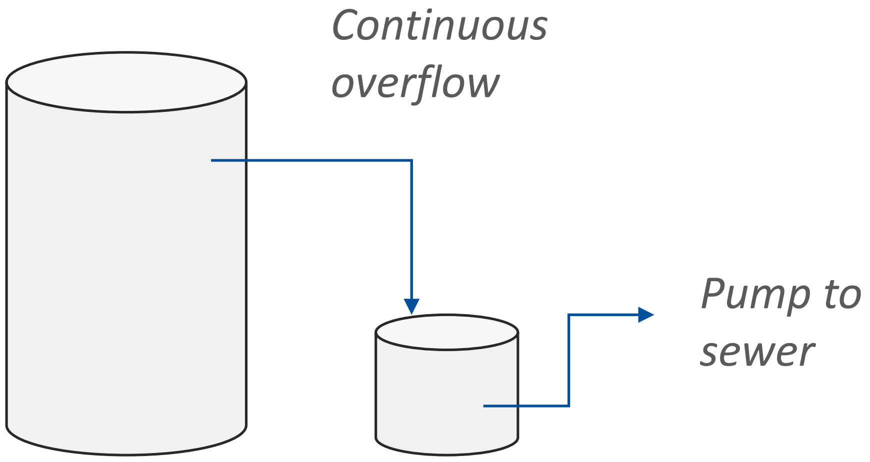


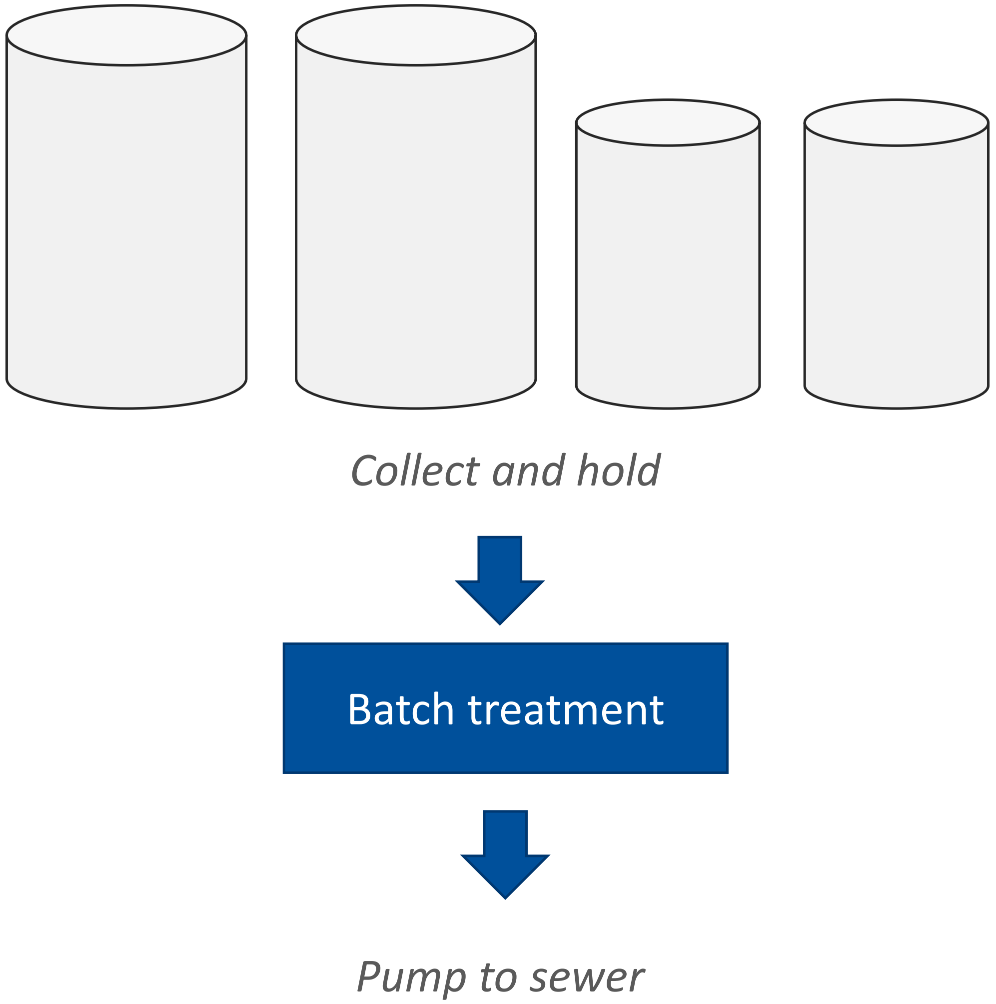
Settling

GAC filtration

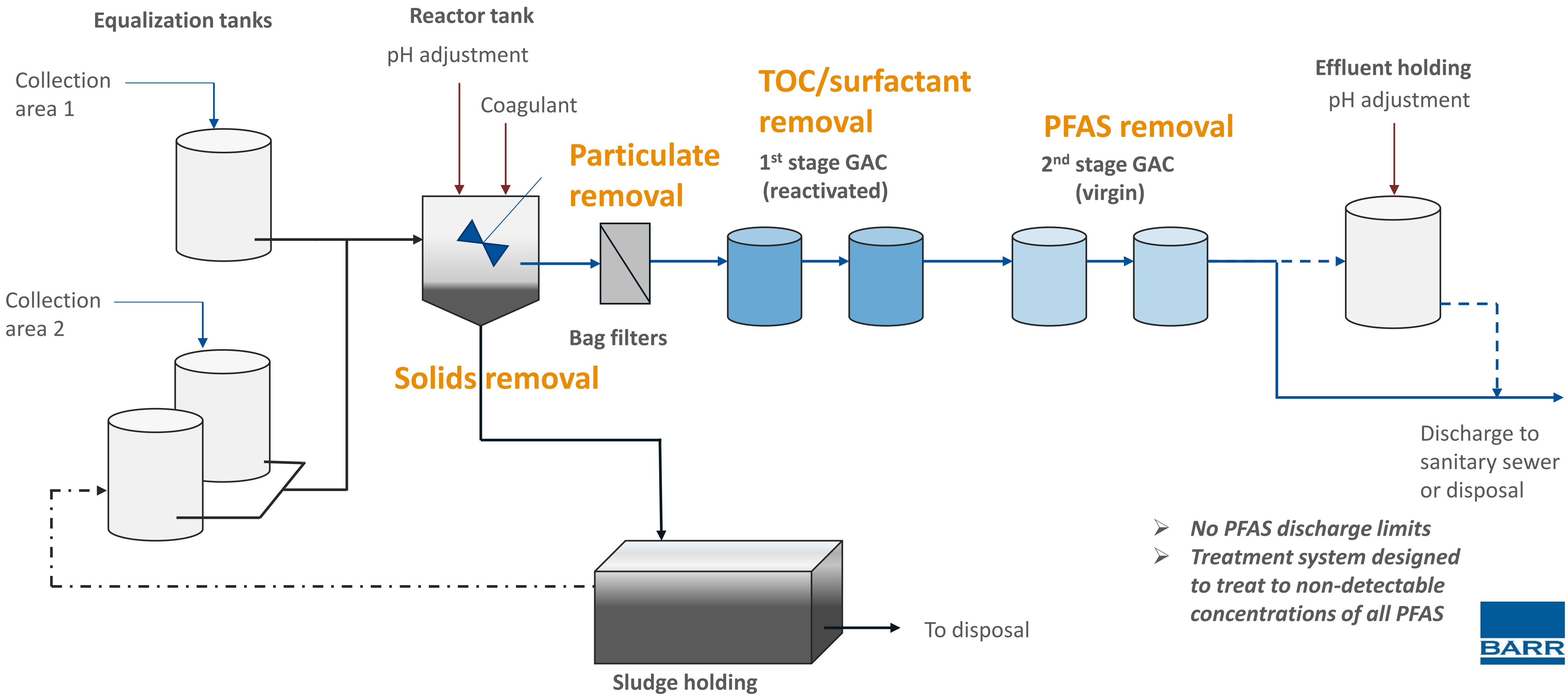
Bag filtration

Full scale treatment system design



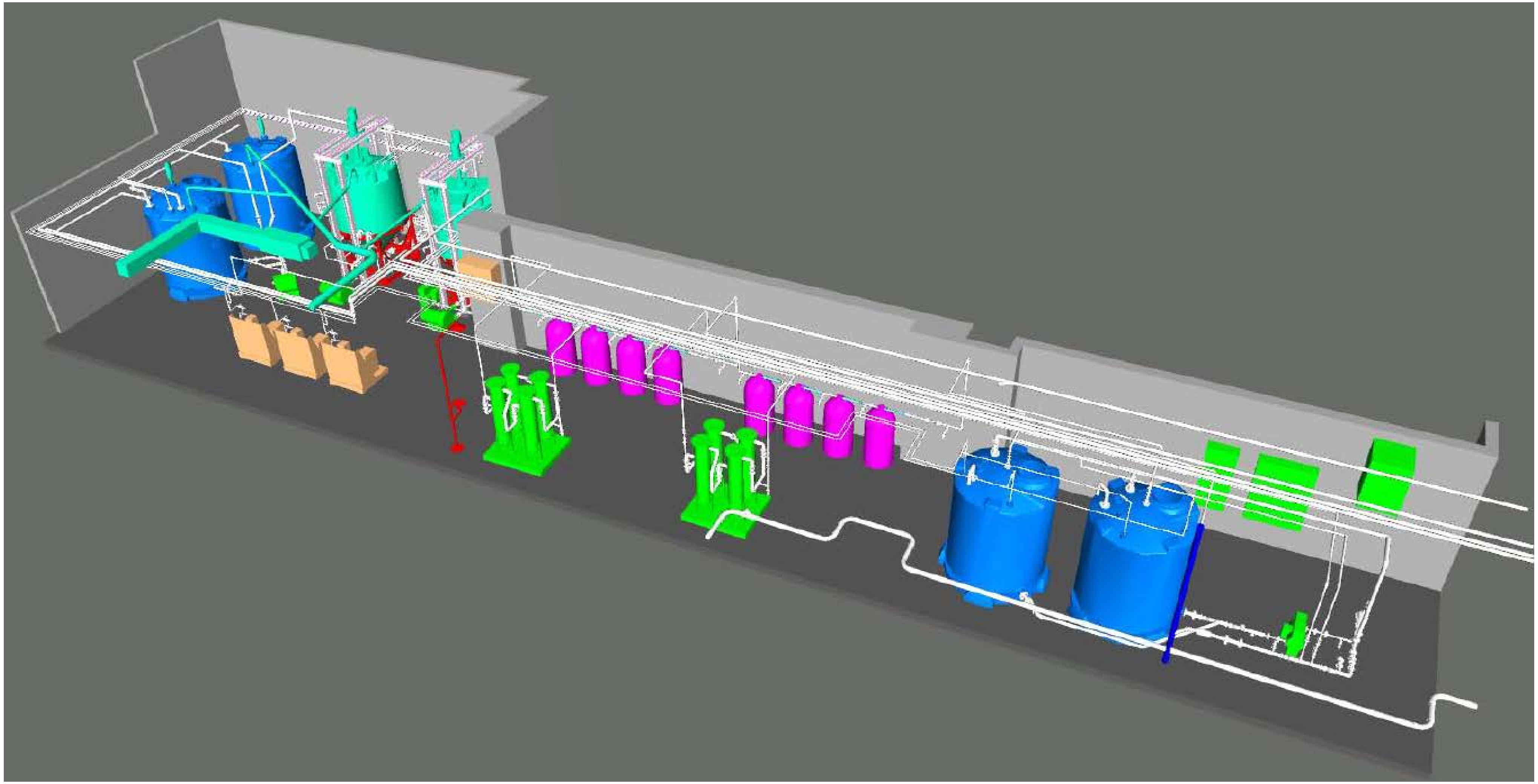


Full-scale treatment system process flow



- ***No PFAS discharge limits***
- ***Treatment system designed to treat to non-detectable concentrations of all PFAS***

Full-scale treatment system layout



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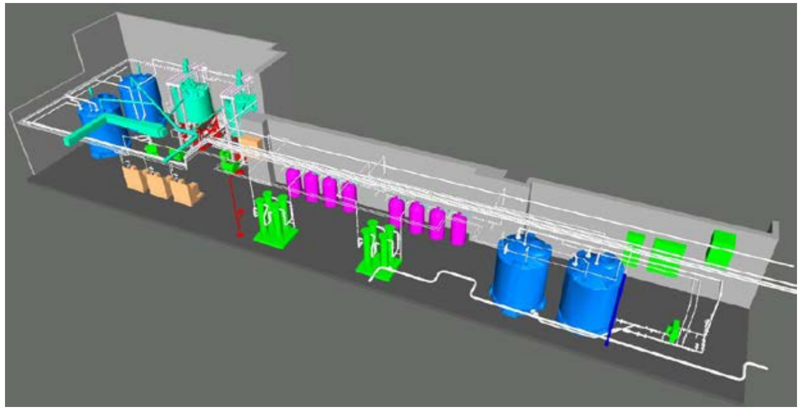
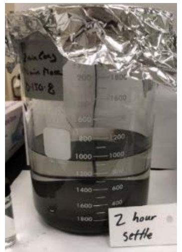
Lessons learned





- PFAS Breakthrough and mass distribution
  - HFPO-DA 50%
  - PFHxA 25%
  - PFPeA 15%
  - PFBA 10%
- Cost drivers—residual management

Conclusions

- Challenges
  - Uncertainty in “treat-to” limits and treatment goals
  - Short-chain PFAS are difficult to treat with current technologies
  - Build flexibility into system for evolving market and technologies
- Direction of PFAS water treatment
  - Move to greater sustainability
  - Develop on-site destruction technologies for PFAS

Thank you!

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Supplemental Slides

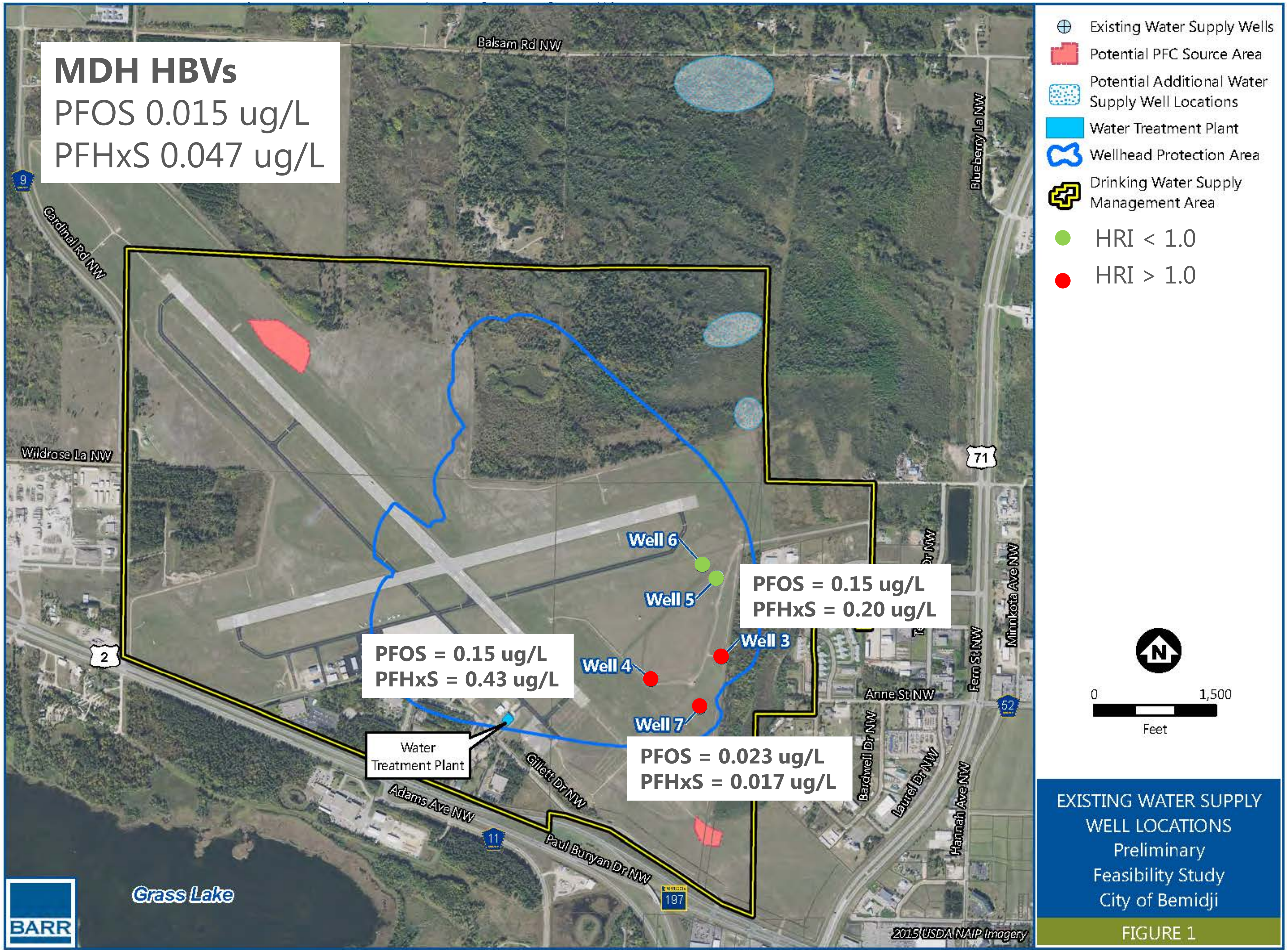
PFAS-impacted drinking water management example

- **Client type:** municipal (City of Bemidji, Minnesota)
- **Water source:** groundwater, drinking water
- **Objective:** supply drinking water below a health risk index of 1.0 per the Minnesota Department of Health's additive PFAS risk calculation

Minnesota Department of Health (MDH) Guidance

Short name	Full Chemical Name	Current Health Risk Limit (HRL) µg/L	Current Health Based Guidance Value (HBV) µg/L
PFBA	Perfluorobutanoic acid	7.0	No value
PFOA	Perfluorooctanoic acid	0.035	No value
PFBS	Perfluorobutane sulfonate	7.0	2.0
PFOS	Perfluorooctane sulfonic acid	0.3	0.015
PFHxS	Perfluorohexane sulfonate	No limit	0.047

$$\textbf{\textit{Health Risk Index (HRI)}} = \frac{PFBA\ conc.}{7} + \frac{PFOA\ conc.}{0.035} + \frac{PFBS\ conc.}{2} + \frac{PFOS\ conc.}{0.015} + \frac{PFHxS\ conc.}{0.047}$$


MDH HBVs
PFOS 0.015 ug/L
PFHxS 0.047 ug/L
Existing Water Supply Wells
Potential PFC Source Area
Potential Additional Water Supply Well Locations
Water Treatment Plant
Wellhead Protection Area
Drinking Water Supply Management Area
HRI < 1.0
HRI > 1.0
Balsam Rd NW
Cardinal Rd NW
Wildrose La NW
Blueberry La NW
Well 6
Well 5
Well 3
Well 4
Well 7
PFOS = 0.15 ug/L
PFHxS = 0.20 ug/L
PFOS = 0.15 ug/L
PFHxS = 0.43 ug/L
PFOS = 0.023 ug/L
PFHxS = 0.017 ug/L
Water Treatment Plant
Adams Ave NW
Gillett Dr NW
Paul Bunyan Dr NW
Anne St NW
Bardwell Dr NW
Laurel Dr NW
Hannah Ave NW
Fern St NW
Minnesota Ave NW
Grass Lake
N
0
1,500
Feet
2015 USDA NAIP Imagery
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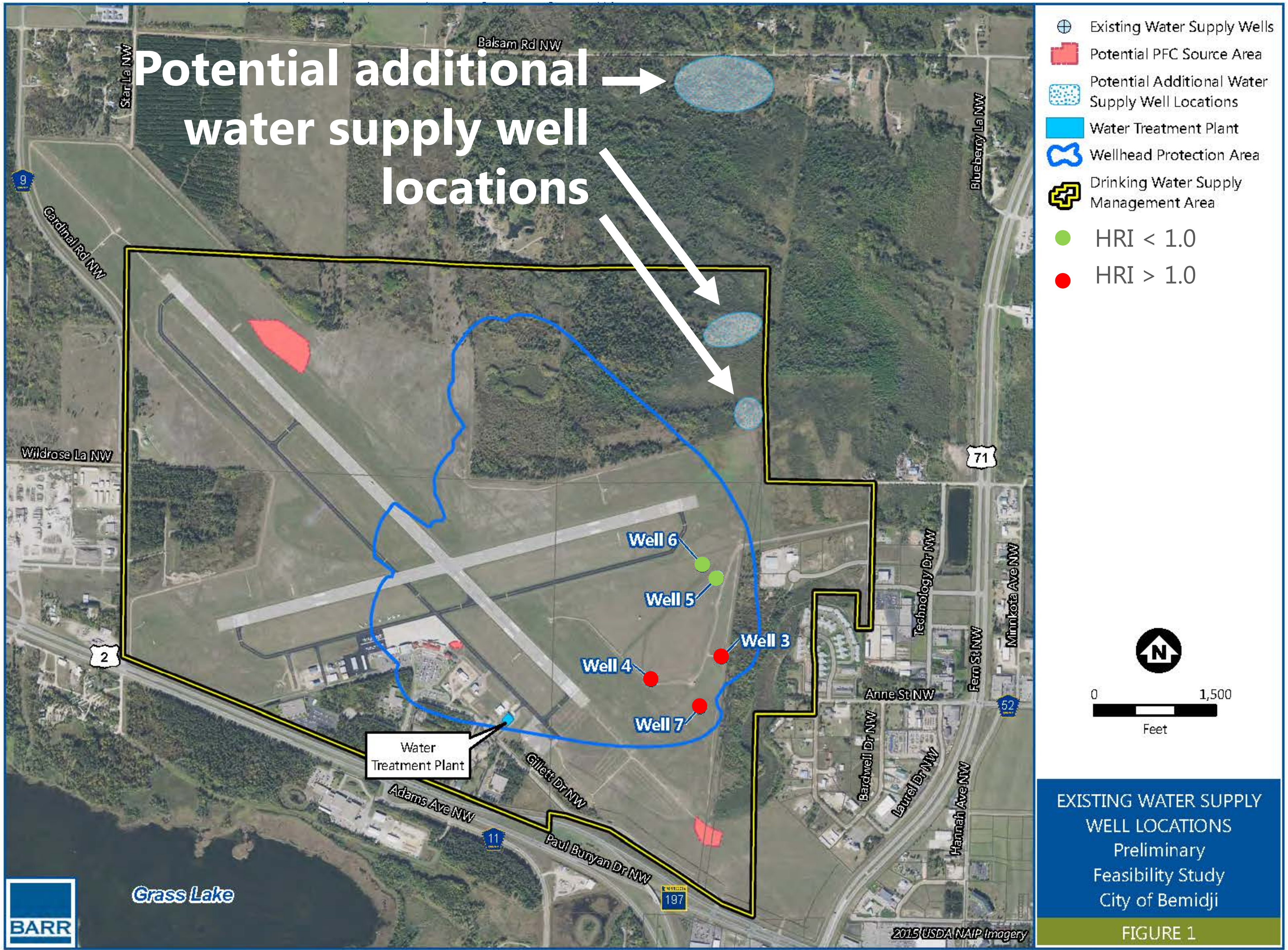
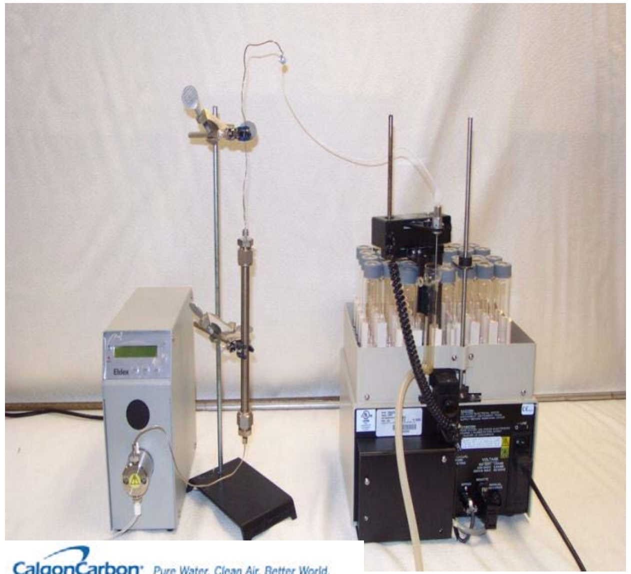
EXISTING WATER SUPPLY WELL LOCATIONS
Preliminary Feasibility Study
City of Bemidji
FIGURE 1



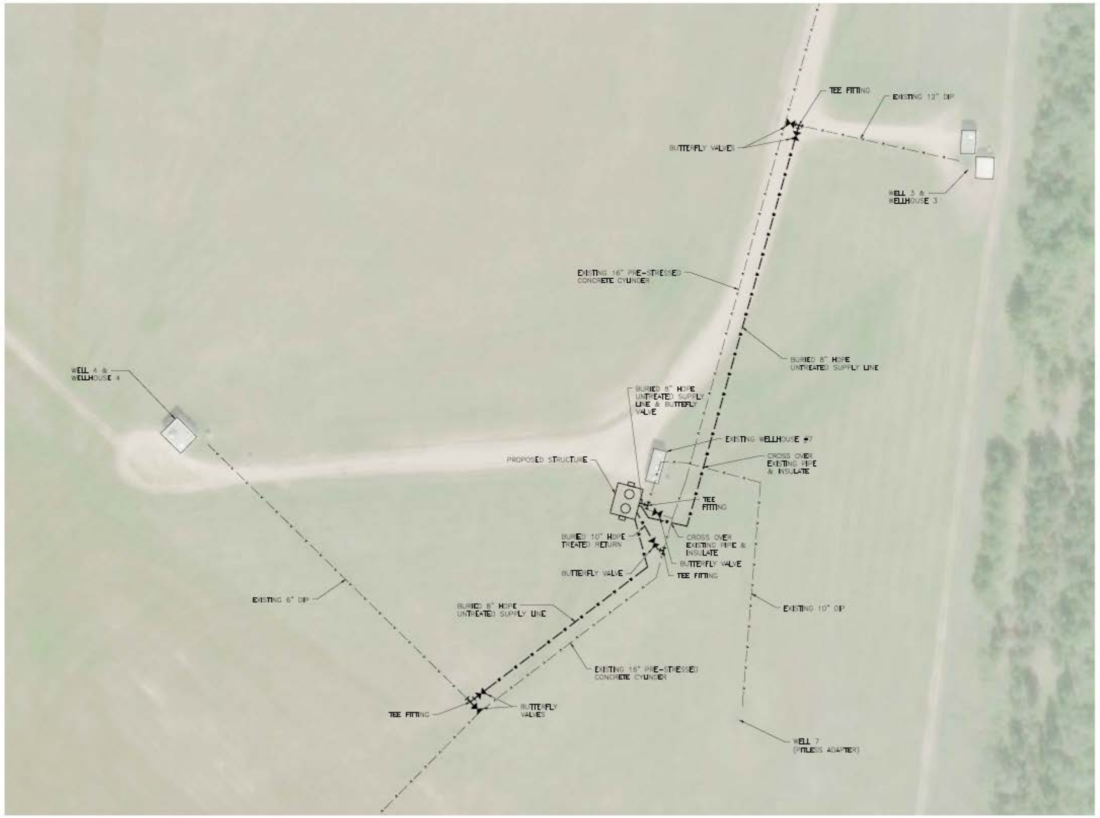
EXISTING WATER SUPPLY WELL LOCATIONS
Preliminary Feasibility Study
City of Bemidji
FIGURE 1

City of Bemidji treatment technology testing

Media	Time until (days)		
	Initial breakthrough of PFAS with a MDH HBV or HRL	Initial lead vessel change-out	Subsequent lead vessel change-outs
GAC	364	840-1,073	677-742
IX	70-88 (PFBA and PFHxS)	1,002	857



CalgonCarbon Pure Water. Clean Air. Better World.



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Groundwater Cutoff Containment

- Pump and treat, or other hydraulic to containment, is currently most utilized
  - Line of recovery wells
  - Interceptor trench
  - Barrier walls
- In-situ options are limited and still under development

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In-Situ Technologies

- Activated carbon injection
  - Commercial products for injection into aquifer
    - Colloidal – PlumeStop® by Regenesis
    - Powdered - RemBind™ by Tersus
      - Includes aluminum hydroxide and Kaolin
      - Create slurry in field and inject into aquifer to adsorb contaminants
- Utilize adsorption in aquifer, but does not breakdown or remove material
- State regulators promoting as an interim response

In-Situ Technologies

- Oxidation
  - PFOS and PFOA testing demonstrated difficult to degrade by oxidation
  - No current full-scale demonstration
- Chemical reduction
  - Some success in controlled environments, potential for intermediates
  - Potential options for ex-situ treatment
- Biodegradation
  - Evidence of incomplete breakdown of some PFAS
  - No evidence of PFOA or PFOS breakdown

Soil Treatment Technologies

- Stabilization
  - Commercial products for stabilization
    - Powdered - RemBind™.
      - Landfill acceptance?
- Thermal destruction
  - Potential high temperature requirements (>950 ºC)
  - Anyone doing it commercially?