Case Study: PFAS Removal from Flue Gases via a Regenerative Thermal Oxidizer at a Manufacturing Facility

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BARR

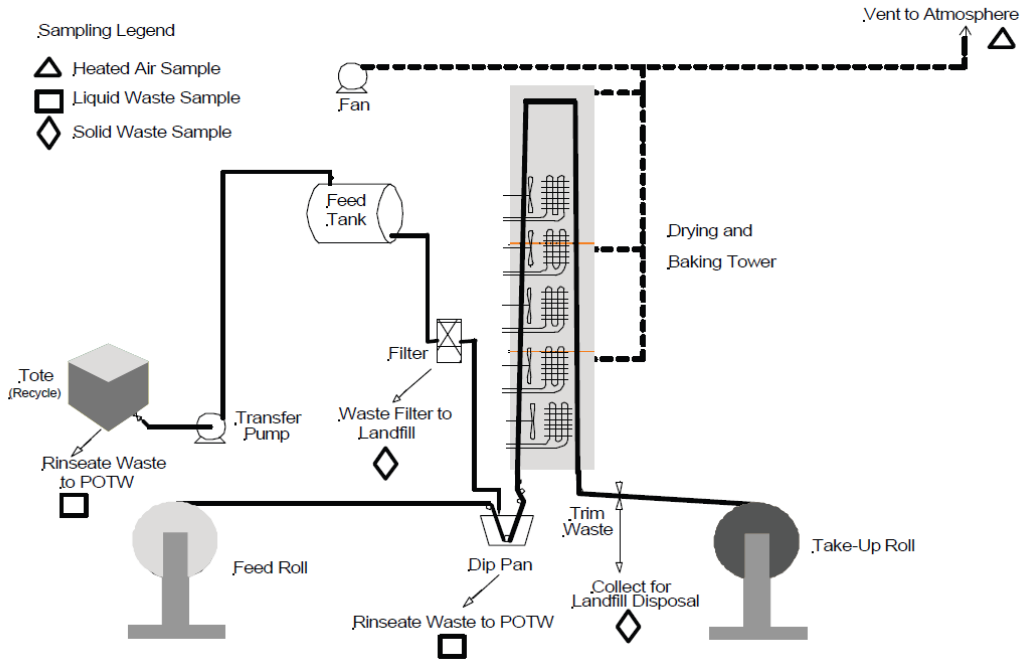
Content

- Manufacturing process overview
- PFAS test history 2004-2023
- PFAS test methodology and approach
- Measured PFAS mass rates at the inlet and outlet of a regenerative thermal oxidizer (RTO)
- Destruction and removal efficiency (DRE) for regulated PFAS compounds
- Comparison of PFAS emission rates to emission limits for regulated PFAS compounds
- Regulatory requirements
- Barr Engineering PFAS overview

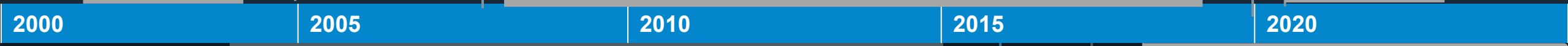
Manufactured Products

Glass Cloth Manufacturing Process

Figure 1 - Typical Glass Cloth Process Diagram



Two decades of PFAS testing experience



2003-2004
- Assessed air, water, waste output for main industry users
- Developed stack sampling and analytical methods for PFOA

2005
- Published nationwide mass balance report to US EPA using purchasing records from fluoropolymer manufacturers

2007-2018
- Conducted early PFOA emission test as request of state agency
- Subsequent tests that contributed to OTM-45/50 method development

2020-2021
- Participated in development of new facility air permit including RTO and air emission limits for PFOA and PFOS

2021-2023
- Conducted annual performance PFAS stack tests to demonstrate compliance with permit at RTO inlet/outlet

2004-2015
- Worked on various PFAS projects for manufacturing and municipal clients

2016
- Developed best practices for sample collection to reduce or eliminate sample-and-blank cross contamination

2017
- Worked with multiple laboratories to help reduce or eliminate method blank cross contamination

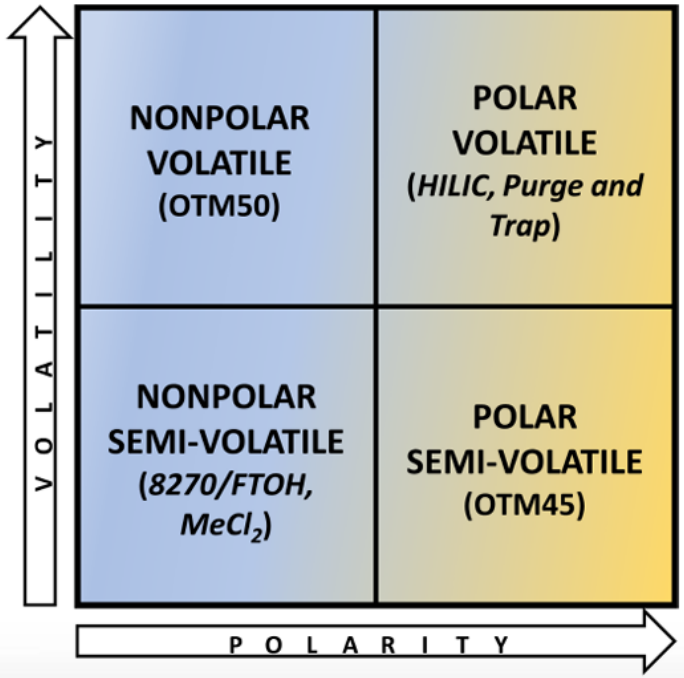
2018-2025
- Active projects across the U.S. and the world for industry and public sector clients

Methodology – USEPA Methods

PFAS Air Measurement Methods

- **Canister sampling (OTM-50) with GC/MS analysis**
- 30 target C1-C8 PFAS
- PIC/PIDs, industrial PFAS
- End of 2023?

- **Method 0010 sampling with GC/MS analysis (OTM-55)**
- FTOHs, select 8270 compounds and potential PICs
- Potential compounds of concern



- **Not a current focus**
- Impinger sampling?
- LC analysis?
- Limited number of PFAS in this class

- **OTM-45 sampling with LC/MS analysis**
- 49 target PFAS (C4 and larger)
- Revision expected end of 2023

Slide courtesy of Ariel Wallace US EPA

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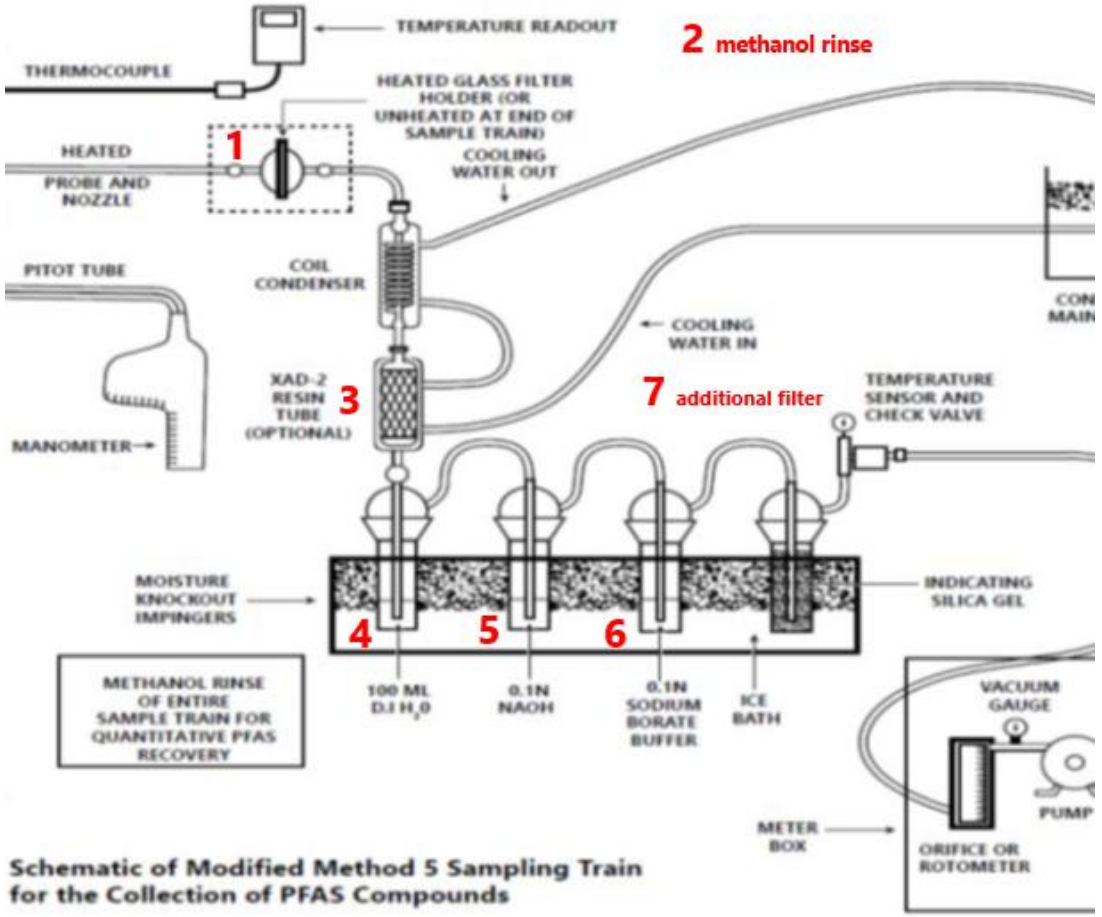
Methodology - Barr PFAS sample train 2003-2021



Schematic of Modified Method 5 Sampling Train for the Collection of PFAS Compounds

Methodology - USEPA OTM-45 PFAS sample train

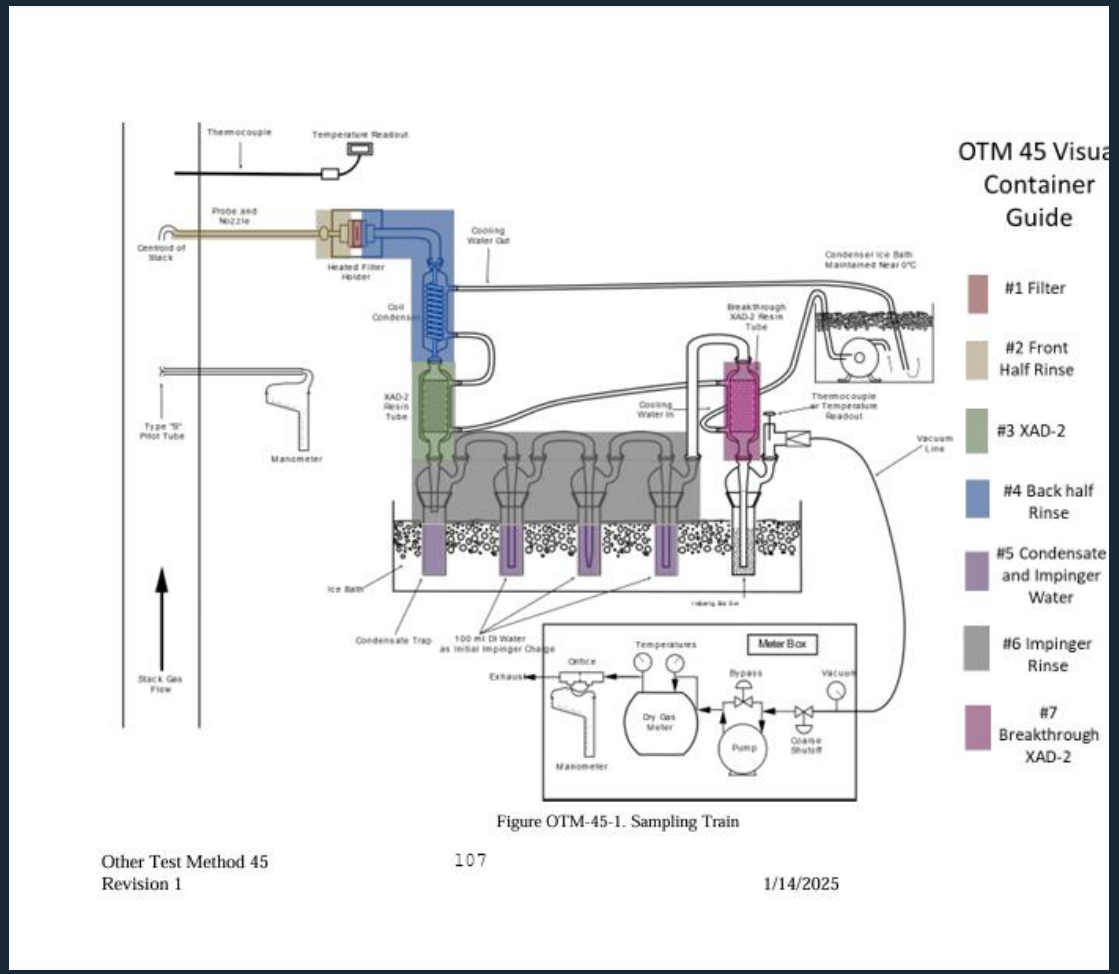
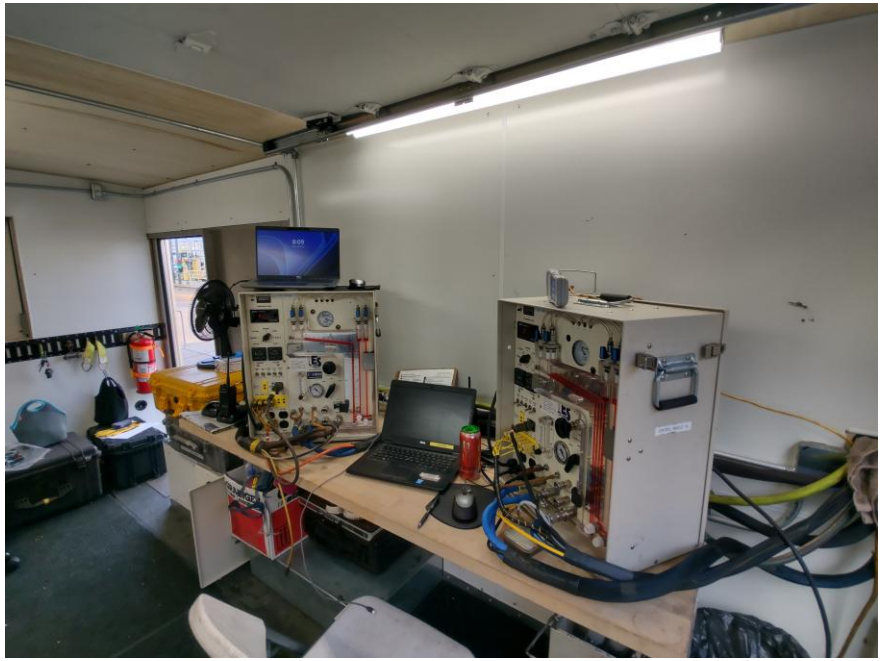


Figure OTM-45-1. Sampling Train

Measured PFAS mass rates at Inlet and outlet of RTO

Average Test Results			
Test Methods 1-4, OTM-45	**RTO Inlet, lb/hr (kg/hr)**	**RTO Outlet, lb/hr (kg/hr)**	**DRE, %**
Test Date	9/20-21/2023		
PFOA	0.000011 (0.0050)	0.0000025 (0.0011)	77
PFNA	0.000014 (0.0064)	0.0000016 (0.00073)	89
PFHxS	0.000000010 (0.0000045)	0 (ND)	100
PFOS	0.00000019 (0.000086)	0.00000009 (0.000041)	53



PFAS Test Results

Test Methods 1-4, OTM-45	Average Test Results RTO Outlet (PCE01)	Permit Limit	Test Result percentage of permit limit
Test Date	9/20-21/23	-	-
PFOA, lb/yr (kg/yr)	0.022 (0.010)	0.69 (0.31)	3.2 %
PFNA, lb/yr (kg/yr)	0.014 (0.0064)	0.98 (0.44)	1.4 %
PFHxS, lb/yr (kg/yr)	0 (ND)	0.75 (0.34)	0.0 %
PFOS, lb/yr (lg/yr)	0.00075 (0.00034)	0.90 (0.42)	0.08 %

Regulatory Requirements

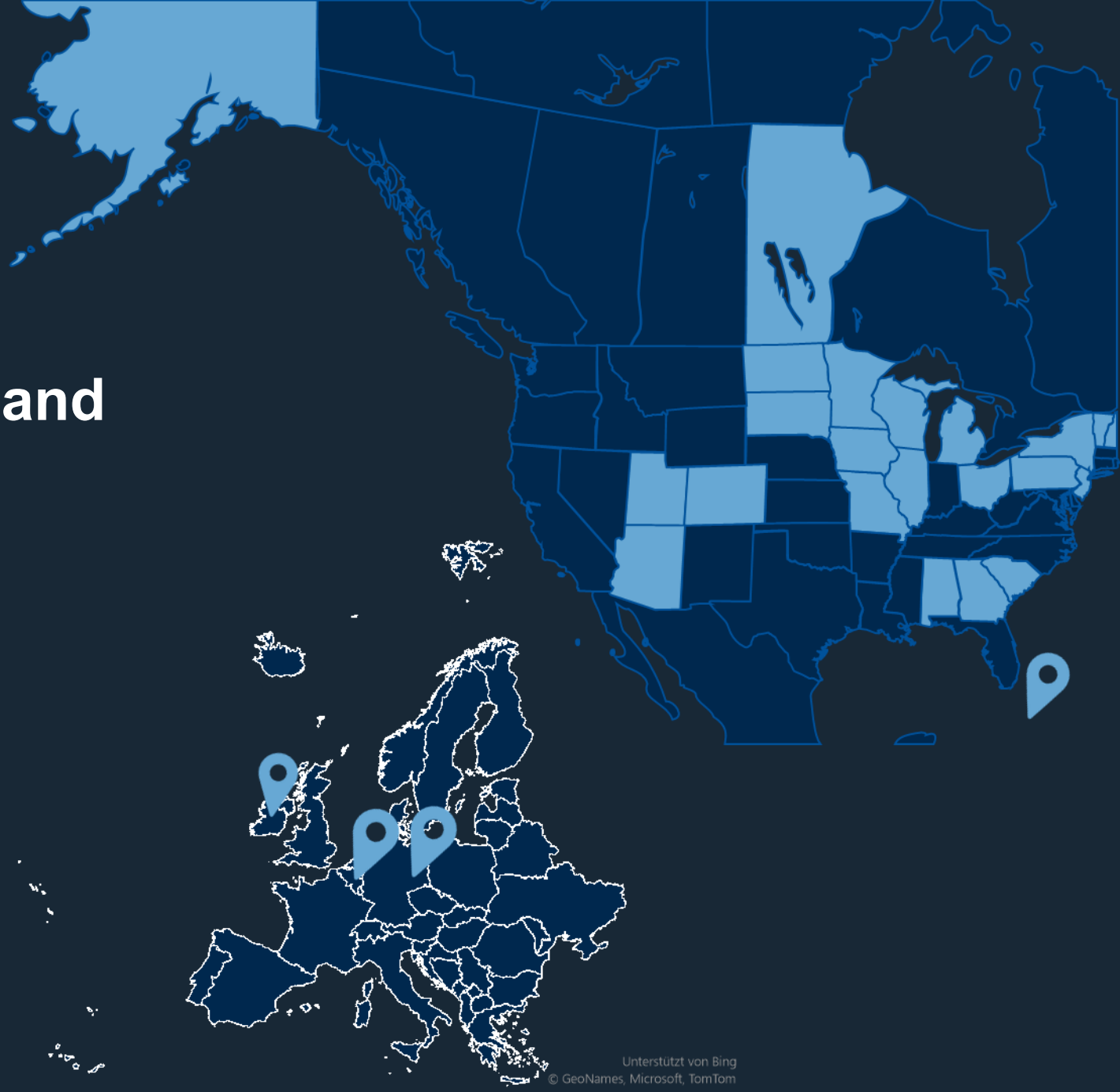
Test Parameter	Test Location	Test Range	Test Average	Limit	Statement
PFOA emission rate, lb/yr (kg/yr)	Outlet	0.016-0.028	0.022 (0.010)	0.69 (0.31)	**In Compliance**
PFNA emission rate, lb/yr (kg/yr)	Outlet	0.0059-0.028	0.014 (0.0064)	0.98 (0.44)	**In Compliance**
PFHxS emission rate, lb/yr (kg/yr)	Outlet	0	0	0.75 (0.34)	**In Compliance**
PFOS emission rate, lb/yr (kg/yr)	Outlet	0.00046-0.0011	0.00075 (0.00034)	0.90 (0.41)	**In Compliance**
Temperature, °F (°C)	Outlet	1848-1854	1850 (1010)	>1832 (1000)	**In Compliance**
RTO Flowrate, scfm	Inlet	58,500-59,400	58,900	<70,000	**In Compliance**
Capture of Covered Coating Towers	Natural Draft Opening	-0.009 to -0.090 Inches water	<-0.007 inches water	-0.007 inches water	**In Compliance**

PFAS-related project sites where Barr has consulted since 2004

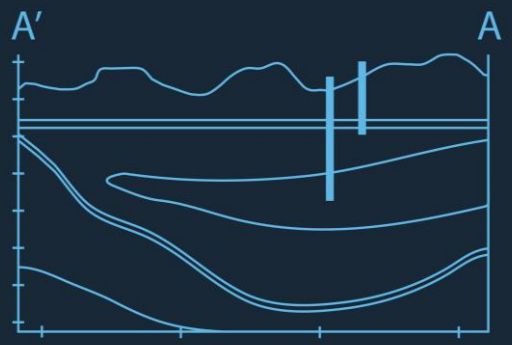
22+ states, Canada, Europe, and US Virgin Islands

Over 800 staff
working on PFAS projects

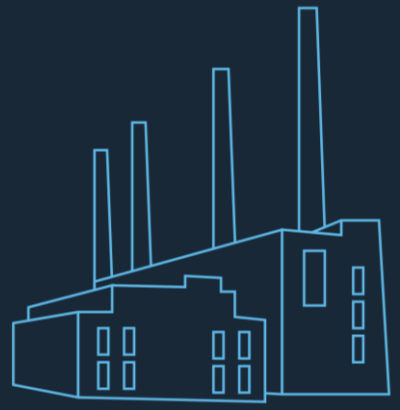
Over 140 staff
with more than 500 hours on PFAS projects in the last year



Practical PFAS solutions



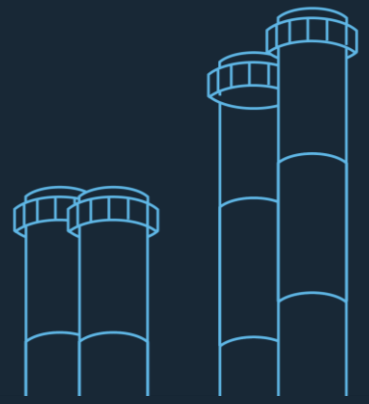
Assessment and remediation



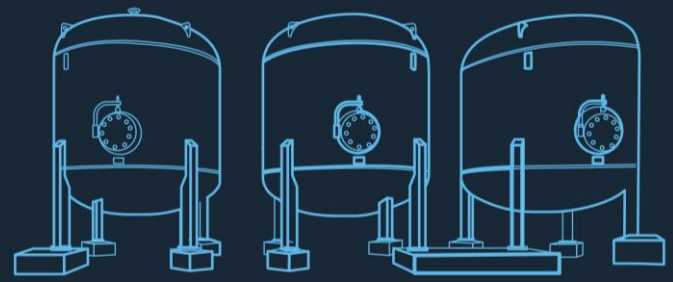
Fate and transport

Water and wastewater

Stormwater



Stack testing



Mass balance

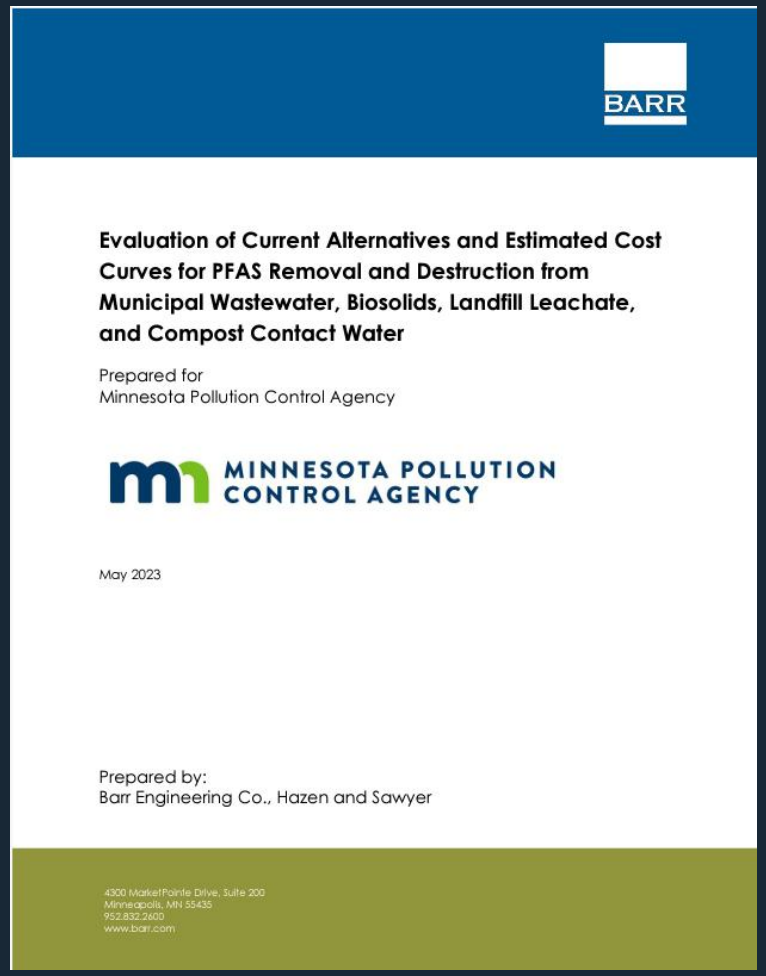
Current Developments

Focus on evaluation of technologies to destroy or remove PFAS from air streams treating a variety of environmental media (gases, liquids and solids)

Barr has performed stack emission tests to evaluate the following technologies:

- Thermal oxidation
- Scrubbing/filtration
- Gasification/pyrolysis
- Plasma Arc
- Carbon filtration
- Municipal waste combustion
- Biosolids combustion
- Landfill gas combustion
- Subsurface thermal treatment
- SCWO (supercritical water oxidation)

Groundbreaking study on PFAS Removal and Destruction



Services provided:

Evaluation of over 50 individual separation and destruction technologies

Focus on water resource recovery facility (WRRF) effluent, WRRF biosolids, mixed municipal solid waste landfill leachate, and compost contact water (waste streams)

Cost estimates were prepared using standard industry practices