In Situ PFAS Smoldering Demonstration

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Agenda

- Introduction to PFAS
- Funding Program
- Technology Overview
- JBCC Demonstration
- Post Characterization and Results
- Summary

Introduction to Per- and Polyfluoroalkyl Substances (PFAS)

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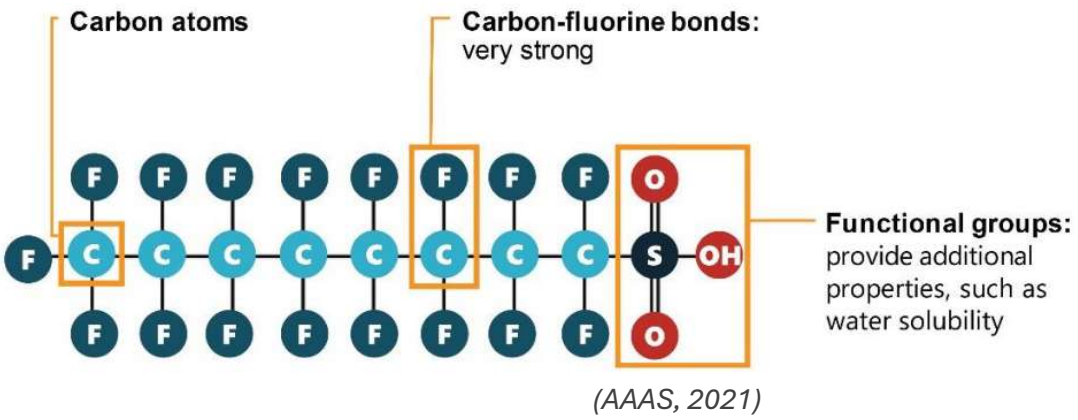
Per- and Polyfluoroalkyl Substances (PFAS)

- Large **group of synthetic chemicals** used in a wide range of applications, including firefighting foams
- Persistent in the environment and **challenging to remediate** due to strong carbon-fluorine bond



(AAAS, 2021)

Environmental Technology Programs

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Environmental Technology Programs

SERDP
DOD ▪ EPA ▪ DOE

Science and Technology

- Strategic Environmental Research and Development Program (SERDP)
- Fundamental research to impact real world environmental management

ESTCP

Demonstration and Validation

- Environmental Security Technology Certification Program (ESTCP)
- Transition innovative technologies from the lab to the field

>$300M invested on PFAS since 2011

Technology Overview

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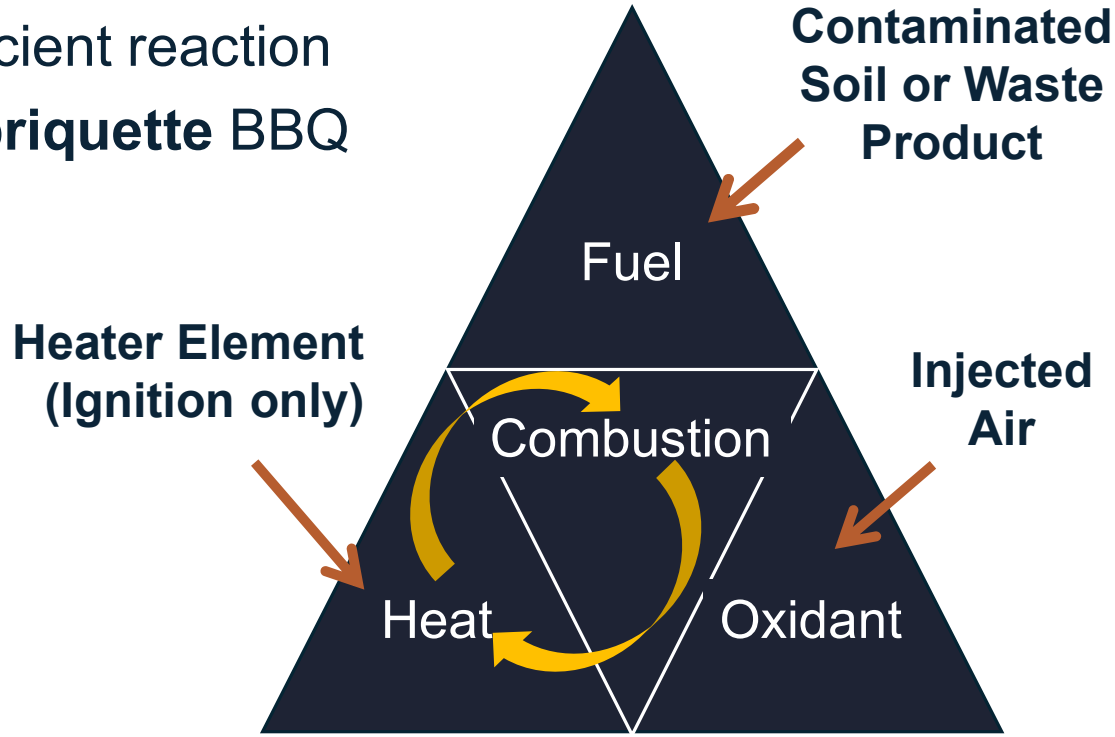
Smoldering Combustion

- **Flameless**, energy efficient reaction
- Similar to a **charcoal briquette** BBQ



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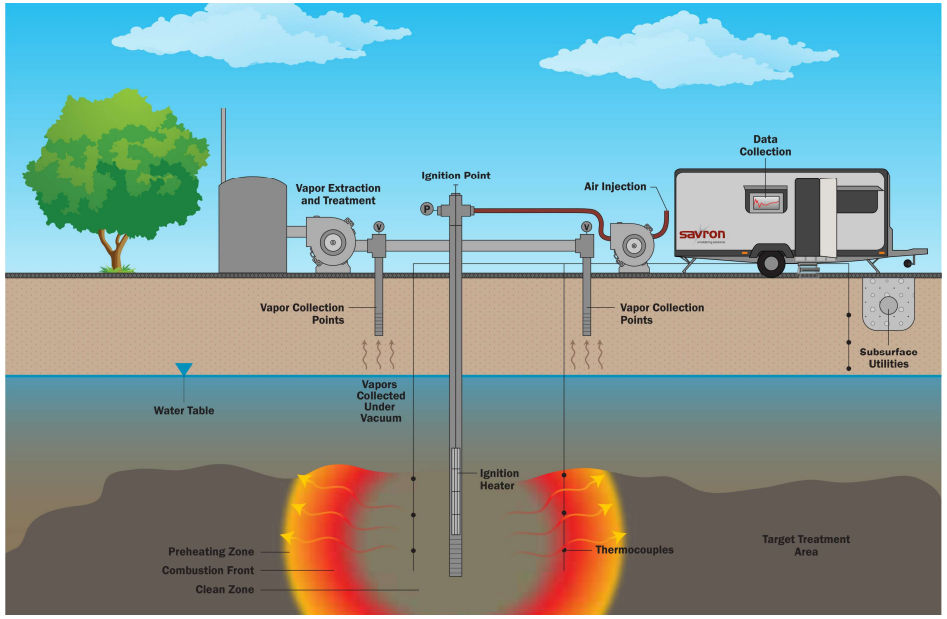
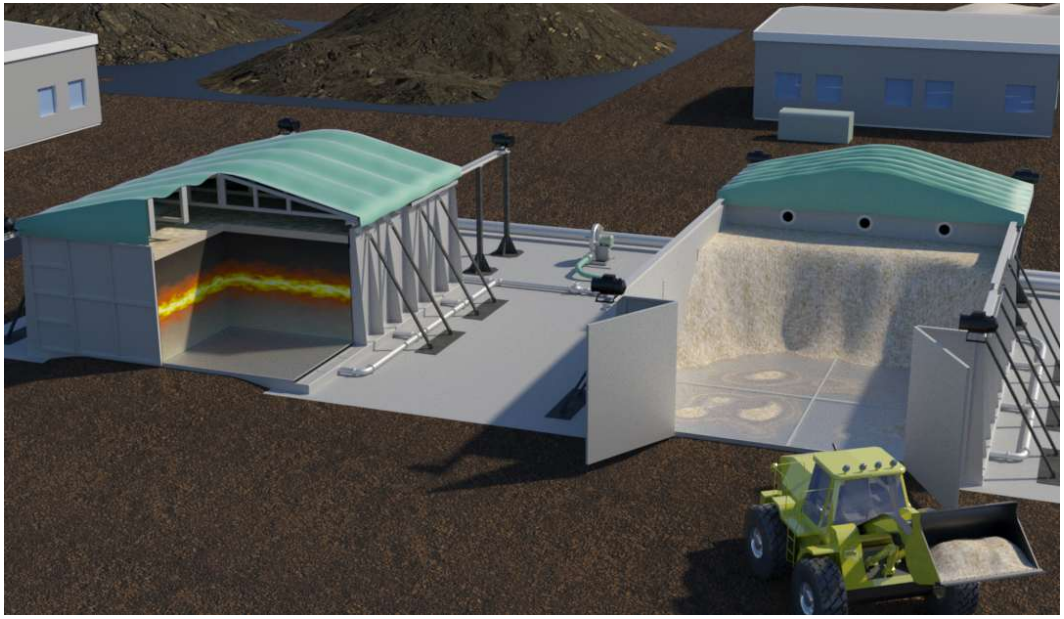
- **In situ (below ground)**
  - Applied via ignition points and portable heaters



STARx

- **Ex situ (above ground)**
  - Applied via engineered soil pile systems



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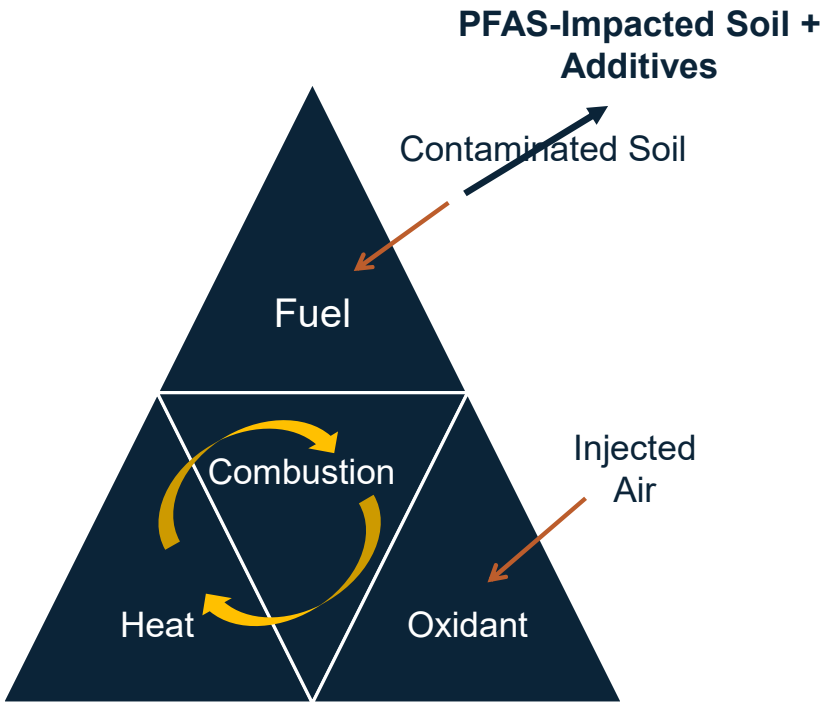
Full scale systems implemented at sites around the world for treating hydrocarbon (oil)-impacted soils and sludges

PFAS Smoldering

Same energy-efficient, flameless form of combustion as used for hydrocarbon applications



- **Carbon-based additive** (e.g., granular carbon): used as fuel to sustain reaction and reach the high temperatures required for PFAS destruction
- **Calcium-based additive** (e.g., Quicklime): used to improve PFAS destruction and minimize byproducts in emissions

Joint Base Cape Cod Demonstration

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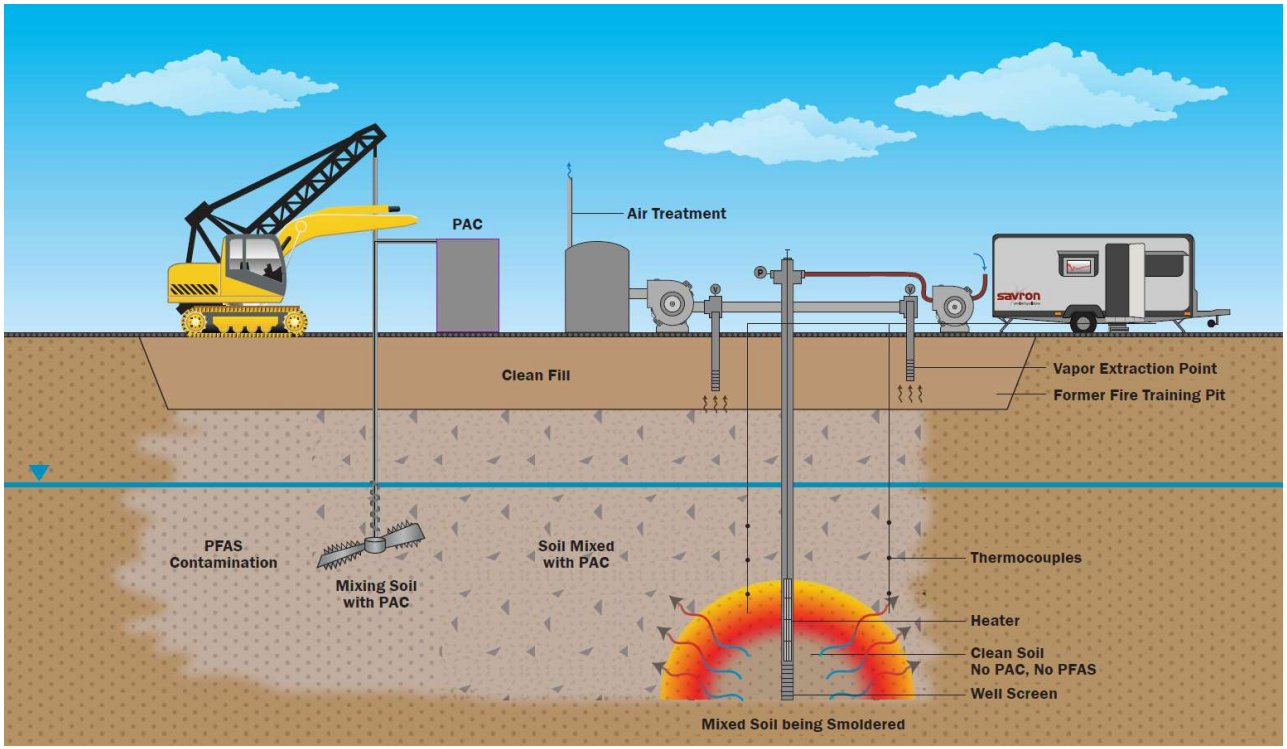
In Situ PFAS Smoldering



- Demonstration of **PFAS destruction** in source zone at Joint Base Cape Cod FTA-1
- In situ **soil mixing** for powdered activated carbon (PAC) and calcium additives
- **4** ignition points, **650 yd^3** soil volume

Field Implementation

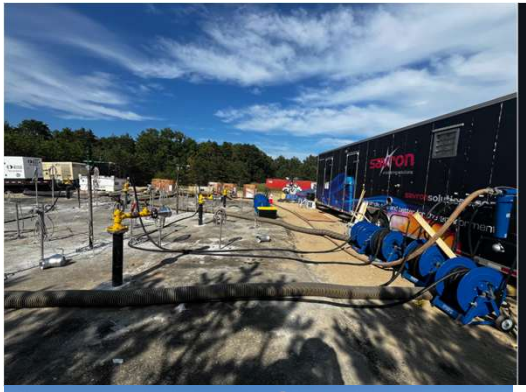
In situ soil mixing of carbon and calcium additives (December 2024)

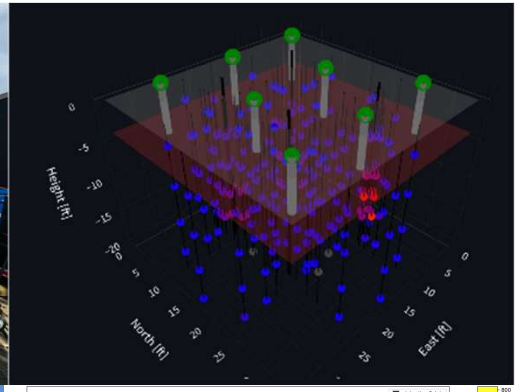
Setup and Operations (June/July 2025)

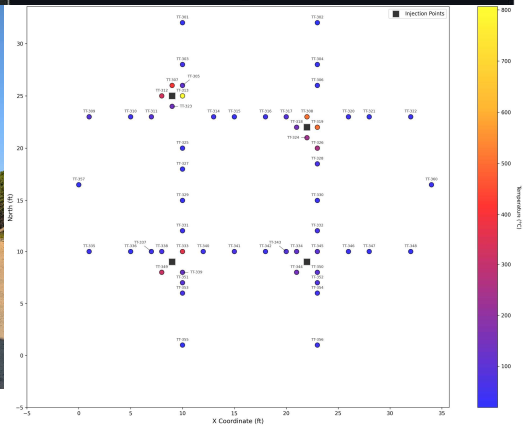
Post Characterization (December 2025)

Operation – Further Detail

- Successful smoldering **ignition achieved**
- Operational **monitoring** was completed using subsurface **temperatures and combustion gases**
- PFAS **emission sampling** was completed by a third-party contractor







Post Characterization and Results

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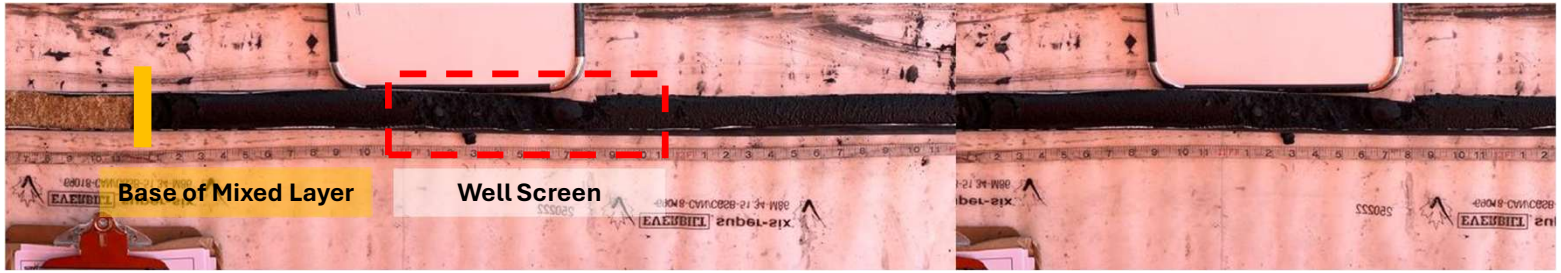
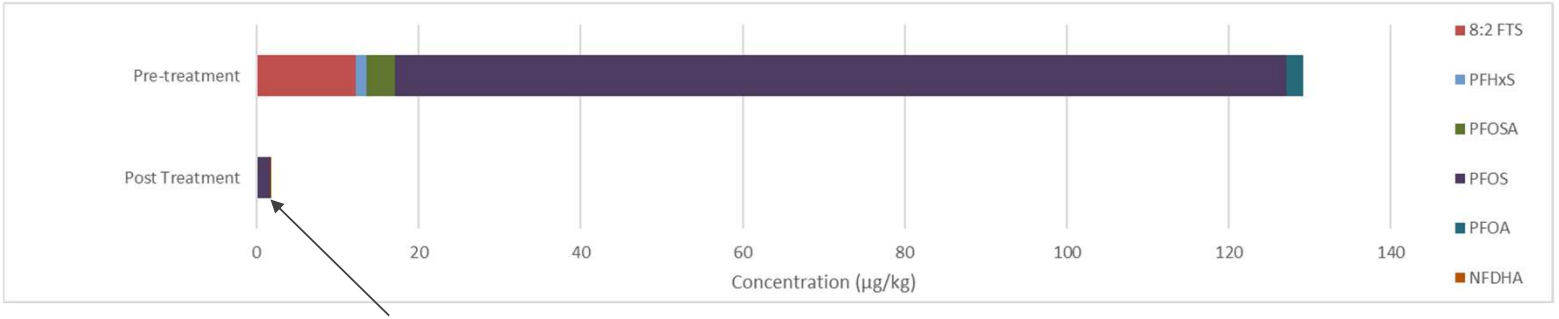
Soil Treatment

Pre-Treatment

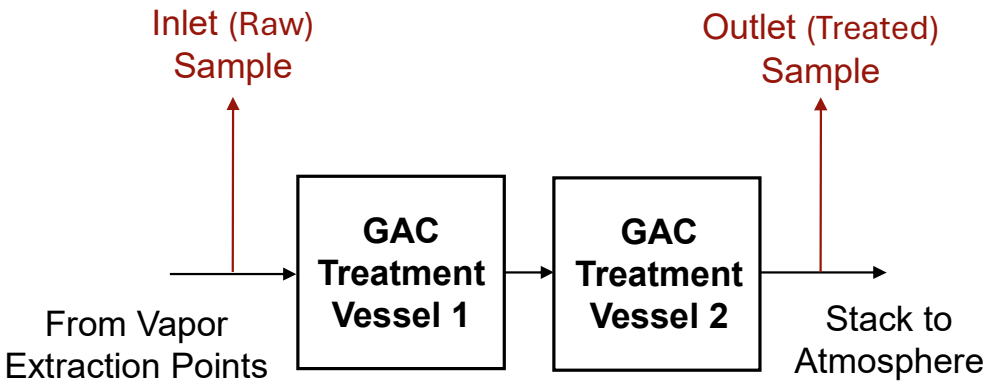


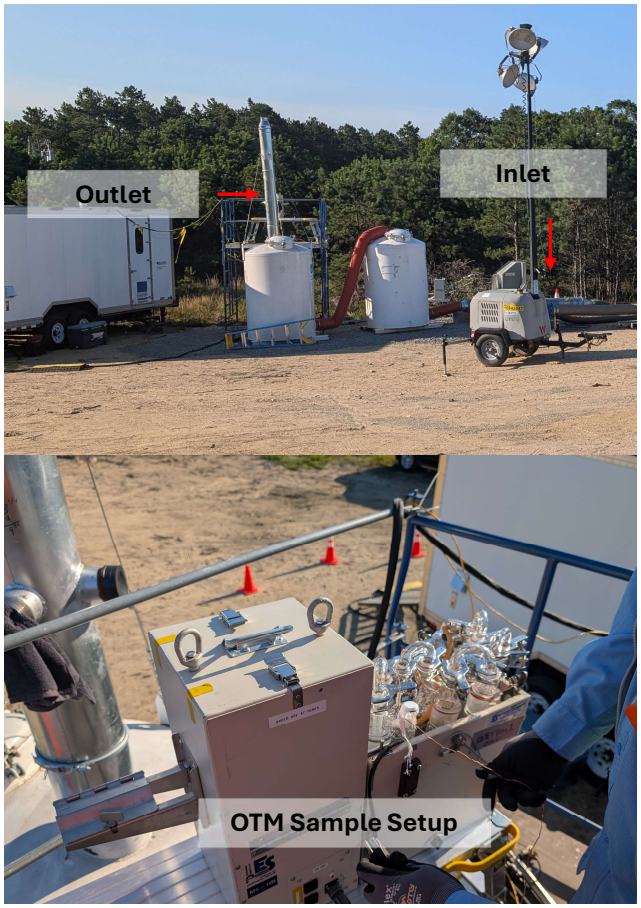
Post-Treatment (~18" from IP)

PFAS in Soil Results (Pre/Post)

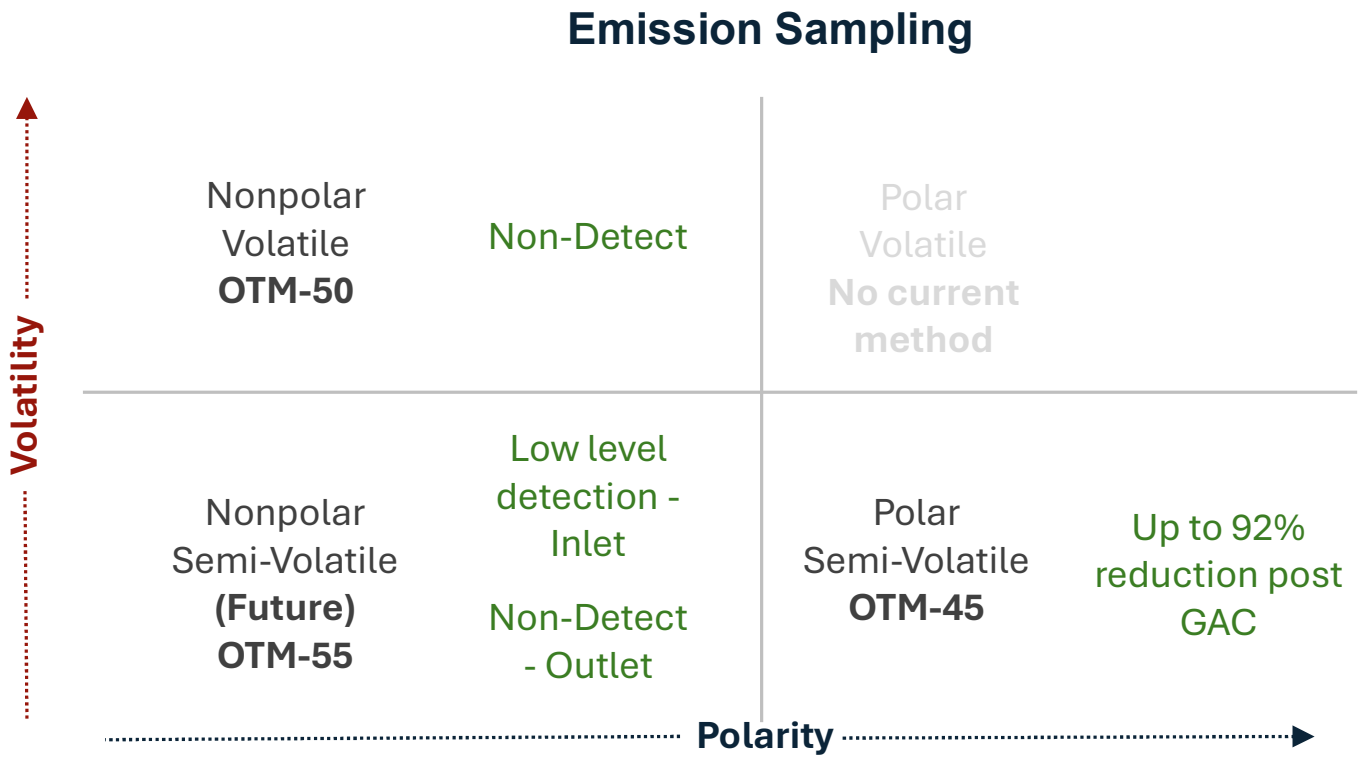


Emission Sampling





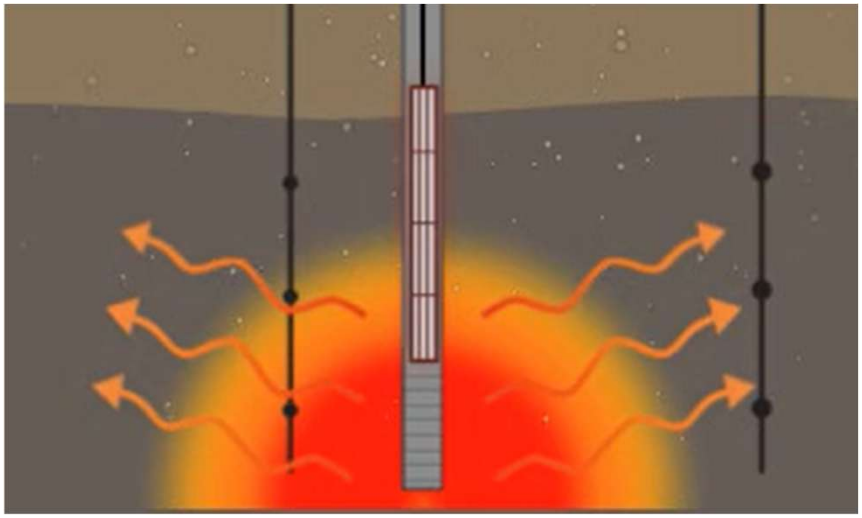
Emission Results



- Low Level Detections near or below reporting limits for all results
- EPA M26 – Hydrogen fluoride (HF) – Non-Detect

Lessons Learned

Limited Front Propagation (~1.5’ – 2’ Radius of Influence)



- **Air permeability limited** due to combination of site soil and addition of powder activated carbon solution
- **Soil mixing process** may have further reduced permeability
- **Potential options for future work** to reduce permeability issues:
  - Use of **granulated activated carbon** or an **injectable fuel**
  - **Ex situ smoldering** may be better suited for some site conditions

Summary

Summary

- **Successful surrogate fuel distribution** and **in situ smoldering ignition achieved**
- **Reduction of PFAS concentrations** in post-treatment soil to below current EPA RSLs at locations where smoldering propagated
- **Challenges with permeability** under field conditions limited horizontal propagation of smoldering front beyond ~1.5 to 2 ft

What's Next?

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Additional development work required to improve fuel delivery / propagation

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STARxpress system commercially available

Questions?

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