Naval Facilities Engineering Systems Command
EXWC Engineering and Expeditionary Warfare Center

NAVFAC Open Environmental Restoration Resources (OER2)

Lessons Learned from In Situ PFAS Sequestration

Laura Cook, NAVFAC LANT

Speaker Introduction

Laura Cook NAVFAC Atlantic	• Bachelor of Science in Geological and Environmental Sciences from Stanford University • Master of Science in Environmental Engineering from Old Dominion University • Subject Matter Expert in Hydrology and PFAS

Disclaimer

This webinar is intended to be informational and does not indicate endorsement of a particular product(s) or technology by the Department of War or NAVFAC EXWC, nor should the presentation be construed as reflecting the official policy or position of any of those Agencies. Mention of specific product names, vendors or source of information, trademarks, or manufacturers is for informational purposes only and does not constitute an endorsement or recommendation by the Department of War or NAVFAC EXWC. Although every attempt is made to provide reliable and accurate information, there is no warranty or representation as to the accuracy, adequacy, efficiency, or applicability of any product or technology discussed or mentioned during the seminar, including the suitability of any product or technology for a particular purpose.

OER2 Webinar Series

- **Why Attend?**
  - Obtain and hear about the latest DOW and DON's policies/guidance, tools, technologies and practices to improve the ERP's efficiency
  - Promote innovation and share lessons learned
  - Feedback to the ERP Leadership
- **Who Should Attend?**
  - ERP Community Members: RPMs, RTMs, Contractors, and other remediation practitioners who support and execute the ERP
  - Voluntary participation
- **Schedule and Registration:**
  - Offered quarterly
  - Registration link for each topic (announced via ER T2 email)
- **Topics and Presenters:**
  - ERP community members to submit topics (non-marketing and DON ERP-relevant) to EXWC.T2@us.navy.mil
  - Selected topic will be assigned Champion to work with presenter

Presentation Overview

- What is PFAS In Situ Sequestration?
- Amendments for PFAS In situ Sequestration
- Types of PFAS In Situ Applications
- Case Studies
- Lessons Learned

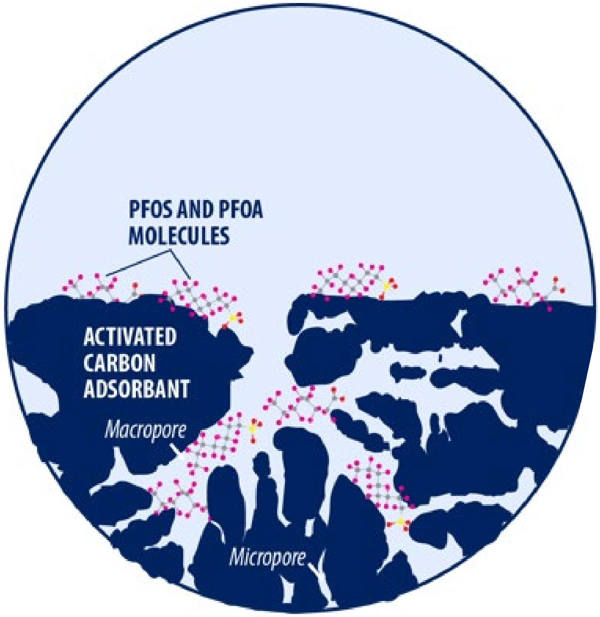
What is In Situ Sequestration?

- Injecting, mixing, or applying amendments directly into the ground to bind with chemicals and reduce mobility in the subsurface
- When performed in the vadose zone, can reduce PFAS leaching/mass flux to groundwater
- When performed in the saturated zone, can inhibit migration

Amendments for In Situ Sequestration

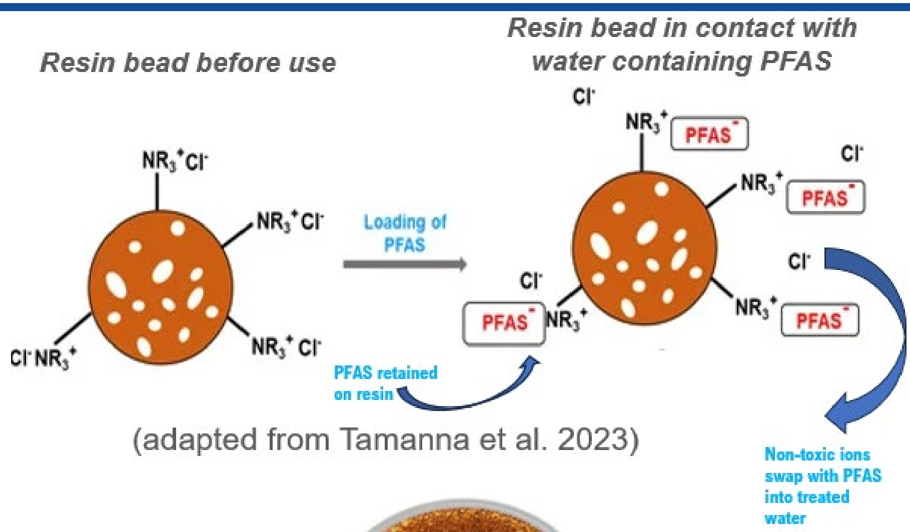
Amendments for In Situ Sequestration - Carbon

- **PFAS binding**
  - Surface functional groups + microporous regions adsorb PFAS to carbon surfaces
- **Types**
  - **Granular Carbon**
    - Largest (~0.2 – 2 mm), about the size of coarse sand
    - More commonly used for ex situ treatment applications
  - **Powdered Activated Carbon**
    - Medium-sized (<0.18 mm), about the size of silt or fine sand
    - Can be injected into aquifers or mixed into the vadose or saturated zone with large diameter augers or other earth moving equipment
    - Distribution limited
  - **Colloidal Activated Carbon**
    - Smallest (<5 μm)
    - Can be injected as a liquid suspension or applied to unsaturated soil through surface application with ease of distribution



Amendments for In Situ Sequestration – Ion Exchange (IX) Resins

- Synthetic microbeads (0.3 to 1.2 mm) composed of polymers (e.g. acrylic, polystyrene)
- Contain charged functional groups in the polymer matrix pre-loaded with non-toxic exchangeable counterions
- When PFAS containing water comes in contact with the microbeads, the exchangeable counterions swap out for PFAS
- Anion exchange resins are used for treatment of the current PFAS of interest (PFOA, PFOS, etc.)
- Can be injected, mixed, or used in applications like funnel and gate or trench barriers.
- Efficacy of injection of ground resin is being studied
- Many brands are available (e.g. Purolite, Dowex, CalRes, etc.)



(adapted from Tamanna et al. 2023)

(iStock 2021)

Amendments for In Situ Sequestration – Others You Might Hear About

- **Surface-modified clays (e.g. FLUORO-SORB, Rembind)**
- **Amine-based Polymers (e.g. PolyDADMAC, polyHIPE)**
- **Metal organic frameworks (MOFs)**

- **Not all amendments have been thoroughly demonstrated. Check with your SME first!**

Types of In Situ Sorption Applications

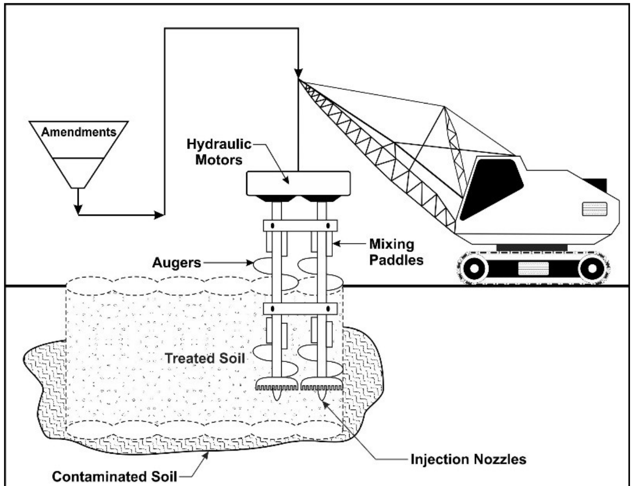
Direct Ground Surface Application

- Colloidal activated carbon can be direct applied through
  - Excavating soils, and spraying in lifts during backfilling operations
  - Creating a boundary wall and flooding it with colloidal carbon, forcing infiltration into the soil
- For sites with thin vadose zones, may reduce mass flux to groundwater
- Most appropriate for sites with higher permeability soils
- Emerging application – will not meet clean up goals for direct exposure; suitable for mass flux reductions

Soil Mixing

- **Aggressive mixing of amendments into the subsurface**
- **Equipment**
  - **Excavators**
    - Suitable for use up to 30 ft bgs
    - Less expensive and most practical option
  - **Large Diameter Augers**
    - For deeper mixing (up to 100 ft bgs)
    - Better vertical uniformity than excavators
    - More expensive and not likely to be many great applications for PFAS sites (more appropriate for DNAPL)
- **For PFAS, mixing is most suitable for use in vadose zone applications and where uniform distribution is key**

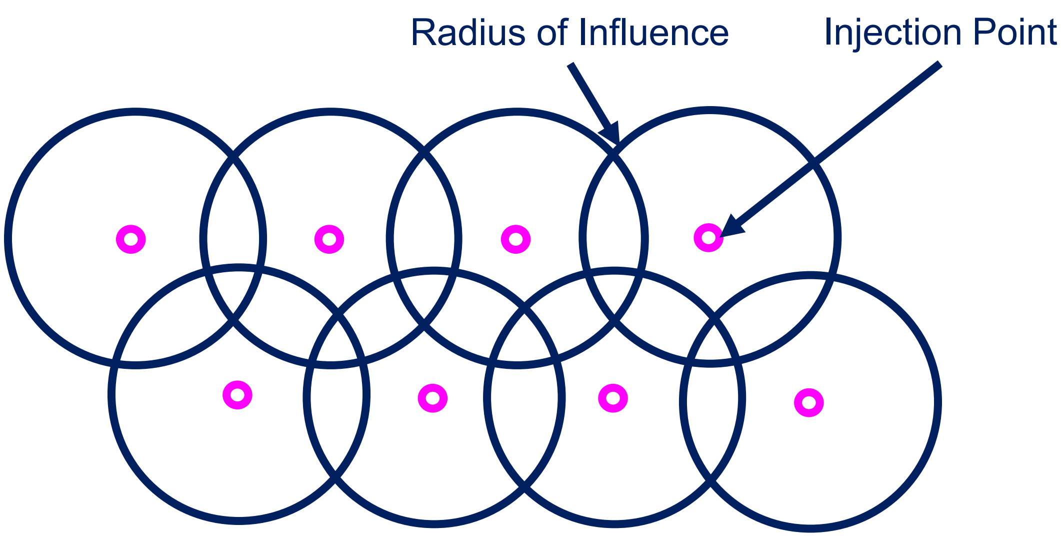
Geo-Solutions, Inc.

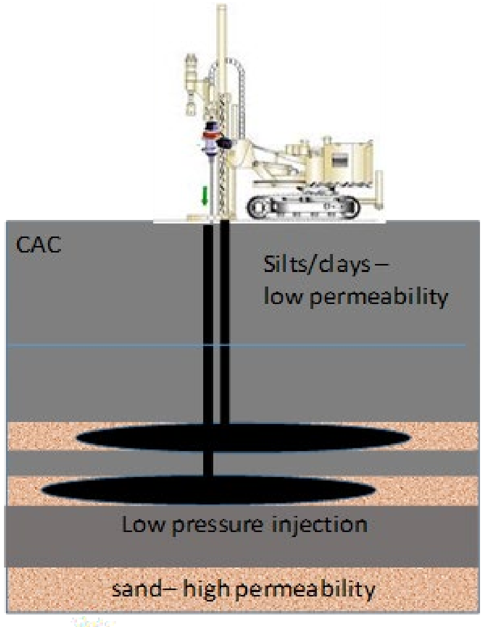


https://frtr.gov/matrix/Large-Diameter-Auger-Mixing/

Source or Downgradient Barrier Injections

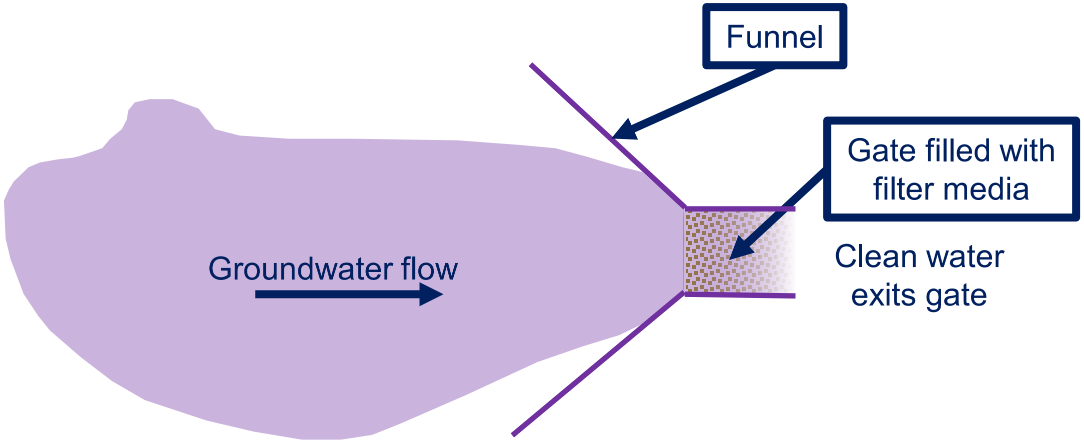
- Direct injection of carbon into the subsurface using DPT
- Can be performed using PAC or CAC, and other amendments
- High and low pressure may be considered





Funnel and Gate

- Makes use of confining units and groundwater flow to capture and filter plume as it travels downgradient
- "Funnel" constructed of slurry wall or sheet pile is keyed into the shallowest confining unit.
- "Gate" filled with filter media (GAC, resin, or other sorbent) is placed between funnel sections
- Groundwater is forced into the gate and treated as it moves downgradient
- Filter media can be removed and replaced when spent (breakthrough occurs above target treatment goals)
- Configurations vary – some are a straight barrier and less funnel shaped
  - May need multiple treatment gates connected to funnel to contain a plume



Case Studies

Case Study 1 – Surface Activation of Colloidal Activated Carbon, Air Station in Southeast

Project Objective:

- Determine the efficacy of surface applied CAC to reduce PFAS mass flux to underlying groundwater

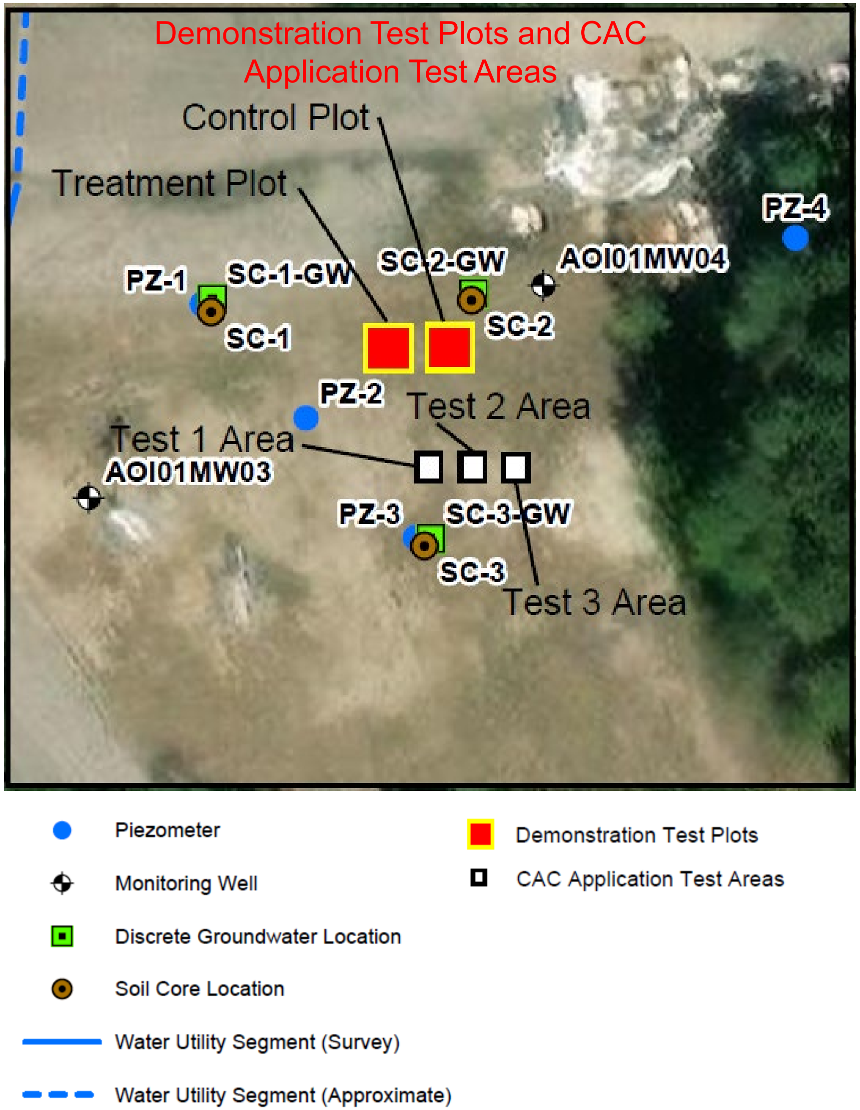
Conceptual Site Model Overview:

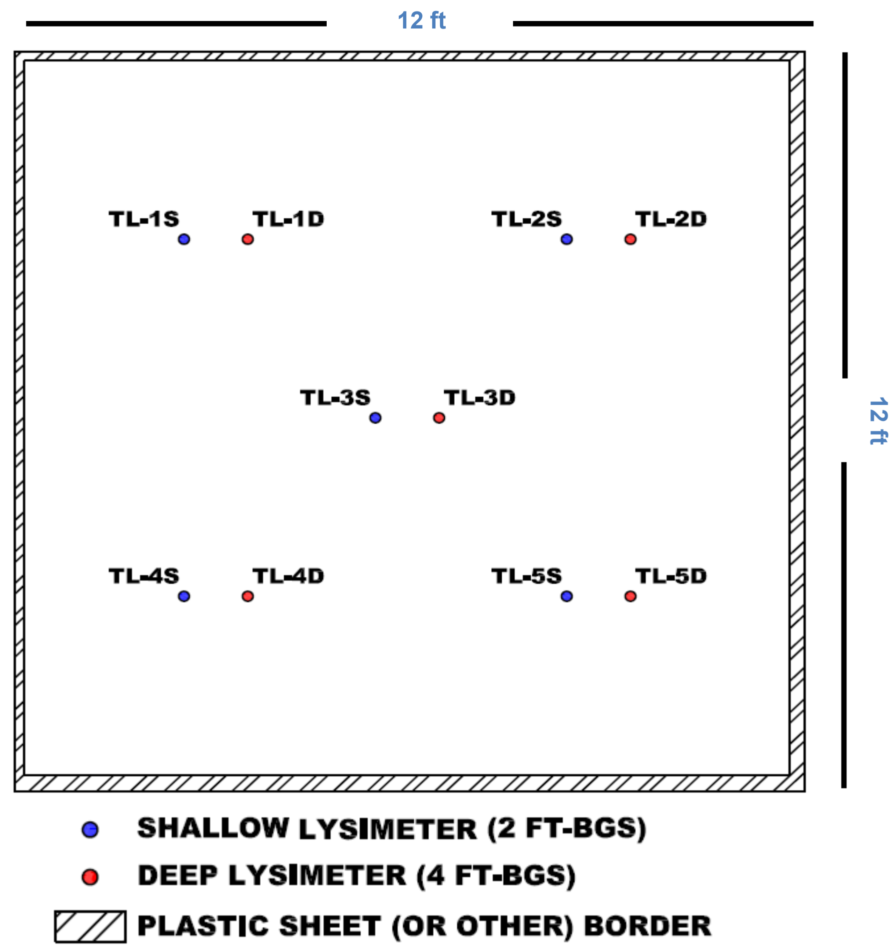
- Vadose zone soil concentrations between 500-5,000 µg/kg, mostly PFOS
- Groundwater concentrations between 100,000 and 600,000 ng/L, mostly PFOS

Approach:

- Site characterization, column testing, lysimeter and piezometer installation, field testing of application methods (explored impact of soil and vadose zone injection), and pilot scale surface application, and monitoring

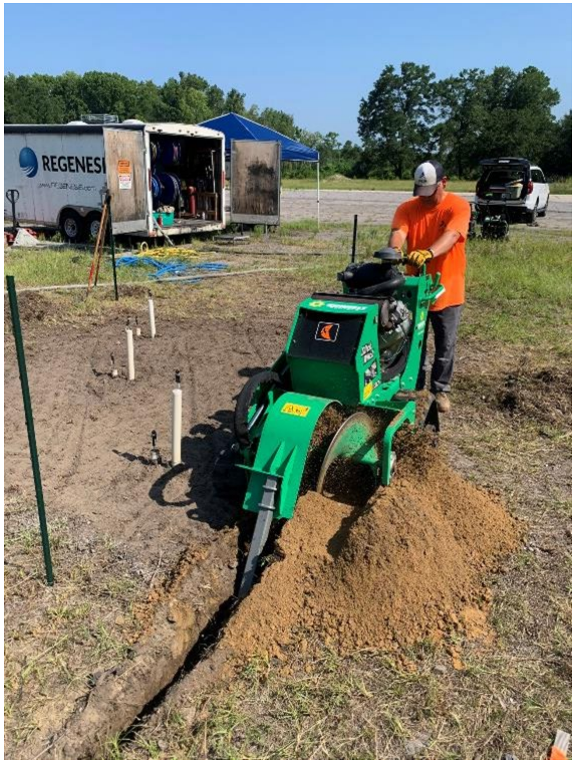
Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast





Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast

- Sod cutter (remove top 2-3 inches) and turf aerator
- Lysimeters installed in control plot and test plot
- Barrier walls installed in control plot and test plot
- Barrier wall sealed with bentonite



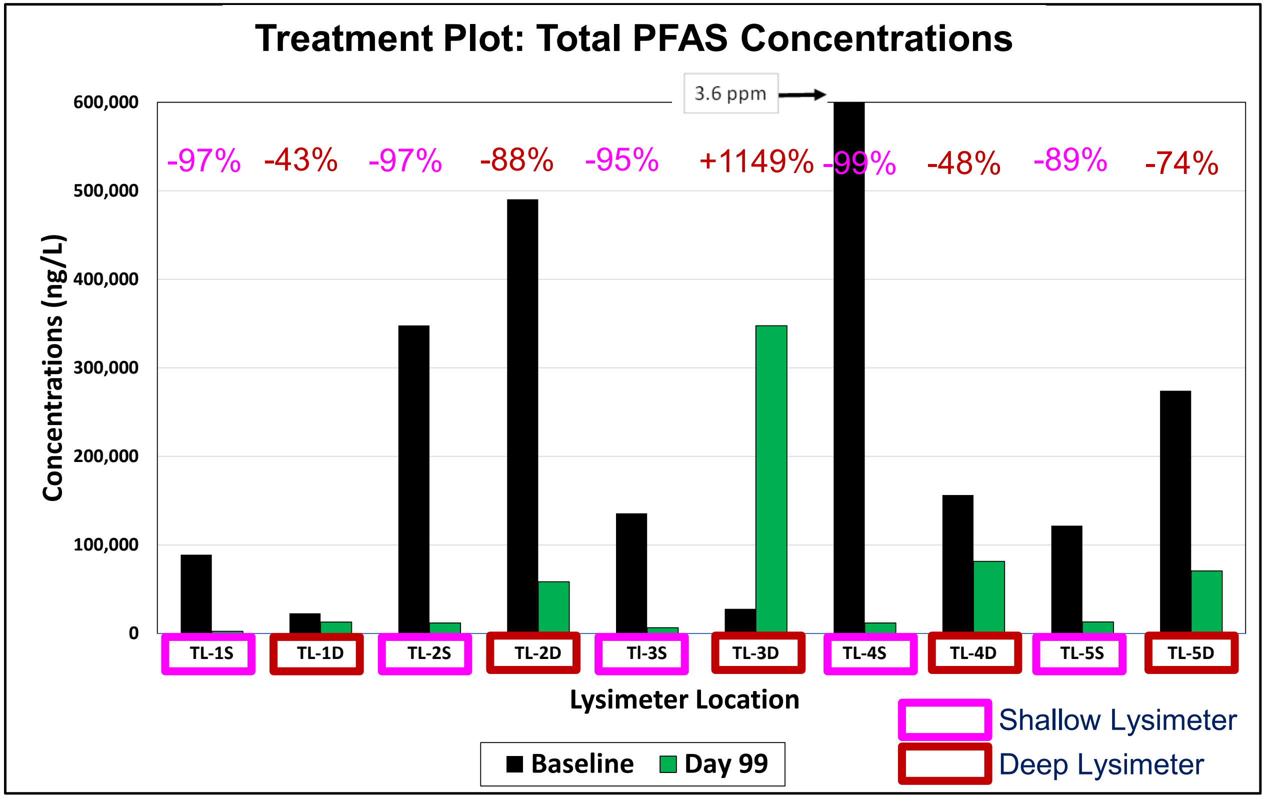
Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast

- **1,900 gallons of a 1.5% CAC solution to treatment plot**
- **1,900 gallons of GAC pre-treated water to control plot**

Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast

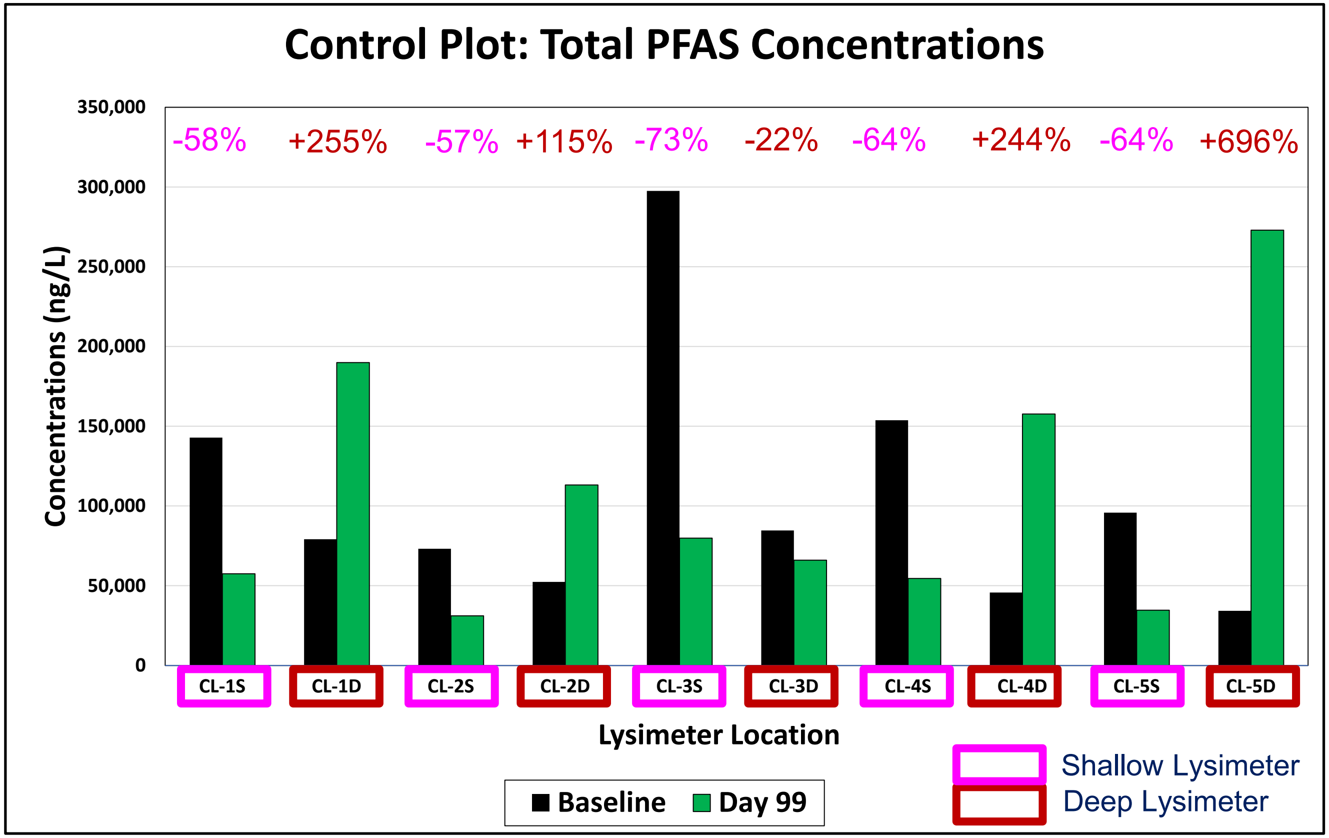
- Monitoring
  - Soil cores: CAC abundant to at least 9 inches and some areas to 37 inches (up to 3,900 mg/kg)
  - Migration into formation not even across treatment area due to very slight grade in treatment area
  - Two pore water events completed to date

Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast



Lysimeter	% change
TL-1S	-97
TL-1D	-43
TL-2S	-97
TL-2D	-88
TL-3S	-95
TL-3D	+1149
TL-4S	-99
TL-4D	-48
TL-5S	-89
TL-5D	-74

Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast



Lysimeter	% change
CL-1S	-58
CL-1D	+255
CL-2S	-57
CL-2D	+115
CL-3S	-73
CL-3D	-22
CL-4S	-64
CL-4D	+244
CL-5S	-64
CL-5D	+696

Case Study 1 - Surface Application of Colloidal Activated Carbon, Air Station in Southeast

Take Aways

- CAC can be surface applied to PFAS impacted soils to reduce mass flux to underlying groundwater
- Some ground surface preparation is advisable prior to surface application
- Feet of CAC infiltration can be achieved

NESDI Project 569

Project Objective:

- Evaluate effectiveness of use of CAC for in situ PFAS treatment

Environmental Questions:

- Does CAC distribute sufficiently in aquifers to effectively treat PFAS?
- What is the in situ treatment effectiveness on different PFAS
- What is the long-term adsorption capacity and potential for re-release of PFAS?
- Are there any significant aquifer effects (e.g. CAC in monitoring wells or hydraulic conductivity impacts)

Approach:

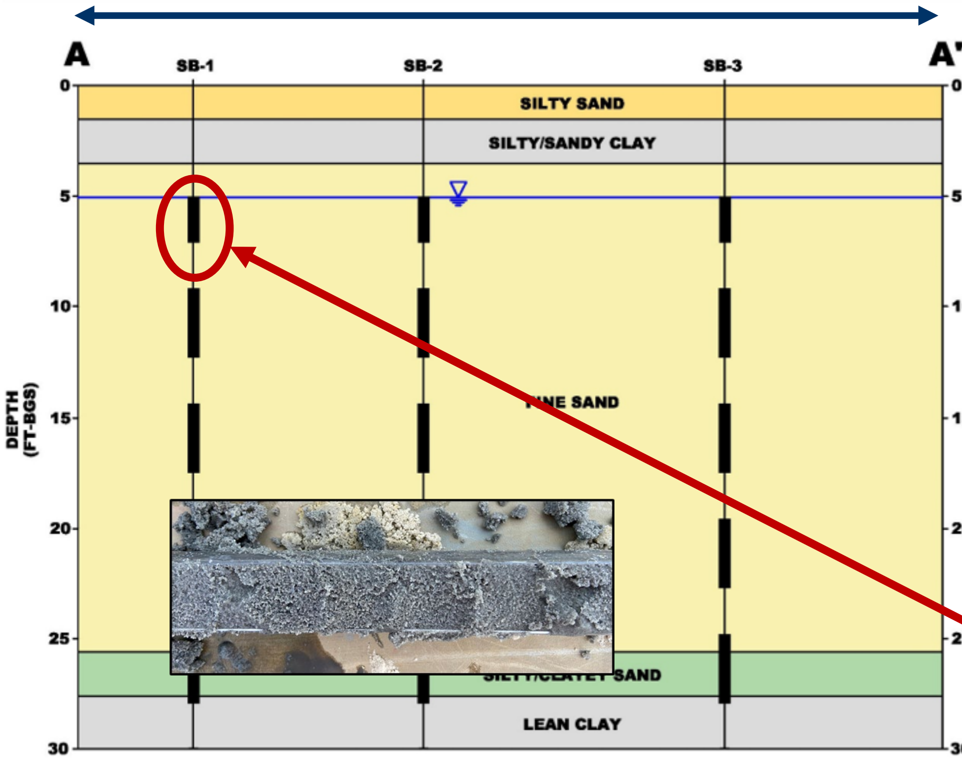
- Site characterization, laboratory testing, barrier installation, and monitoring

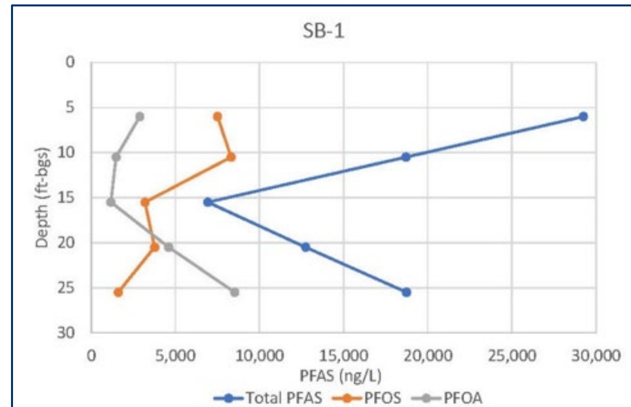
Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic

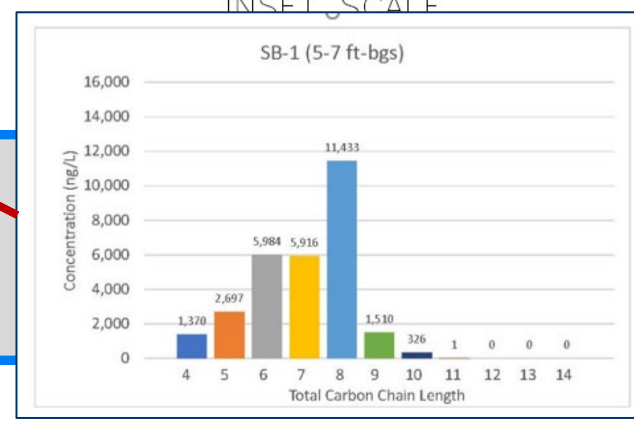
- **Conceptual Site Model**
  - AFFF Storage Area at Installation used for field carrier landing and helicopter training operations
  - High permeability sandy formation
  - Water table within 6 feet of ground surface
  - Relatively homogenous
  - Higher PFAS concentrations – up to about 20,000 ppt PFOS in groundwater

PFOS Concentrations in Groundwater (ng/L)

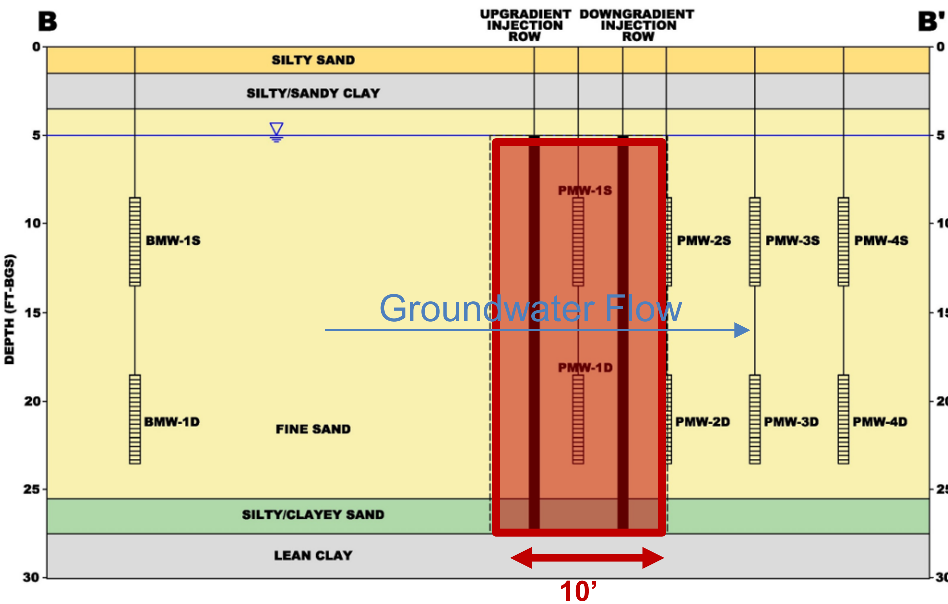
Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic





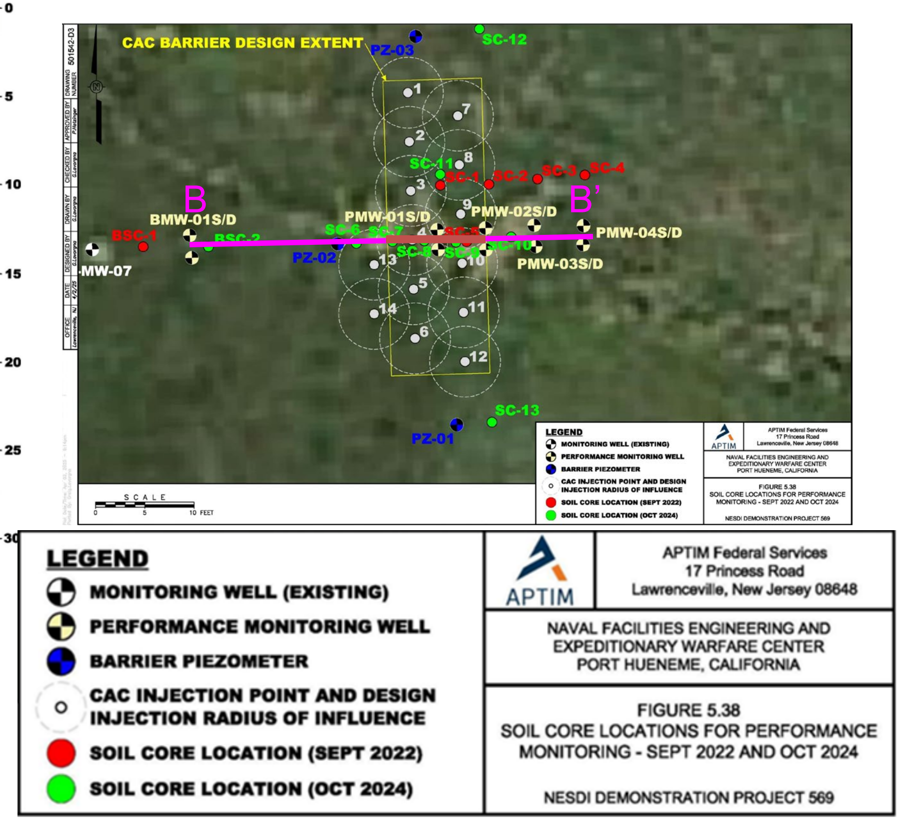


Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic



30' Long x 10' Wide barrier

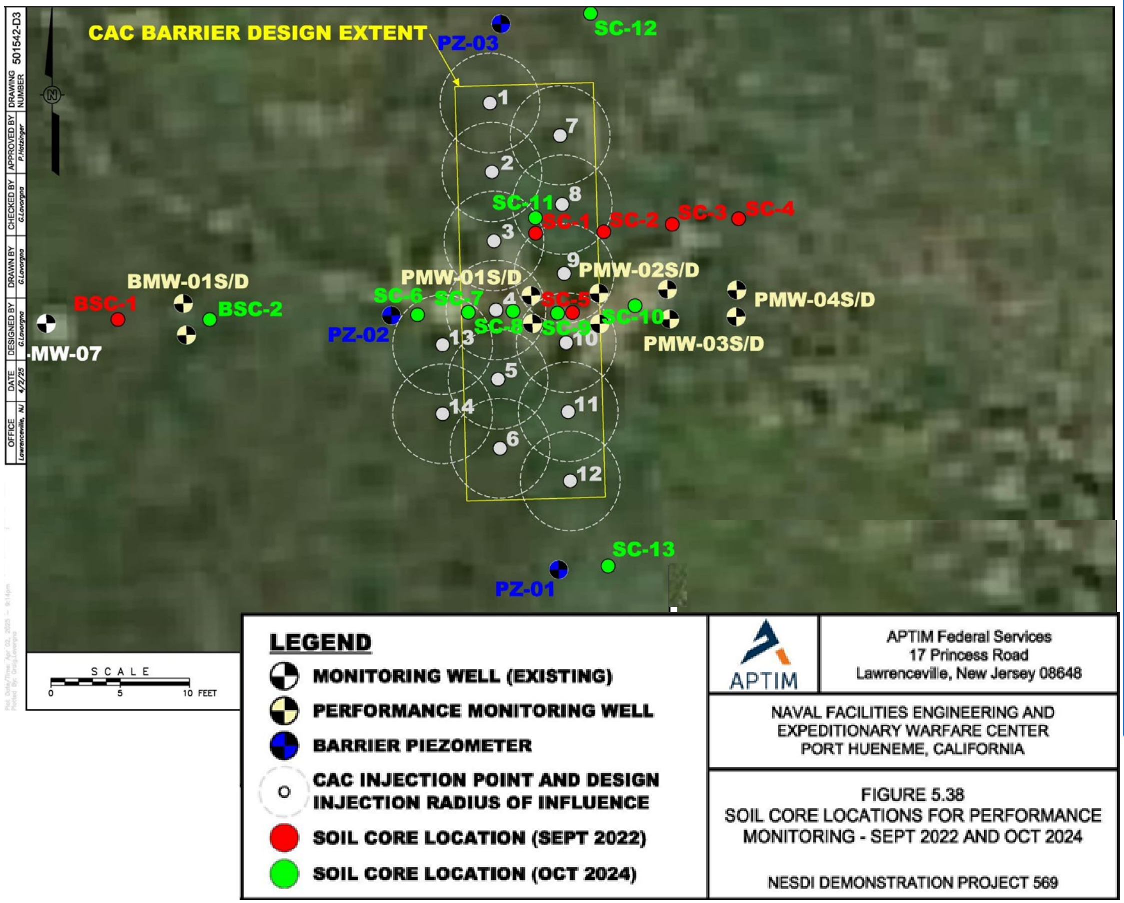
DEMONSTRATION WELL AND INJECTION POINT LAYOUT



Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic

Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic

CAC INJECTION



Quarterly Groundwater Monitoring

- Field parameters (meter)
- Anions (EPA 300.0)
- PFAS

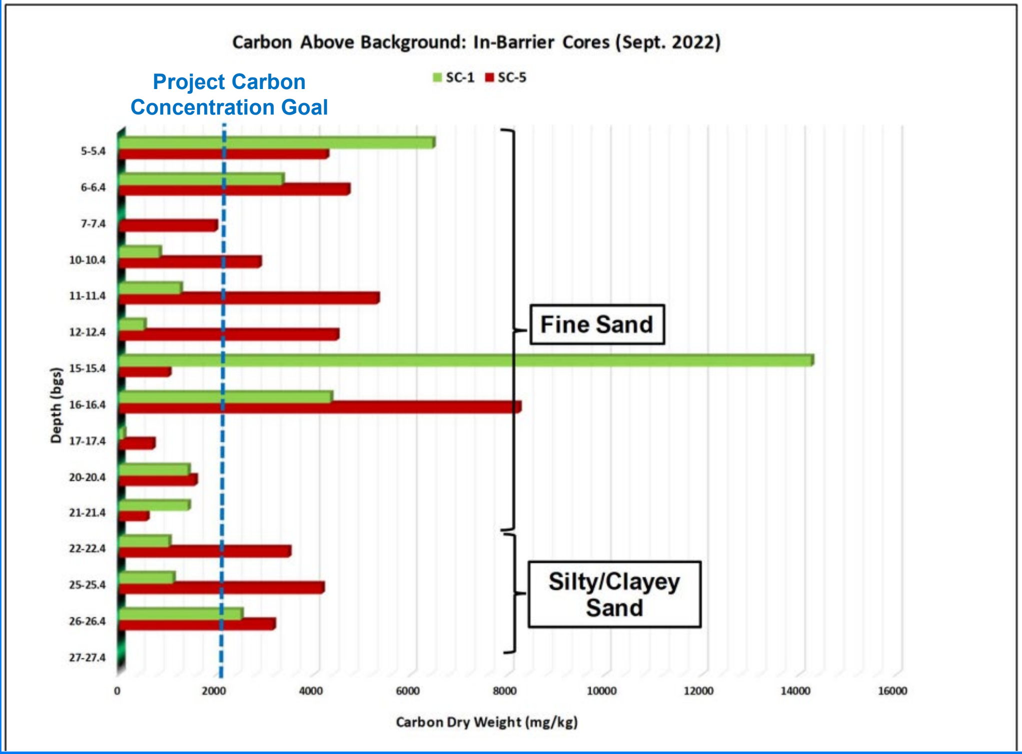
Soil Cores

- 1 & 24-months post injection
- Measure CAC (combustion method)

Passive Flux Meters (6)

- Before barrier Installation
- 1 and 2 years after barrier installation

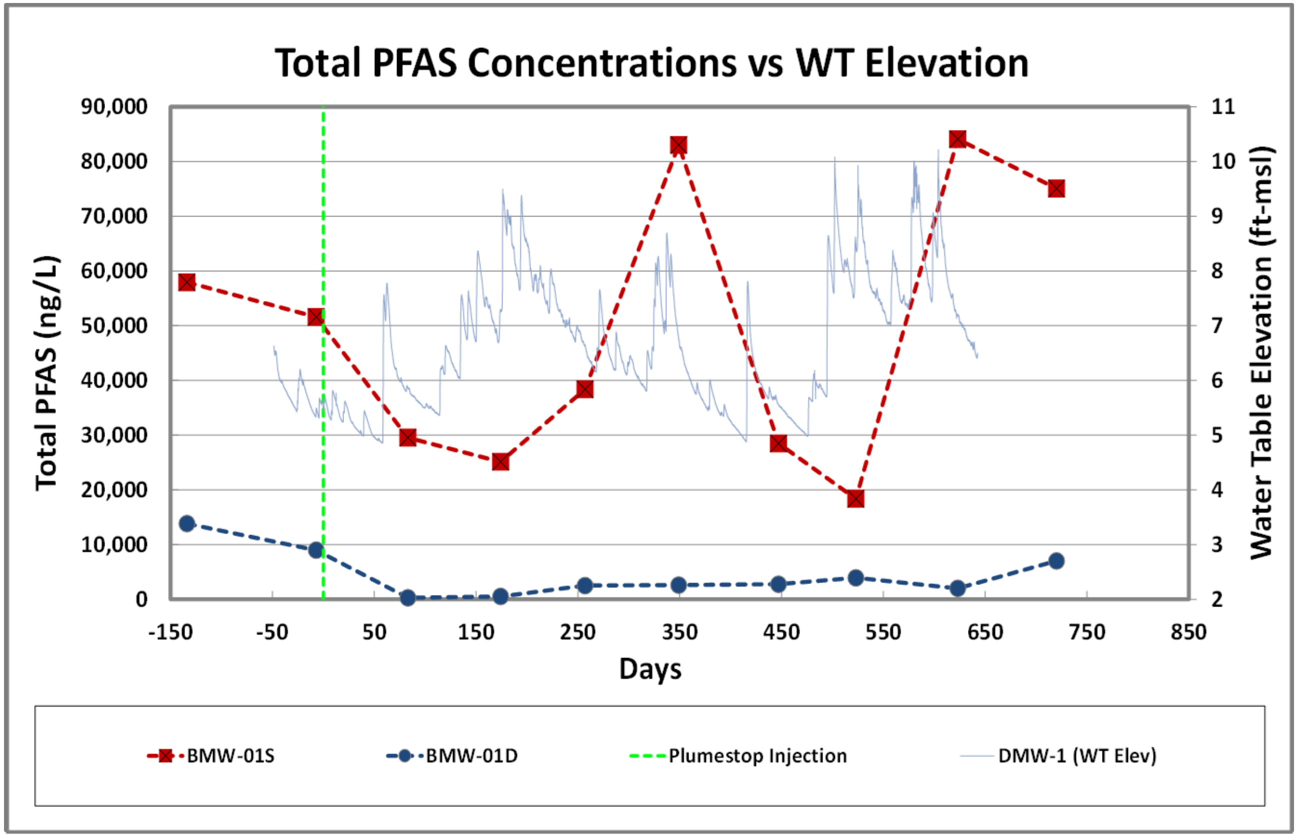
Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic



Key Takeaway – Collodial activated carbon can be effectively distributed in the subsurface using direct injection methods

Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic

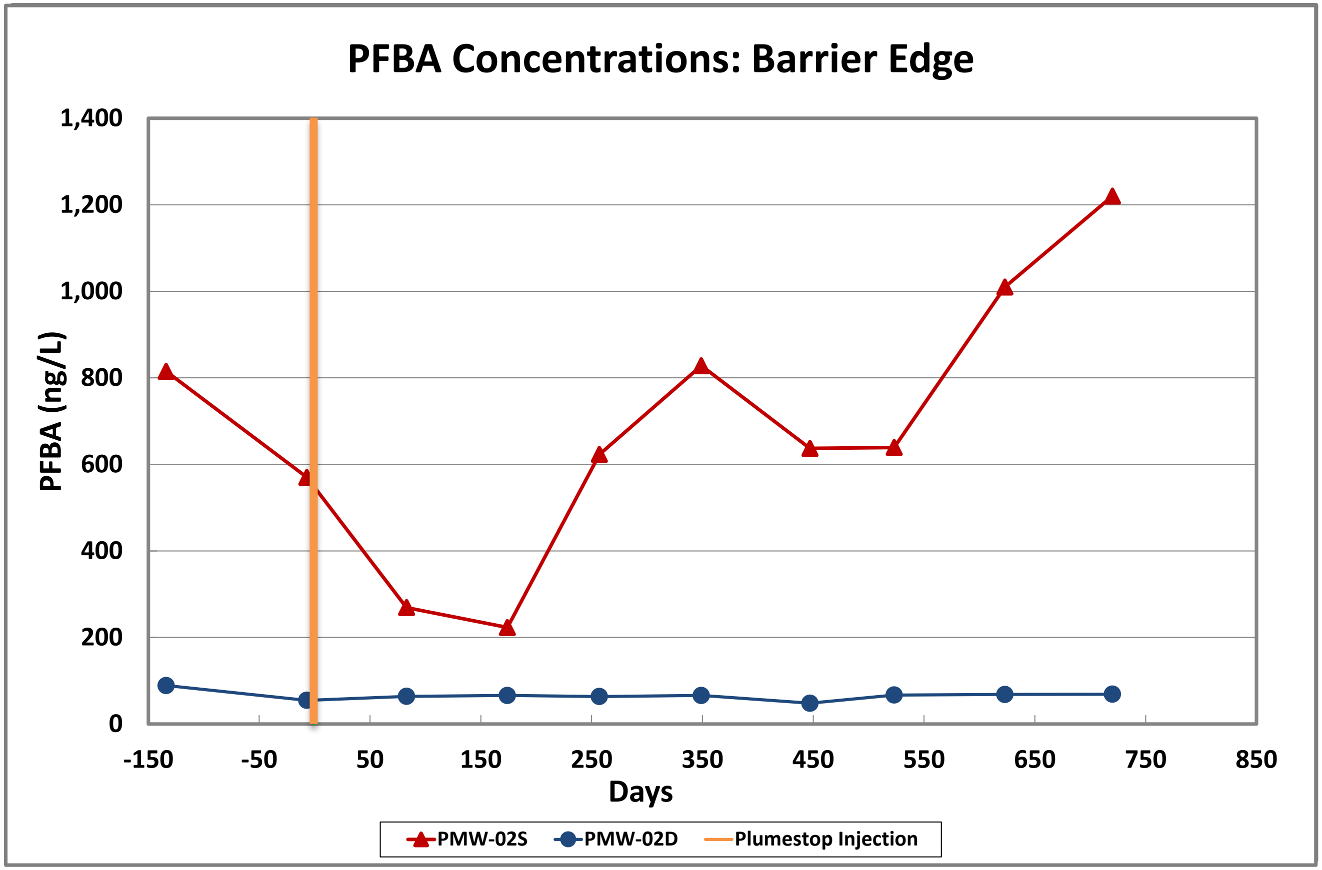
Upgradient Data



<u>Upgradient– 2 YRS</u>

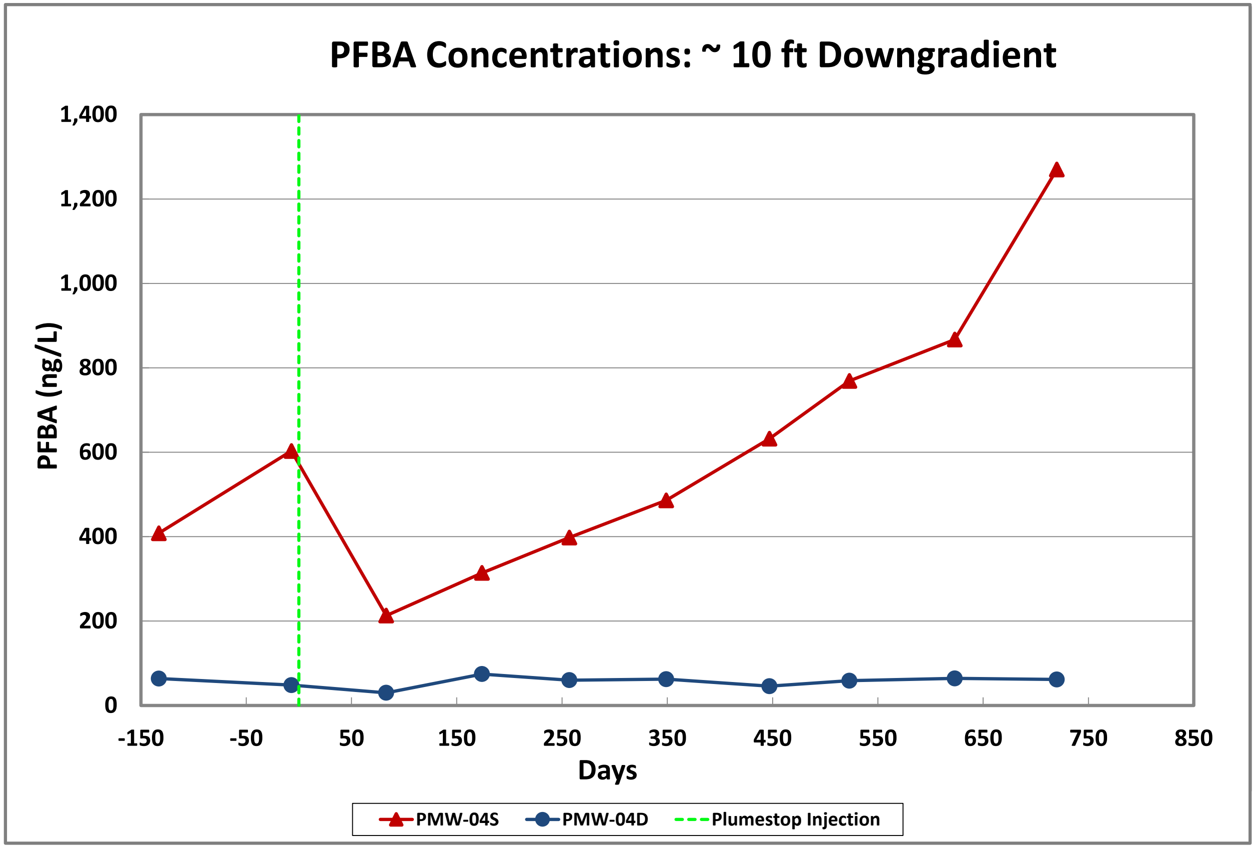
- Pre-injection baseline
  - Shallow: 52 – 58 µg/L
  - Deep: 9 –14 µg/L
- Over time variability in shallow GW suggests vadose zone impacts - groundwater elevation
- Less variability in Deep Zone

PFAS Data - Downgradient Barrier Edge



- **<u>2 years after injection</u>**
- 96.8% reduction in shallow zone
- 96.3% reduction in deep zone
- Complete breakthrough of PFBA
- PFPeA, PFHxA also increasing gradually with time (some wells increased to 100-200 ppt after initial reductions)
- Excluding PFBA, 99.85% removal at downgradient edge

PFAS Data – 10 ft downgradient



- **<u>2 years after injection</u>**
- 91.2% reduction in shallow zone
- 95.3% reduction in deep zone
- Complete breakthrough of PFBA
- Rate-limited and back-diffusion downgradient of barrier + new vadose zone addition

Case Study 2 – Field Demonstration of Colloidal Activated Carbon for In Situ Sequestration of PFAS, Airfield in Mid-Atlantic

Key Takeaways

- Injected CAC barriers can sequester PFAS and reduce downgradient migration of PFAS in groundwater
- Breakthrough of short chained PFAS like PFBA may occur
- If source mass still remains downgradient of treatment, achieving clean up goals may be challenging due to vadose zone leaching and matrix diffusion/desorption

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

ESTCP Project: ER20-5252

Project Objective:

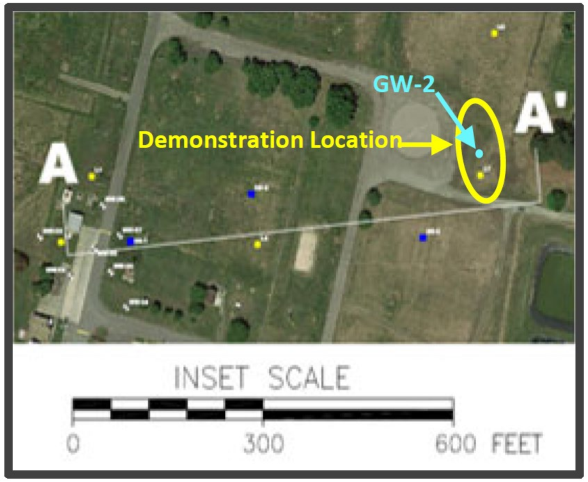
- To demonstrate the long-term and cost effective application of a passive in situ Funnel and Gate Permeable Adsorptive Barrier to capture and remove PFAS emanating from an AFFF source area

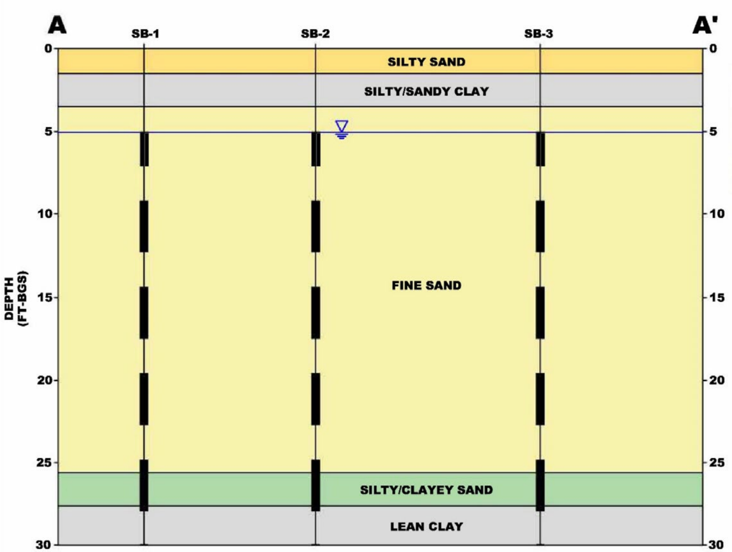
Generalized Conceptual Site Model:

- Naval Air Station Fire Training Area
- PFAS in groundwater from AFFF storage/transfer and fire training activities
- Water table 5’ below ground surface
- Sandy surficial aquifer
- Confining Unit 27’ below ground surface
- Total PFAS (sum of 1633 analytes) up to 365,830 ng/L
- Groundwater migrating off-site toward drinking water receptors (exposure already addressed)

Approach:

- Site characterization, laboratory testing, groundwater modeling, design, installation, monitoring





Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

- **Bench scale column testing performed to select adsorptive media**
- **Three IX resins and one surface modified clay evaluated in columns**
- **Two of the resins performed similarly, one resulted in resin bed expansion**
- **The IX resins were more effective in removing PFAS compared to the surface-modified clay**
- **Selected Dowex Amberlite PSR2 Plus for Field Scale Demonstration**

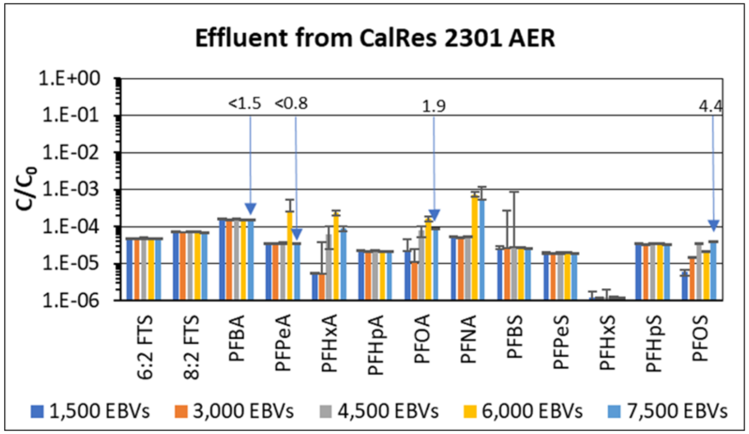


Figure 5.9 PFAS Removal in the CalRes 2301 Columns. Average values plotted. The error bars represent the 95% confidence interval among the three experimental replicates.

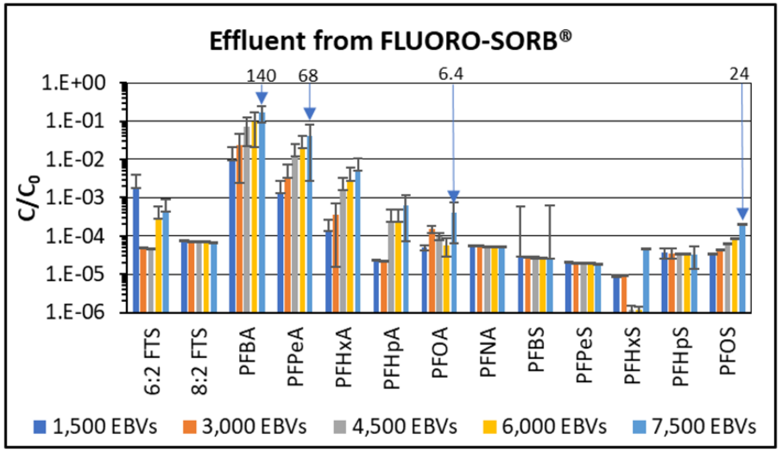
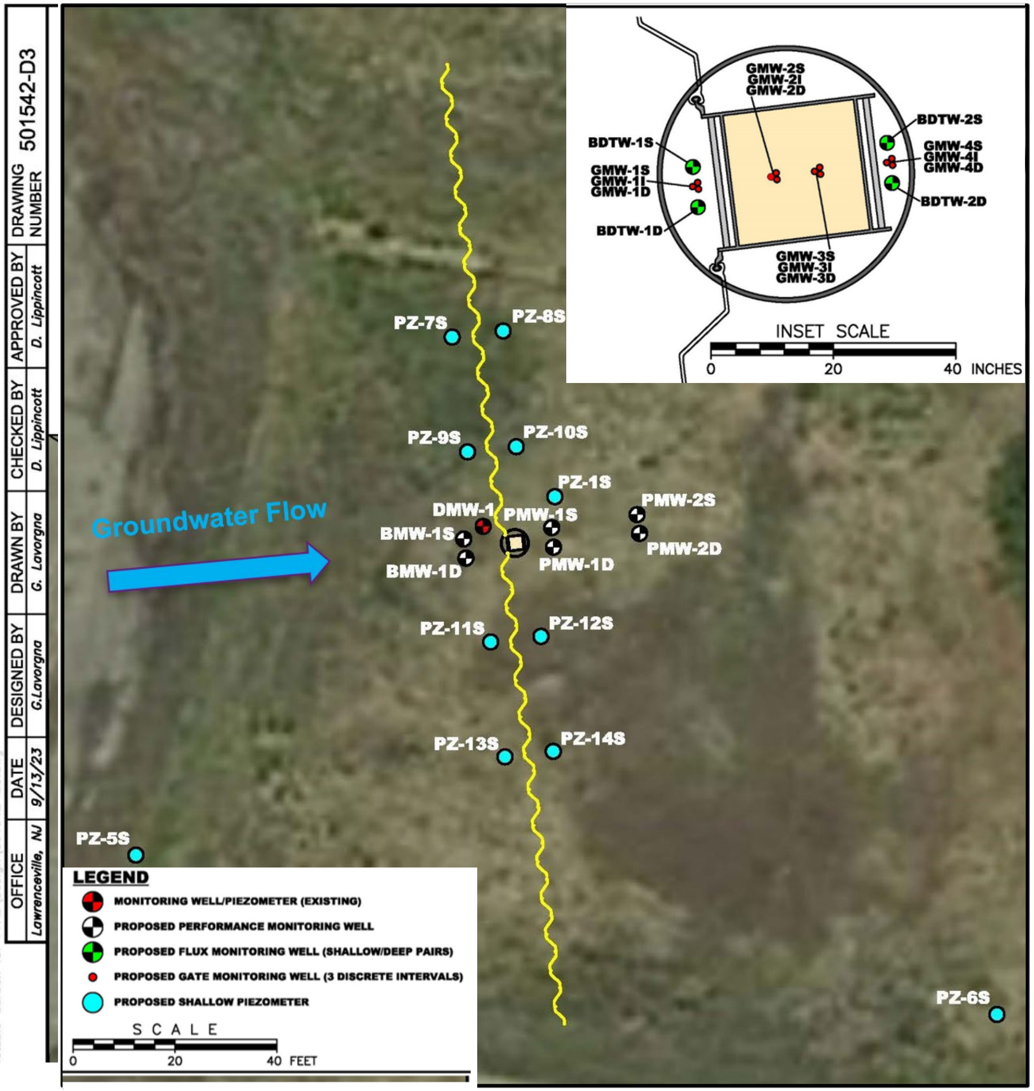
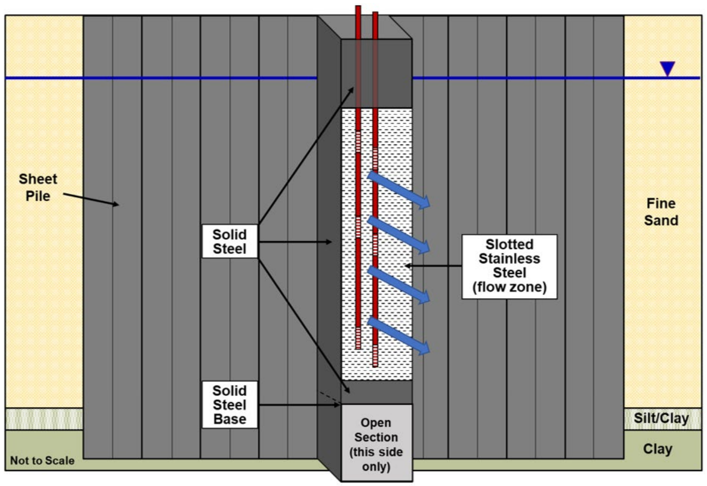


Figure 5.10 PFAS Removal in the FLUORO-SORB® Columns. Average values plotted. The error bars represent the 95% confidence interval among the three experimental replicates.

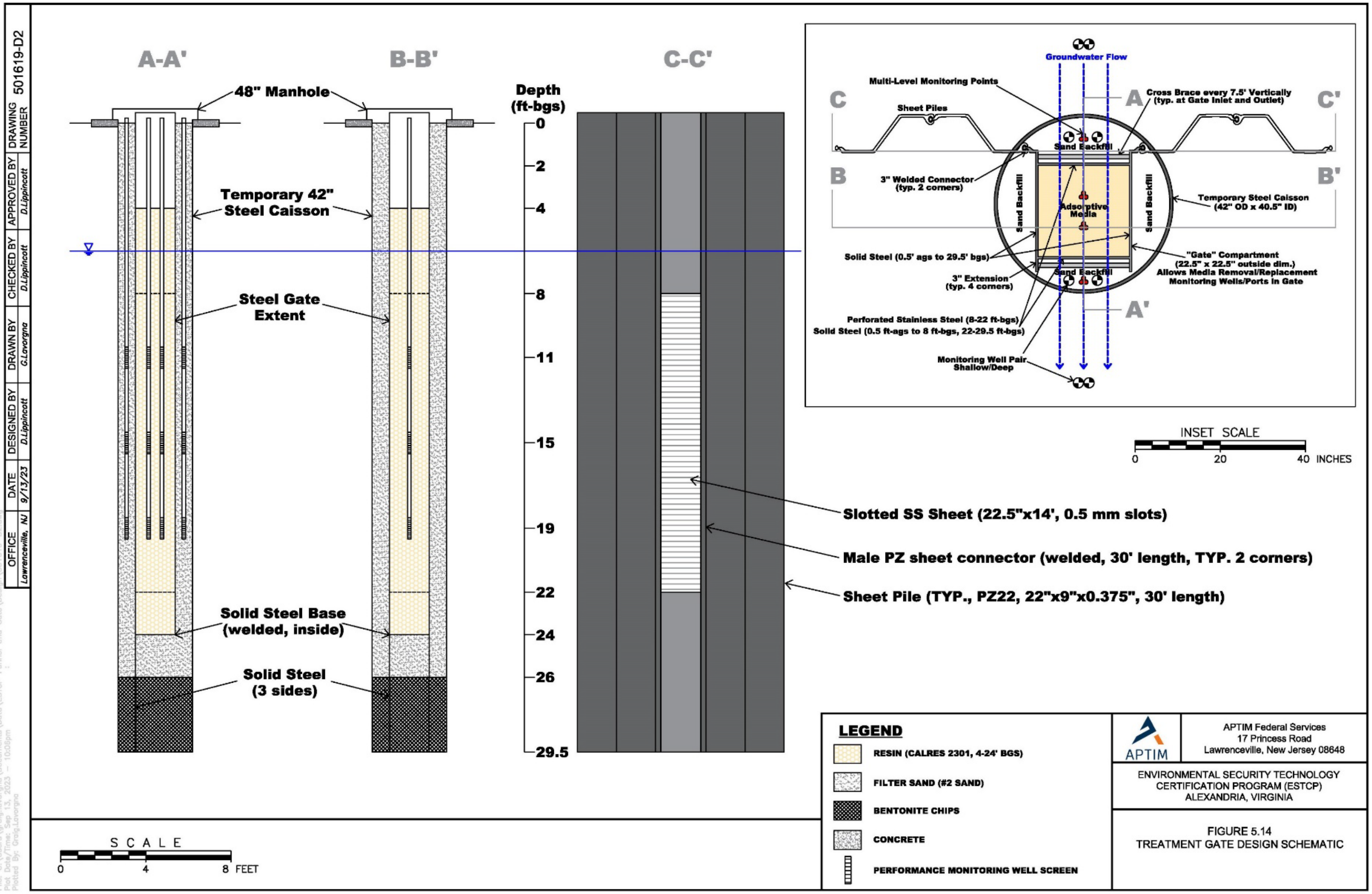
Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic



System Design



Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

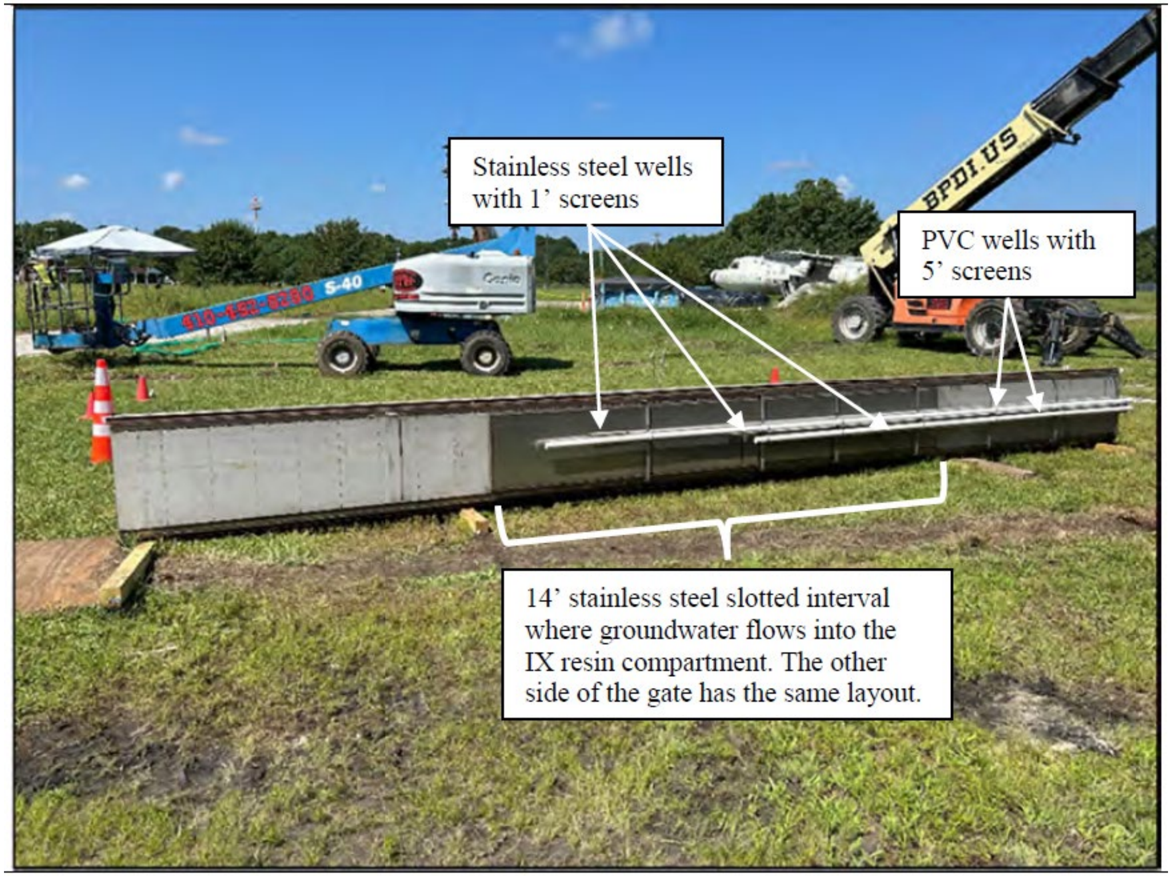


Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

Caisson Installation

Soil Removal from Caisson Using Drill Rig

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic



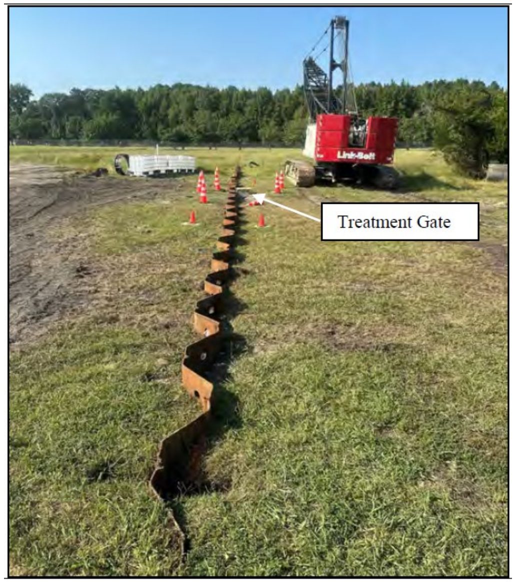
Gate prior to installation

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

Gate Installation

Sand Filter Installation

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic



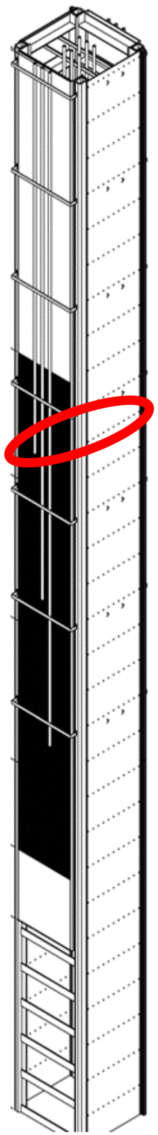
Sheet Pile Installation

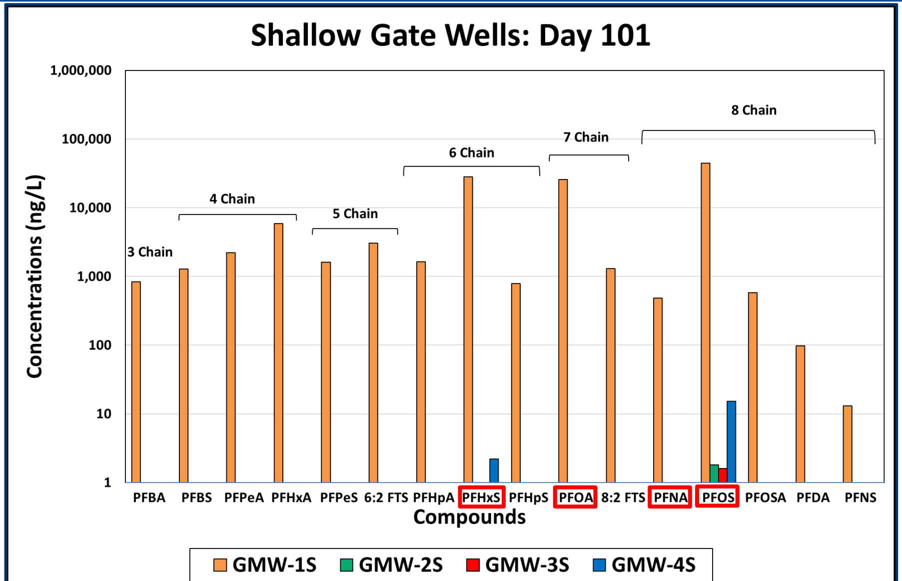
Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

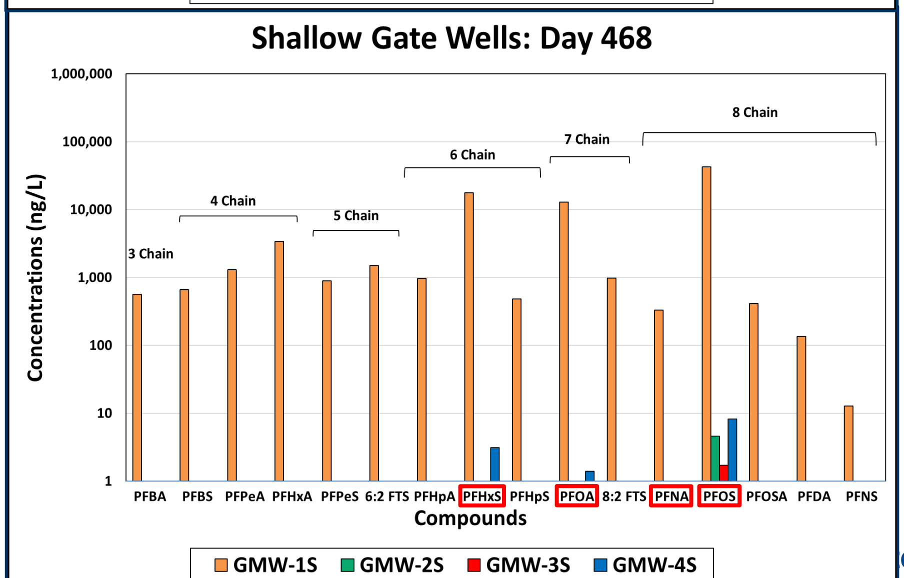
Completed Gate

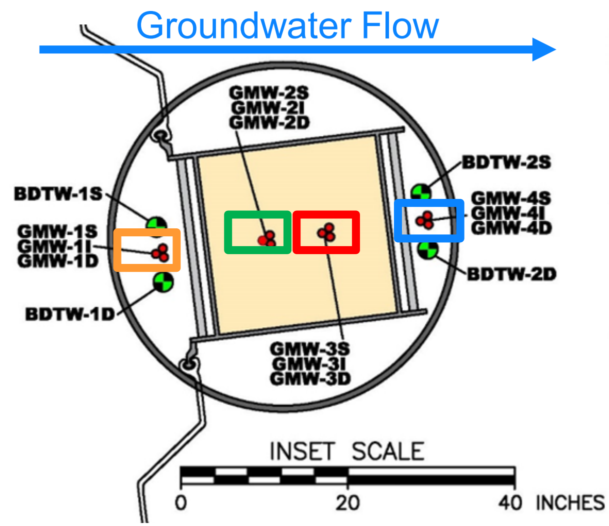
Completed Wall at Surface

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic







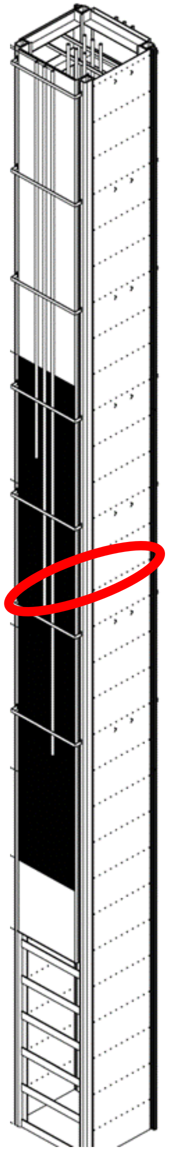


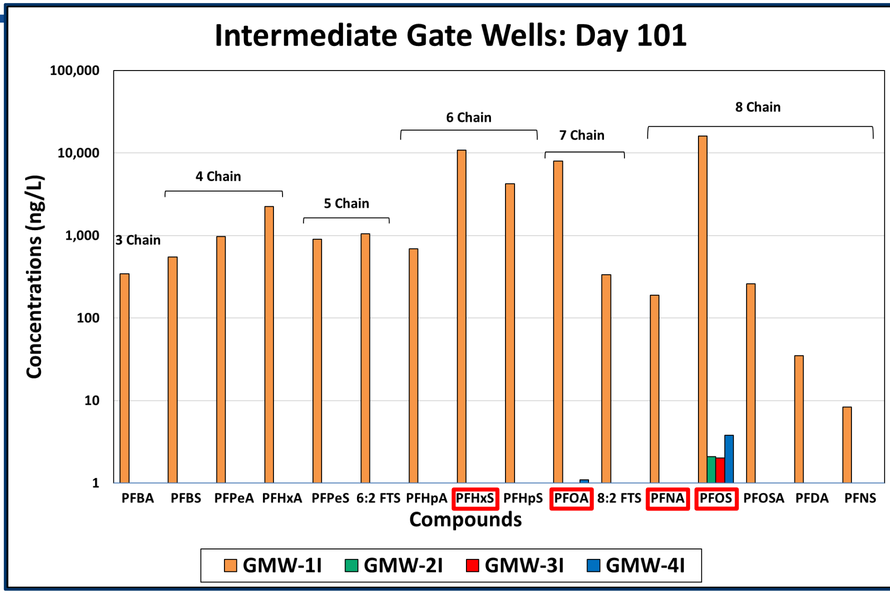
Shallow Gate Wells

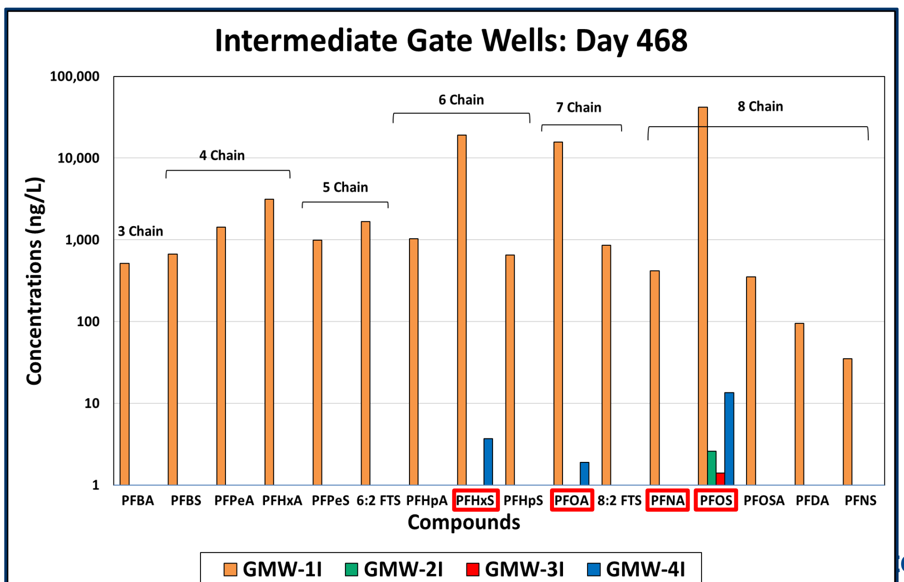
- Up to 5 orders of magnitude decrease in gate and effluent well
- Short-chain PFAS removed
- MCLs* achieved:
  - PFHxS: 11 out of 12 samples
  - PFOA: 12 out of 12 samples
  - PFNA: 12 out of 12 samples
  - PFOS: 6 out of 12 samples*

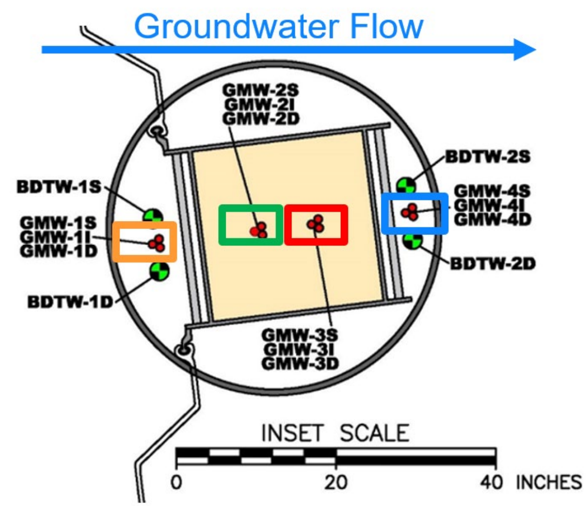
*MCLs have not been established as groundwater clean up goals for this site; however, they were used as performance metrics for this research project.

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic









Intermediate Gate Wells

- Up to 4 orders of magnitude decrease in gate and effluent well
- Short-chain PFAS removed
- MCLs* achieved:
  - PFHxS: 11 out of 12 samples
  - PFOA: 12 out of 12 samples
  - PFNA: 12 out of 12 samples
  - PFOS: 6 out of 12 samples*

*MCLs have not been established as groundwater clean up goals for this site; however, they were used as performance metrics for this research project.

Case Study 3 – Funnel and Gate Permeable Adsorptive Barrier (PAB) for *In Situ* PFAS Immobilization and Removal, Airfield in Mid-Atlantic

Key takeaways

- **Funnel and gate systems can treat high levels of PFAS to at or near MCLs* for over a year**
- **Funnel and gate systems are a passive treatment with low O&M costs**
- **Adsorptive media can be exchanged, removing PFAS from the subsurface**
- **May need multiple funnels and gates to capture plume**

*MCLs have not been established as groundwater clean up goals for this site; however, they were used as performance metrics for this research project.

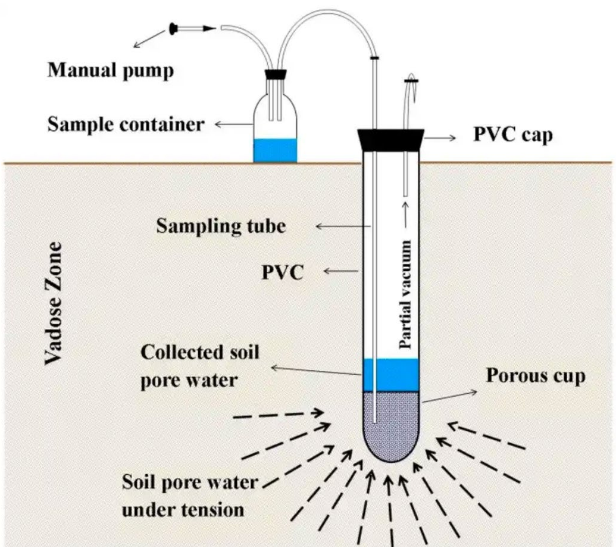
Lessons Learned

Lesson Learned: Characterization Recommended Before Designing

- **PFAS via Method 1633 – target list**
  - Do not use total organic precursor (TOP) assay, total organic fluorine (TOF), non-target analytical list, or other non-standardized PFAS analytical methods without clear objectives, intent for use, and chain of command and SME agreement
- **Groundwater chemistry may impact treatment efficacy**
  - TOC (SM 5310)
  - Metals (especially iron and manganese) (Method 6010D)
  - Anions (Method 300.0)
  - Alkalinity (SM 2320B)
  - Field parameters (pH, ORP, specific conductivity, temperature, turbidity)
- **Co-contaminants (VOCs, petroleum related constituents)**
- **Hydraulic characteristics**
  - Water levels
  - Hydraulic conductivity
  - Detailed geologic characterization (especially soil type/grain size)
  - Tidal study (coastal sites)

Lessons Learned: Recommendations for Monitoring System Performance

- For materials that can be seen with the eye, soil cores are useful to evaluate distribution
- For all barrier remedies
  - Upgradient and downgradient wells to ensure treatment across the barrier
  - Wells along the sides of the barrier to assess potential migration around the barrier
  - Capture multiple depths as appropriate based on lithology
  - Understand groundwater flow velocity and direction
  - Several rounds of quarterly monitoring likely needed
  - Keep potential desorption in mind when placing wells
- Lysimeters or another leaching assessment as well as groundwater beneath the application area is recommended for vadose zone applications
  - Pre-treatment samples should be collected for comparison to post-treatment
  - May have difficulty meeting 1633 volume requirements



Suction Lysimeter

Lessons Learned: Recommendations for Monitoring System Performance

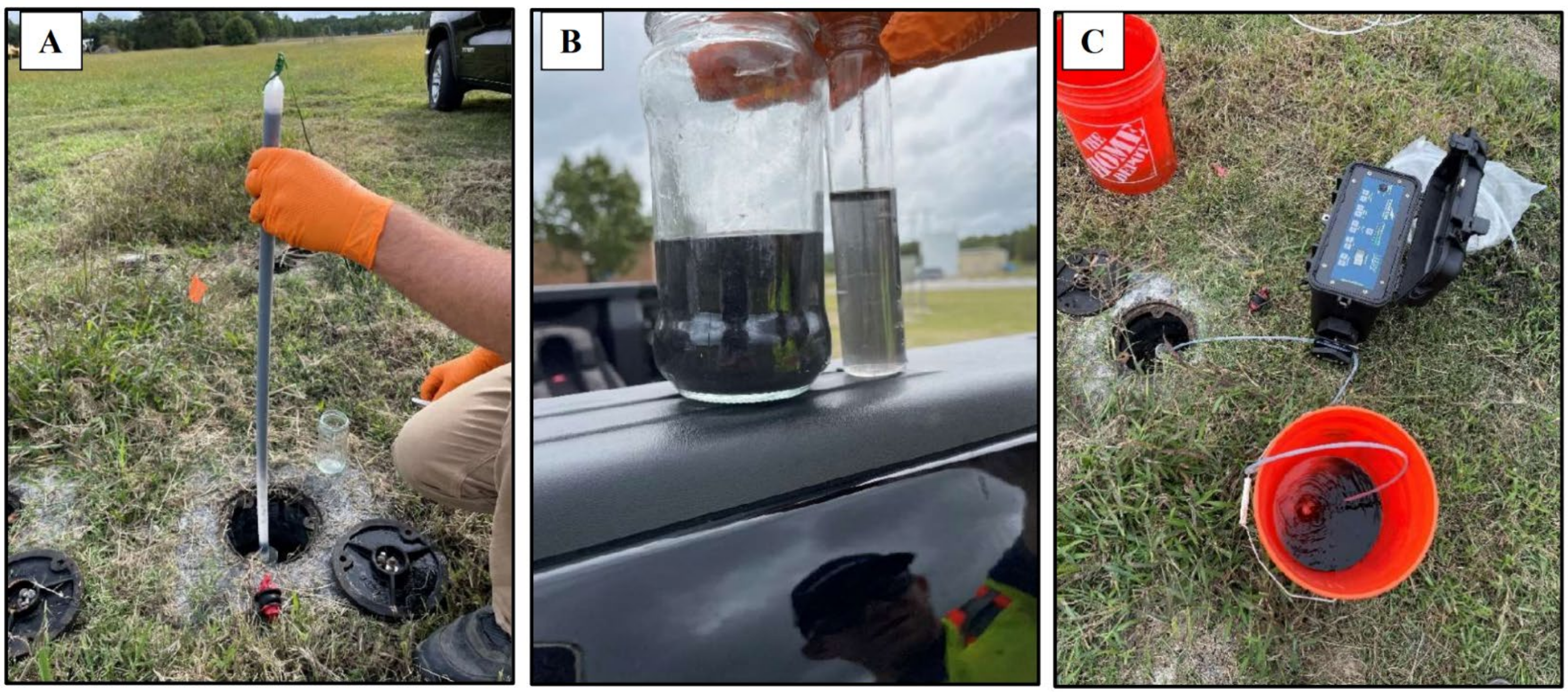
- **REMEMBER:**
  - Eventually adsorption capacity of the treatment media will be reached
  - Once in the subsurface, for most application approaches, there is no simple or inexpensive way to extract the amendment
  - If there is still mass downgradient of a barrier, it may still contribute to downgradient concentrations for some time
  - Important to continue to monitor; reapplication or (when possible) media replacement may be needed

Lesson Learned: Recommendations for Post-treatment Monitoring Analytical Suites

- Pare down list as appropriate based on what you learned during the initial characterization
- PFAS via Method 1633 – target list
- Groundwater chemistry ()
  - TOC (SM 5310)
  - Metals (especially iron and manganese) (Method 6010D)
  - Anions (Method 300.0)
  - Alkalinity (SM 2320B)
  - Field parameters (pH, ORP, specific conductivity, temperature, turbidity)
- Co-contaminants (VOCs, petroleum related constituents)
- Soil cores (for distribution)
- Hydraulics (check to see what changed)

Lesson Learned: Managing Migration of Activated Carbon

- Colloidal carbon may migrate readily into monitoring wells or adjacent surface water features/sewer systems
  - May be regulatory concerns with analyzing samples containing carbon
  - Lab may have to do additional processing and charge more for analysis
  - May dissipate after a few quarters of monitoring
- May be perception problems if carbon is observed in surface water



Lesson Learned: Managing Migration of Activated Carbon

- Use of "parking agent" is the most common mitigation approach to address carbon migration to wells and prevent migration to surface water
  - Flocculates the carbon by reducing the repulsion between particles
  - Allows particles to aggregate and settle out
  - Examples: calcium chloride, enzymes
- Parking agents may enhance PFAS adsorption to CAC
- May be regulatory concerns with analyzing samples containing carbon and with potential biases from increased adsorption
- Be sure to get team consensus on approach!

Monitoring Well Location	Flushing Interval (feet)	Clean Water Injected (gallons)	$CaCl_2$ Solution Injected (gallons)	$CaCl_2$ Injected (pounds)	Total Injected (gallons)	Final Activated Carbon Concentration (ppm)
PMW-01S	13-8	33.5	36.5	34	70.0	0 ppm
PMW-01D	23-18	34.5	36.0	33	70.5	<50 ppm
PMW-02S	13-8	33.5	36.5	34	70.0	<50 ppm
PMW-02D	23-18	43.5	36.5	34	80.0	600 ppm
PMW-03S	13-8	20.0	37.0	34	57.0	0 ppm
PMW-03D	23-18	20.0	37.0	34	57.0	0 ppm
PMW-04S	13-8	N/A	N/A	N/A	N/A	0 ppm
PMW-04D	23-18	20.0	37.0	34	57.0	0 ppm

Lesson Learned – Unanticipated Byproducts

- **Project team must ensure injected or added materials do not present other hazards to human health or the environment unrelated to those they are intended to address**
- **Additives which use amine chemistry are potential contributors of n-nitrosodimethylamine (NDMA), a probable human carcinogen with a tap water RSL and health advisories in several states**
- **Other possible concerns are additives like cetyltrimethylammonium chloride (CTAC), which may extend carbon life expectancy, but is ecotoxic and should not be used in in situ treatment**
- **When in doubt, check with an SME!**

In Situ Sequestration in CERCLA Remedies

- **Unlikely to be a stand-alone remedy**
  - **Reduces mobility but not toxicity or volume**
  - **Not capable of achieving risk-based clean up goals in source areas**
- **Can be useful as an interim action to prevent migration to sensitive receptors**
- **Can be part of a remedial treatment train:**
  - **High Concentration Source Area Example:**
    - Soil removal, groundwater foam fractionation, and supercritical water oxidation of foamate in source area
    - Sequestration barrier to prevent downgradient migration while source treatment is ongoing
    - Monitoring
    - Land use controls
  - **Lower Concentration Source Area Example**
    - Soil cover and groundwater sequestration in low concentration groundwater source area
    - Monitoring
    - Land Use Controls
  - **Other combinations too!**

Key Messages

- In situ sequestration can be a good option to reduce mass flux and PFAS migration depending on the CSM
- In situ sequestration is not suitable to address direct exposure hazards to soil
- Site characteristics (geology, co-contaminants, geochemistry, etc.) may influence effectiveness of treatment
- Media eventually reaches capacity and reapplication or media replacement (where possible) may be needed
- Monitoring is key to meeting treatment objectives
- Set realistic treatment objectives in order to meet long-term protectiveness

Points of Contact

- **Laura Cook**

  laura.j.cook2.civ@us.navy.mil

- **Tony Danko**

  anthony.s.danko.civ@us.navy.mil

- **Jason Speicher**

  jason.a.speicher2.civ@us.navy.mil

Questions? Email to EXWC.T2@us.navy.mil

Wrap Up

A short Survey Monkey will be emailed to webinar registrants and participants

Stay tuned for upcoming OER2's via email: *EXWC.T2@us.navy.mil*

You can find previous presentations on the *ERB Website> OER2 Presentations* and our *OER2 YouTube channel* all found on https://exwc.navfac.navy.mil/go/erb

Thank you for participating!