Naval Facilities Engineering Systems Command
NAVFAC Atlantic

Perspectives on and Examples of Integrating Ongoing DoD Research into Long-Term Remediation Strategies for PFAS

8 November 2022

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Presentation Overview

- Overview of SERDP/ESTCP
- Thoughts on Research to Commercialization
- Examples of integrating technology testing into existing pilot test systems
- Summary and Final Thoughts

What is SERDP and ESTCP?

SERDP
DOD ▪ EPA ▪ DOE

Strategic Environmental Research and Development Program

Science and Technology

- Fundamental research to impact DoD environmental management
- Advanced technology development to address near-term needs

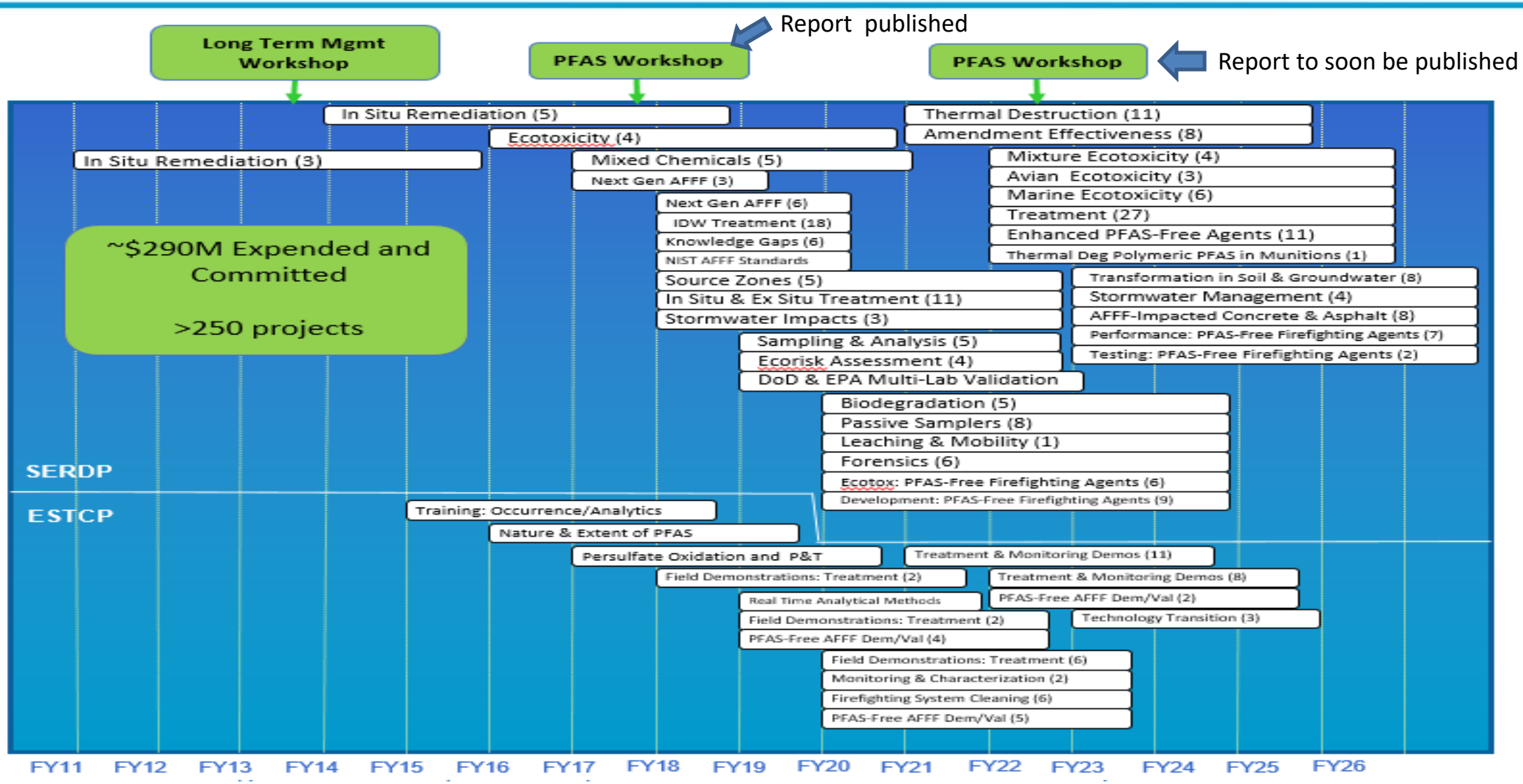
ESTCP

Environmental Security Technology Certification Program

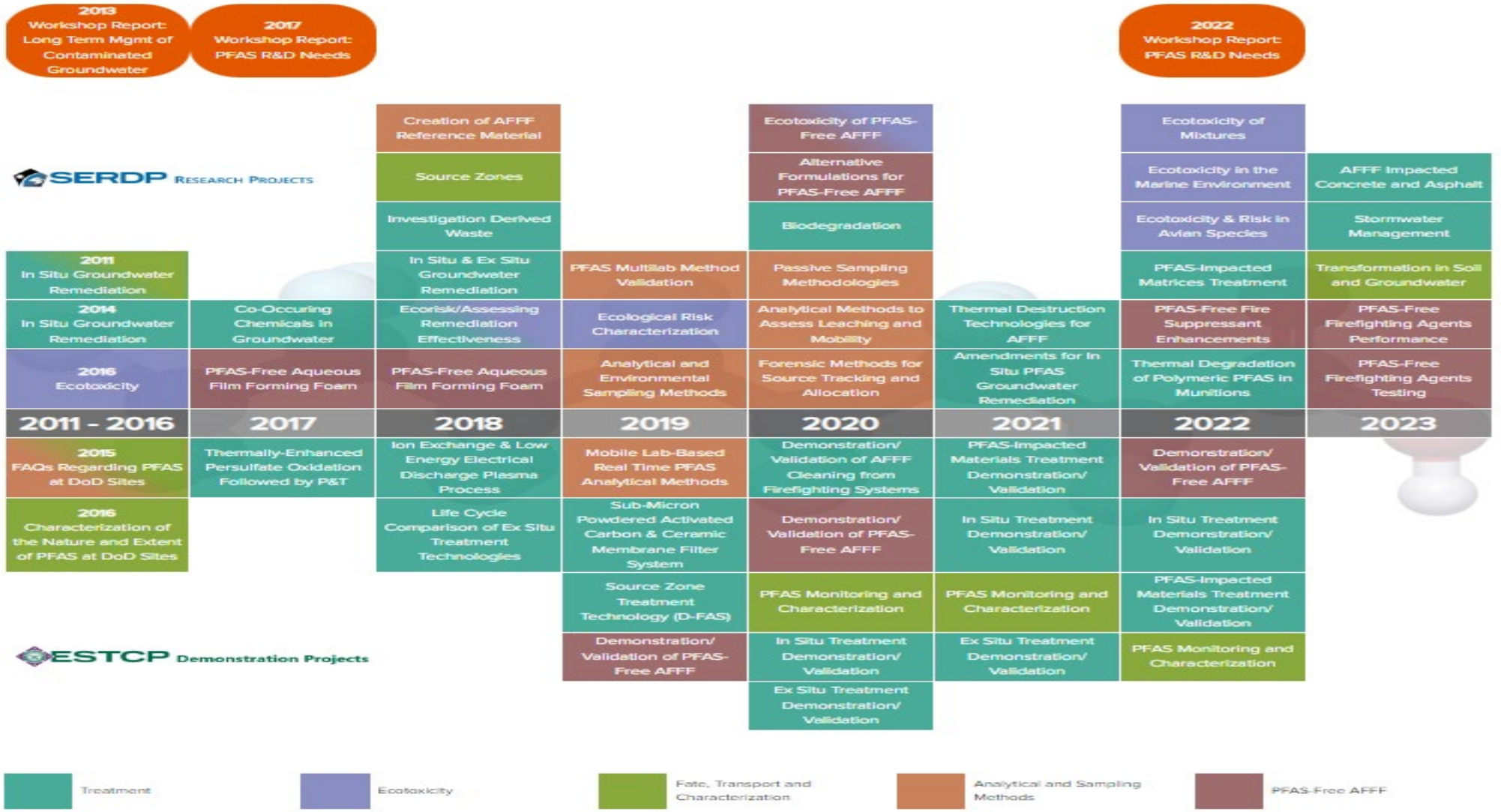
Demonstration/Validation

- Innovative cost-effective environmental and energy technology demonstrations
- Promote technology implementation by direct insertion and partnering with end users and regulators

SERDP/ESTCP PFAS Timeline Efforts



Another Look at PFAS R&D Timeline



Important Links to SERDP/ESTCP Efforts

- SERDP/ESTCP has recently updated their website in the PFAS Focus Area to enhance its navigation and user experience.
  - Link to PFAS focus area - https://www.serdp-estcp.org/focusareas/e18ec5da-d0de-47da-99f9-a07328558149/pfas-afff#subtopics
  - Link to Research Projects - https://www.serdp-estcp.org/focusareas/e18ec5da-d0de-47da-99f9-a07328558149/pfas-afff#project
  - Link to Tools and Training - https://www.serdp-estcp.org/focusareas/e18ec5da-d0de-47da-99f9-a07328558149/pfas-afff#tools-training

"Trust, but Verify" – Absolute Must

- Eternal scientific optimist – Smart minds with adequate time can solve some of the toughest scientific problems
- **Caution Ahead** – Greater $$$$$ can = path to stretching and skipping crucial steps in the scientific process, which ultimately could lead to commercialization of unproven technologies based on insufficient science
  - Remediation of PFAS in environmental media is not going to be easy just based on chemical structure
  - In the race for quick solutions and answers sometimes undo pressure can be place on researchers to provide immediate results and publish those results
  - Results shouldn't always = successes, because sometimes the greatest knowledge can be gained from understanding what doesn't work – That is the beauty of science and life in general!!!!!
- The road traveled from research to commercialization of technologies for remediation of PFAS should be expected to be bumpy and have turns ahead.
  - Performing real world demonstrations under multiple site conditions with scientific oversight is an absolute necessity – Defines advantages and disadvantages of technologies
  - Understanding and adequately summarizing cost-benefits of technologies needs to have some standardization

Avenues to Field Demonstration

- **Proof of Concept** – The science that serves as the basis of technology development first starts in the lab.
  - Often works with spiked media under controlled or understood conditions
- **Validation of Concept** – Researchers transition to field collected media which introduce factors such as environmental weathering, mixed contaminants, varying natural conditions (e.g, pH, TOC, etc) to further evaluate in lab or even potentially in the field on small scales
- **Demonstration Phase** - Eventually researchers must test their technologies in the field where there are increasing variables and less control on conditions
- **Commercialization** – Practitioners must challenge and push researchers in this path, but also provide guidance and avenues to complete the demonstration phase so optimization and commercialization can be achieved.

Providing Opportunities for Demonstrations

- Providing opportunities for field demonstration helps understand:
  - Advantages and limitations of technology applications under various site conditions.
  - Ways to optimize technologies – Improvement based upon lessons learned
  - If there could be unintended consequences of implementing technology under certain field conditions (arguably should be considered under laboratory testing).
  - Ways to provide performance and cost comparison information between technologies that is vital to remediation selection.
- Providing Testbed Demonstration Sites is not new to DoD
  - In the late 1990s/early 2000s these sites were available to evaluate technologies for chlorinated solvent remediation
- A concerted effort to identify pseudo testbed demonstration sites needs to occur again for PFAS, not just within DoD.

DoD Demonstration Site Considerations

- Researchers and Consultants have various important site considerations for considering demonstrations (not a comprehensive list):
  - Active vs Closed Bases
    - Utility Access
    - Security Requirements
    - Access to demonstration area
    - Current site operations
    - Currently above and below ground infrastructure
    - Etc., Etc., Etc.
  - Data availability and concentrations present (ppm vs ppb vs ppt)
  - Commingled contaminants present (e.g., petroleum, cVOCs, etc.)
  - Geology and hydrogeology considerations
  - Regulatory and public willingness to be open to demonstrations

Providing Opportunities for Demonstrations

Naval Air Station Joint Reserve Base (NASJRB) Willow Grove

- Located in Horsham Twp. Pennsylvania
- Originally 1,142 acres (~900 Acres Awaiting Transfer)
- Open from 1942 to 2011
  - Provided support infrastructure and services to assigned units and support commands.
  - Supported Navy, Marine Corps, Air Force Reserve, and PA Air National Guard and Army Guard Units
- In 2005 the Defense Base Closure Realignment Commission (BRAC) recommended NASJRB for closure.
- In 2011, NASJRB ceased flight operations and entered caretaker status, pending property transfer to the Horsham Land Redevelopment Authority
- CERCLA Site
- PFAS impacts have evolved as a major onsite and offsite issue related mainly to historical use of AFFF.
- CERCLA investigation (RI) and interim removal actions taken or ongoing

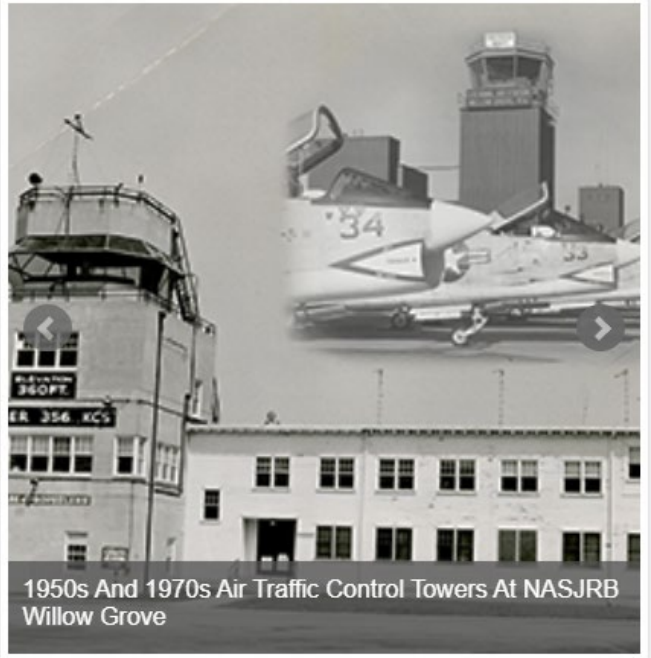
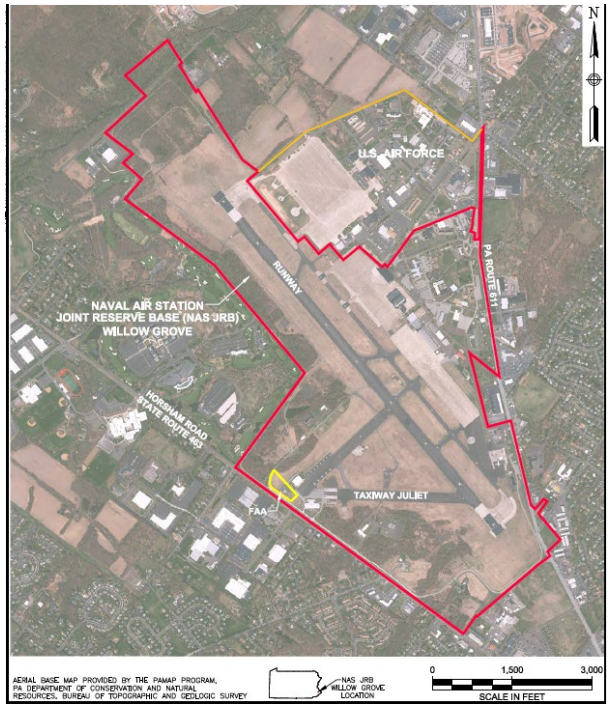


Photo from BRAC NASJRB Willow Grove website: https://www.bracpmo.navy.mil/BRAC-Bases/Northeast/Former-Naval-Air-Station-Joint-Reserve-Base-Willow-Grove/



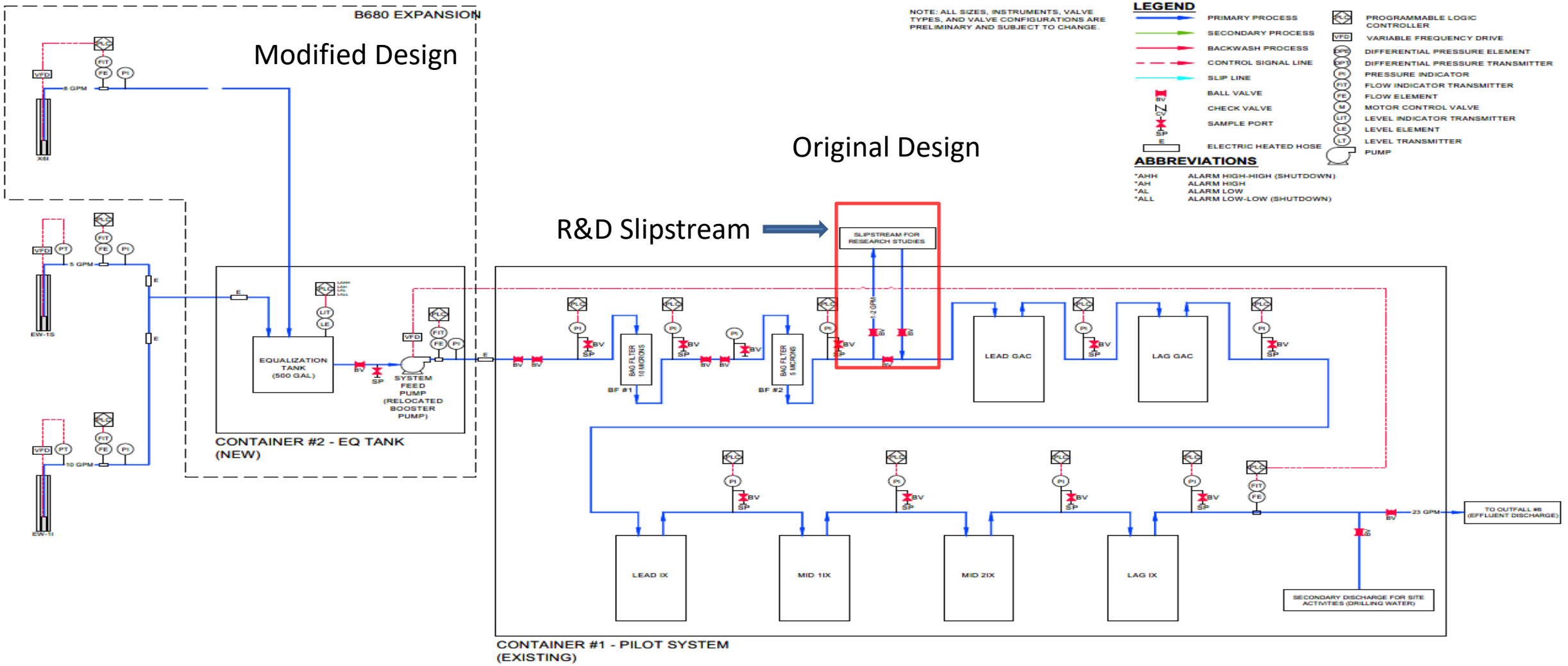
Philosophy to Being a Demonstration Site

- Integrate an approach involving pilot testing and host R&D at NASJRB Willow Grove:
  - **Near-Term** – Implement pilot treatment systems with existing commercially available technologies to identify efficient and cost effective remedial approaches
  - **Mid-Term** – Support the demonstration of emerging treatment or characterization technologies through ESTCP or Navy NESDI Programs
  - **Long-Term** – Support potential remediation technologies or innovative characterization technologies through SERDP in hope they will lead to successful technologies that can be used at Willow Grove, greater Navy, or DoD PFAS sites in the future

Example 1 - Building 680 Pilot GWETS

- Building 680 is a former hangar at NAS JRB Willow Grove
- Pilot GWETs placed in operation in March 2020
- Extraction wells installed in area of highest PFOS + PFOA concentrations in bedrock gw across entire base.
  - Avg. Influent concentrations 9,400 – 50,600 ng/L
- Designed as 20-25 gpm treatment system.
- Initially 2 extraction wells (1 shallow, 1 intermediate), but as of July 2022 three extraction wells.
- Discharged to surface water through NPDES permit equivalency

Building 680 Pilot GWETS Design



Building 680 Pilot Summary to Date

- > 25 million gallons treated to date
- Single use IX resin very effective at WG
  - Through 300,000 bed volumes no breakthrough of PFOA and PFOS
- ~ 36 lbs of Total PFAS and ~6 lbs of PFOA + PFOS removed from GW
- Operative uptime >99% over period of operation
- Still operating since breakthrough in first resin vessel hasn't been achieved

Example Integrations into Building 680 Pilot

*Field Work Completed

SERDP Project ER18-1300

THE COLLEGE OF WOOSTER

*Field Work Completed

SERDP Project ER18-1063

SCHOOL OF MINES 1874 COLORADO

*Field Work Completed

ESTCP Project ER19-5181

ARCADIS

AQUA-AEROBIC SYSTEMS, INC. A Metawater Company

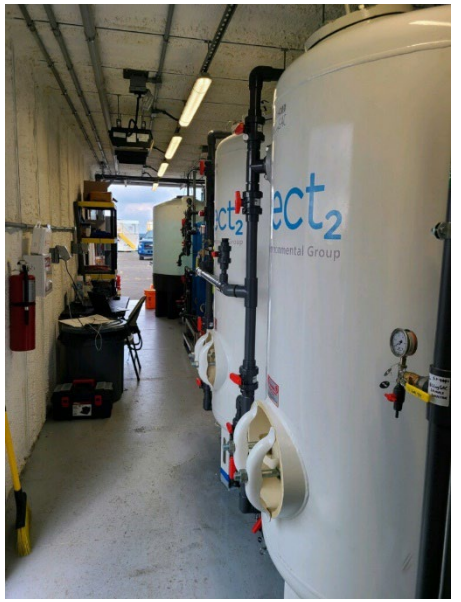
*Field Work Completed Oct. 2022

ACOE ERDC - 1-Week Demonstration of their PFAS Effluent Treatment System (PETS) to further assess ability of system to remove elevated concentrations of PFAS to ND or near ND levels in impacted groundwater.

*Scott Waisner – ACOE ERDC Point-of-Contact for System

Example 2 – Site 5 Pilot GWETs

- Site 5 is Willow Grove's former FTA
  - cVOCs in GW – remedy bioaugmentation
  - PFAS found in GW
    - 2nd Highest concentrations of PFOA + PFOS on base
      - Highest PFOA conc. (5,000 to 8,000 ng/L)
- System had to accommodate for PFAS treatment and low level cVOCs
- Commenced full-time operation in January 2022
- 20 gpm total from 2 extraction wells down gradient of Site 5 source area
  - 13 gpm through different single use IX resin
  - 7 gpm through regenerable IX resin
- Discharge to surface water through NPDES permit equivalency



Site 5 Pilot Summary to Date

- ~5 million gallons of gw treated to date
- Different single use IX resin also very effective
  - Through 60,000 BVs no breakthrough of PFOA and PFOS
- Regenerable IX resin first cycle not as effective as anticipated
  - Breakthrough of PFOA at <10,000 BVs
  - 1st Regeneration event completed successfully
  - Completed change-out of regenerable resin after first cycle to enhance efficiency
  - 2nd Cycle showing much better efficiency on PFOA BV curve

Picture of before and after of resin regeneration showing solution after regeneration (left), solution after distillation process (center), and concentrated still bottoms produced (right) after distillation for treatment via Plasma OR other ESTCP/SERDP technologies.

Example of Integration of R&D into Site 5 Pilot

- From 1st Regeneration Event for Site 5 = 9.6 gallons of PFAS concentrated still bottoms were produced
- **Original Plan** - At the end of the Pilot a commercially available plasma destruction system (D-Max) will be tested to treat all still bottoms produced
- **Modified Plan** – Provide samples of still bottoms to 5 additional SERDP/ESTCP projects testing developing technologies for PFAS Destruction + Original Plan
- Will allow for 6 different promising technologies to be tested and overall results compared.
- All SERDP/ESTCP PIs Talking and Sharing Findings

SERDP/ESTCP Projects – Focused on Still Bottoms Treatment

- ER18-1501 – Hydrothermal Technologies for Onsite Destruction of Site Investigation of Investigation Wastes Impacted by PFAS – Lead PI Timm Strathmann (Colorado School of Mines) - https://www.serdp-estcp.org/projects/details/b34d6396-6b6d-44d0-a89e-6b22522e6e9c/er18-1501-project-overview (Follow on HALT Project)
- ER18-1063 – Regenerable Resin Sorbent Technologies with Regenerant Solution Recycling for Sustainable Treatment of PFAS – Lead PI, Timm Strathmann, Colorado School of Mines - https://www.serdp-estcp.org/projects/details/d3ede38b-9f24-4b22-91c9-1ad634aa5384/er18-1063-project-overview
- ER21-5152 – Demonstration of Cost Effective and Sustainable Destruction of PFAS in Concentrated Waste Streams – Lead PI, Dr. John Xiong (Haley & Aldrich, Inc) - https://www.serdp-estcp.org/projects/details/4c073623-e73e-4f07-a36d-e35c7acc75b6/er21-5152-project-overview
- ER18-1027 – Ex Situ Treatment of PFAS-Impacted Groundwater Using Ion Exchange with Regeneration – Lead PI, Mark Fuller (APTIM Federal Services, LLC) - https://www.serdp-estcp.org/projects/details/af660326-56e0-4d3c-b80a-1d8a2d613724/er18-1027-project-overview
- ER19-1403 – Validation of UV/TIO2 Activated Alkaline Media (CFM) for Destruction of PFAS in Concentrated Liquid Waste Streams – Lead PI, Megan Hart (Univ. of Missouri Kansas City) - https://www.serdp-estcp.org/projects/details/68df5faf-224d-4ec1-9494-0bd267acb006/er19-1403-project-overview
- ER21-EO-7569 – Photoactivated Reductive Defluorination PFAS Destruction – Co-PIs Denise Kay/Meng Wang with Enspired Solutions – No ESTCP link yet as they just recently came under contract.

**This last project is one of three projects selected in 2021 as part of "EPA PFAS Challenge"*

Summary and Conclusions

- SERDP/ESTCP are DoD Environmental R&D programs that have initiated over >250 projects and obligated significant funding, a significant portion of which has gone towards developing potential remedial technology solutions for PFAS.
- As technologies develop, the DoD, and our regulatory counterparts, should be supportive of this development, BUT yet be cautious and insist on verification of data, potential for widespread applicability, relevant limitations, and cost-benefits.
- Field demonstrations, and availability of sites for demonstration, is a necessity for technology development and commercialization.
- There are many variables that have to be considered for field demonstration sites.
- Integration of SERDP/ESTCP projects with existing or planned pilots allow for real world testing of potential technologies/absorbents of tomorrow.
  - The combination of ongoing WG groundwater pilot studies, coupled with SERDP/ESTCP/NESDI R&D projects are aimed at assisting in the design of planned full scale system as well as potential ways to optimize that system in the future.

Special Thanks!

- SERDP/ESTCP – Dr. Andrea Leeson, ERP Manager

- BRAC/NASJRB WILLOW GROVE TEAM
  - BRAC Management – Greg Preston and David Barclift
  - Willow Grove Team – Brian Helland (RPM), Dawn DeFreitas (BEC), and Willie Lin (Deputy BCM)
  - CSO Willow Grove – Jim Rugh and Marty Schy
    - Assist with a lot of coordination, information gathering, and day-to-day activities on everything covered in this presentation

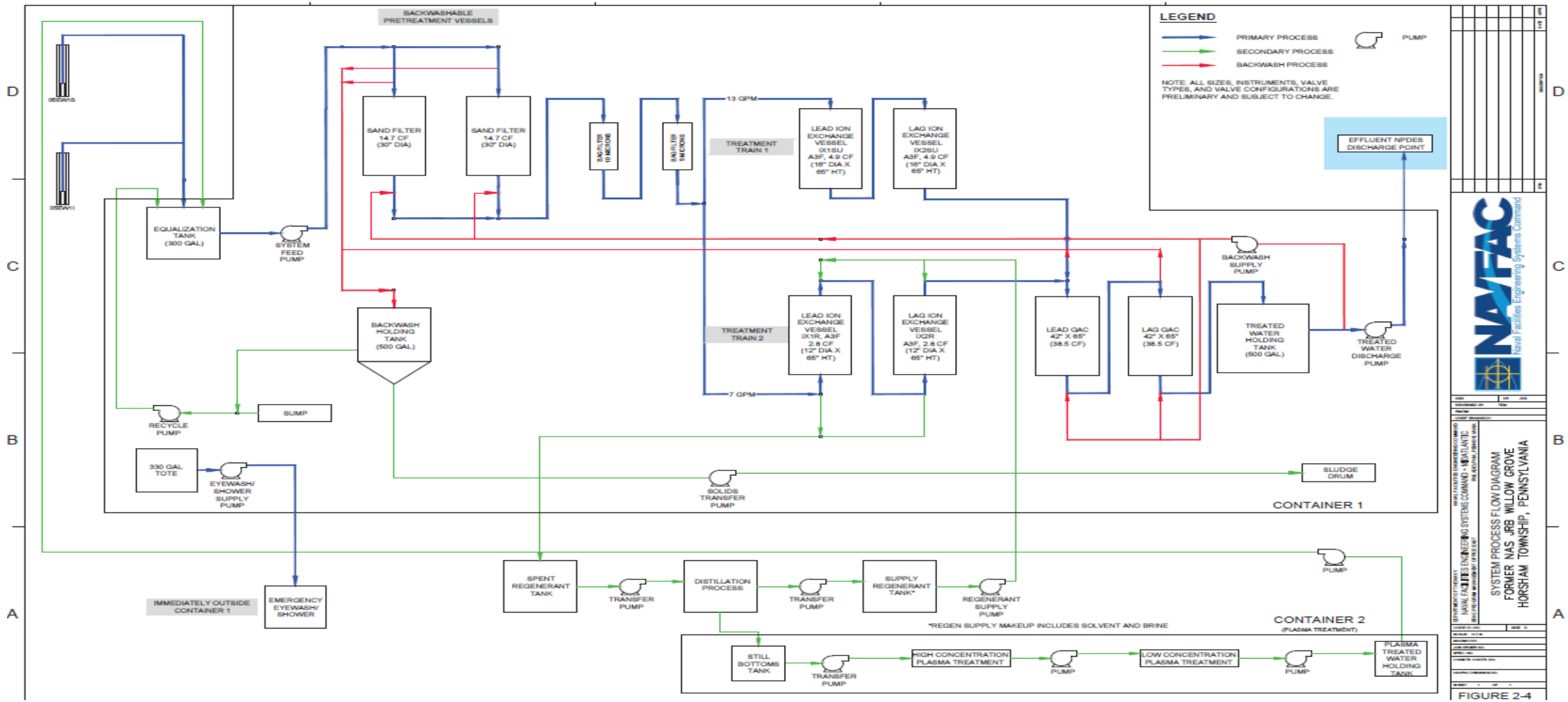
Questions?

Backup Slides

Combining Knowledge of Pilots

- Pilot systems have been installed in two highest areas of PFAS concentrations found in gw across Willow Grove
- Pilot system have helped test different treatment trains to not only address PFAS, but likely low level cVOCs, that will be in influent for larger planned GWETs for overall site.
- Pilot systems have helped test two commercially available PFAS specific single use IX resins and combination of regenerable resins to assist in selection of main PFAS absorbent/s to use in full-scale system.
  - Results so far have matched very nicely with SERDP project results for IX resins
- Lessons have been learned from sampling and operational standpoint that will likely apply to larger planned full-scale system

Site 5 Pilot GWETs Design



SERDP Project ER18-1063

SERDP Project ER18-1063

Project Funding: $1.4M

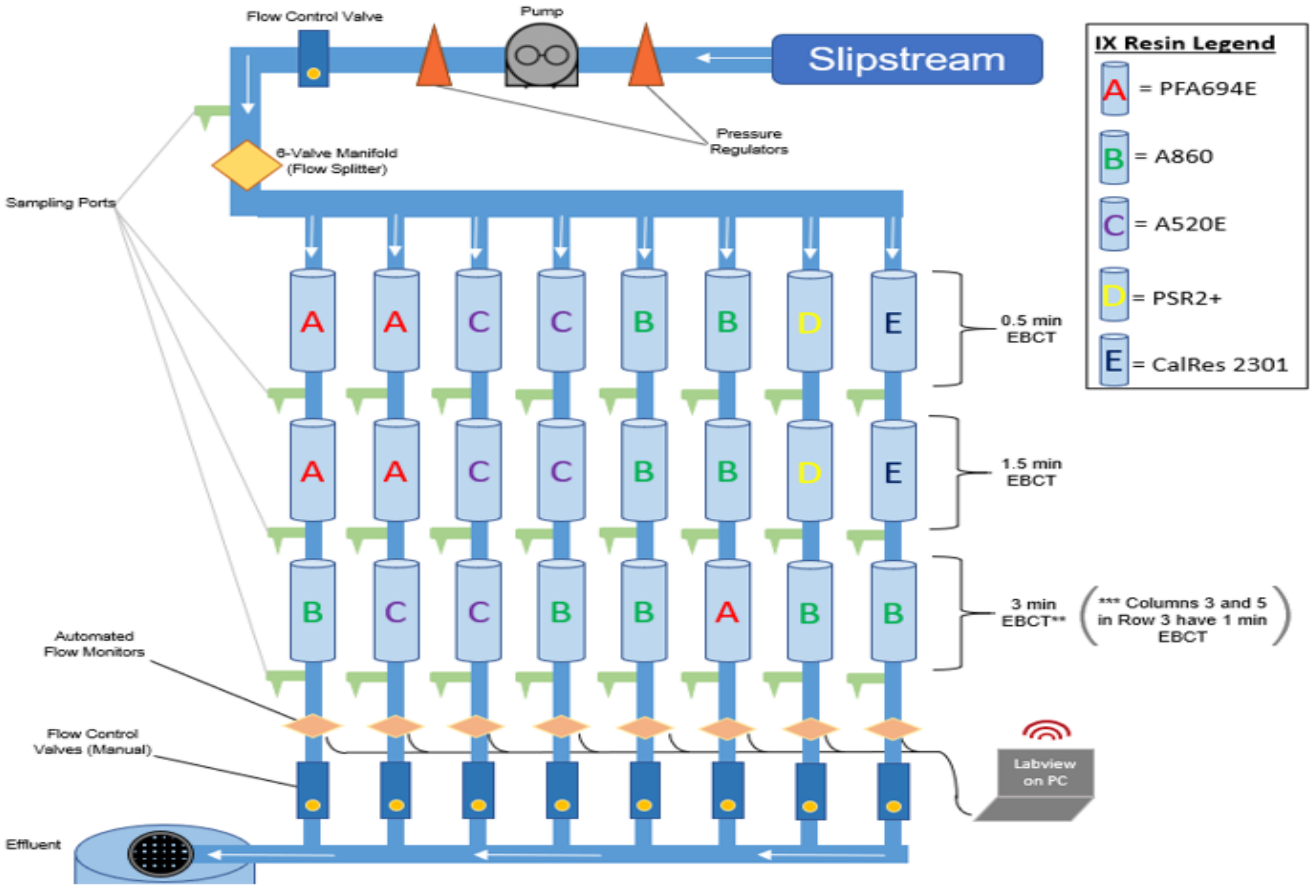
Start Date: May 1, 2018

Completion Date: Dec 2022

Project Goals: Develop a sustainable resin-based treatment system for remediation of the full diversity of PFASs. Optimal treatment strategy incorporates resin performance data, a life cycle assessment (LCA) framework, and a life cycle costing (LCC) methodology.

Project Partners:

Site Pilot: Eight parallel streams of Willow Grove groundwater treated with different ion exchange resins



ESTCP Project ER19-5181

ESTCP Project ER19-B3-5181

Project Funding: $935,580

Start Date: November 18, 2019

Completion Date: September 22, 2022

Project Goals: Demonstrate reduced life-cycle cost and increased treatment efficacy for PFAS using superfine powdered activated carbon and ceramic membrane filter (SPAC-CMF)

Site Pilot: The field-scale demonstration and validation of the SPAC-CMF system consisted of a multi-month field pilot at an existing groundwater treatment system at two DoD facilities.

Project Partners:

ESTCP

SCHOOL OF MINES 1874 COLORADO

AQUA-AEROBIC SYSTEMS, INC. A Metawater Company

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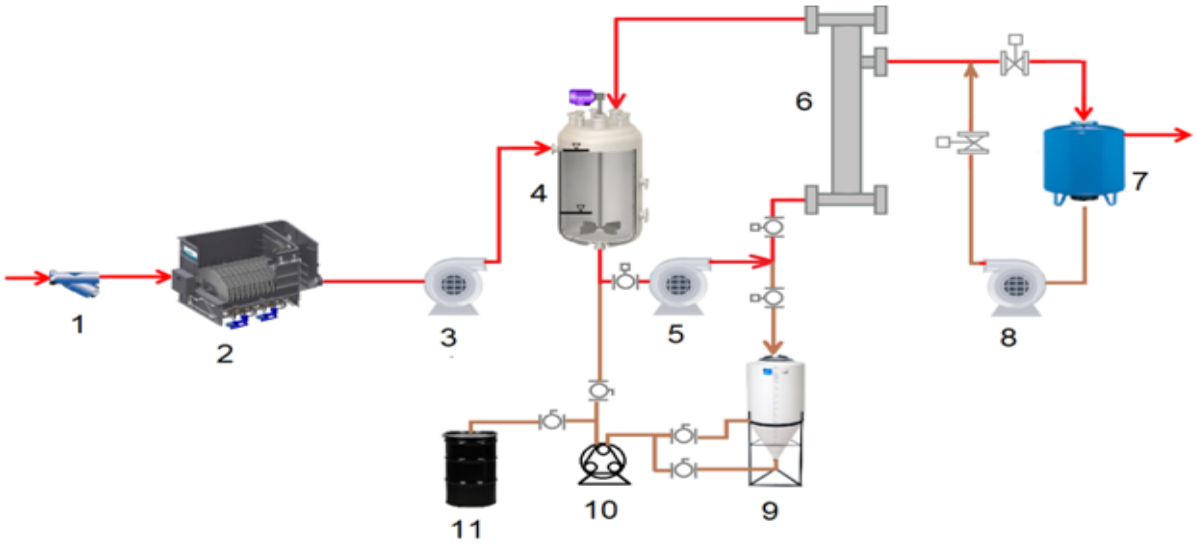
SPAC-CMF Flow Diagram



1. Influent Strainer
2. Cloth Media Filter
3. Feed Pump
4. Adsorption Reactor
5. Recycle Pump
6. Separator
7. Effluent Tank
8. Backpulse Pump
9. Sorbent Concentrator
10. Supernatant Pump
11. Waste Container