NEWEA Residuals & Microconstituents 2018 Specialty Conference

Wastewater Per- and Polyfluorinated Alkyl Substances

October 2018

PFAS Confirmed – Now What Do We Do?

PFAS Continues to Make Headlines…

DES to give water contamination update

■ **Merrimack:** Public informational meeting will provide results of recent tests taken from Saint-Gobain smokestacks.

By KIMBERLY HOUGHTON
Union Leader Correspondent

MERRIMACK — Residents will be updated this week

"Saint-Gobain," said town councilor Bill Boyd.

A new law that went into effect on Sept. 8 allows the department to require controls for air emissions of certain PFAS compounds that impact soil and water. As a result, DES has since notified Saint-Gobain Performance Plastics that the company must investigate and apply for a permit to install air pollution controls at

eager to learn more about the state's ongoing investigation.

DES will update residents on the site investigation, ongoing water remediation projects with private wells in Merrimack and nearby communities, the air emission tests and Merrimack Village District's work to improve public wells.

A question and answer session will be held, and break-out conversations

Following Wednesday's meeting, DES will then be holding three additional work sessions with the public to potentially set public drinking water and groundwater standards for PFOA and other contaminants.

"At each of the work sessions, NHDES will provide information on the current approach to deriving the health based numbers, as well as costs and benefits and ask for comments," a release states.

NEW HAMPSHIRE UNION LEADER

September 12, 2018 11:00PM

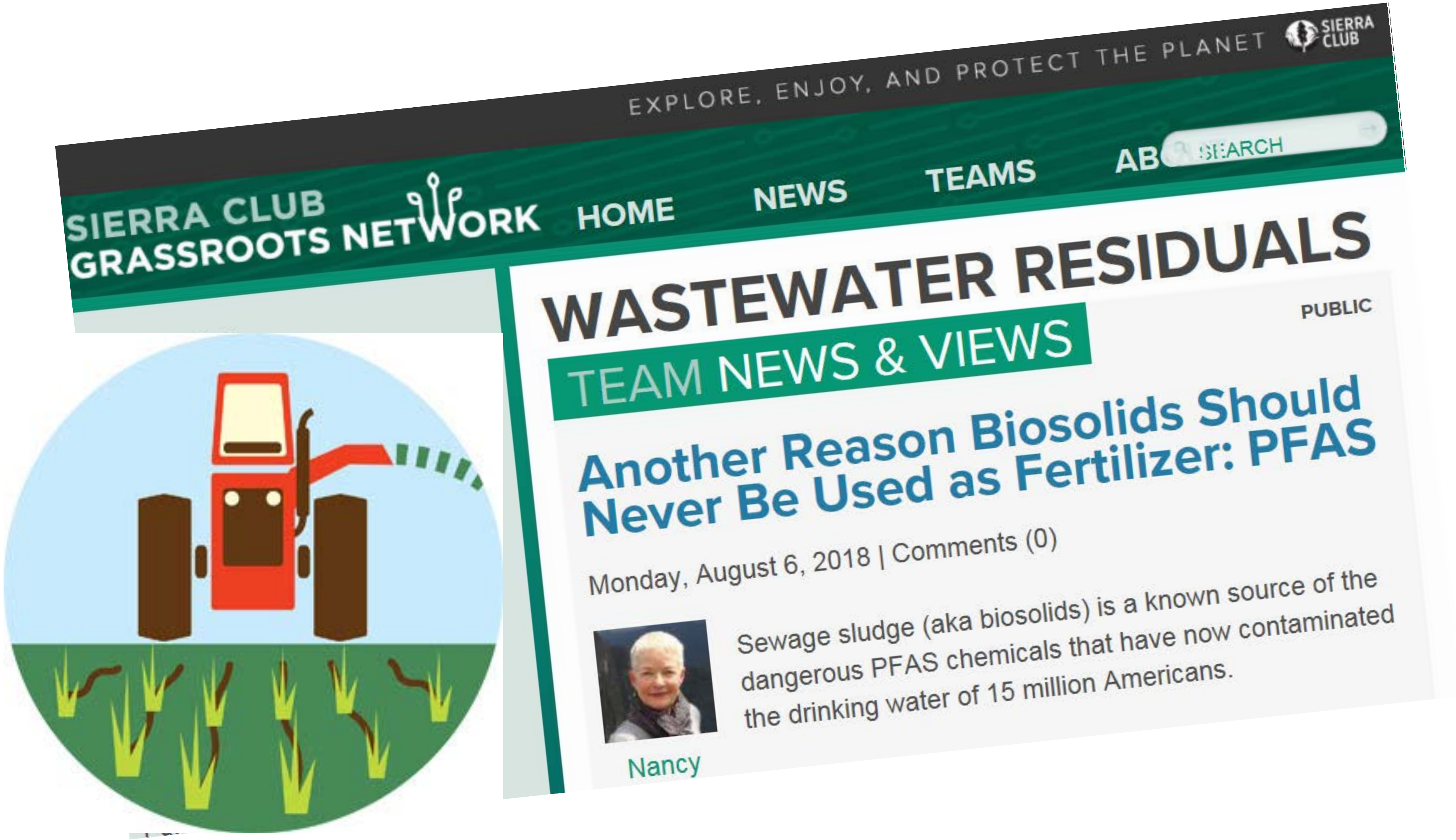
EPA finds PFOS in eel, shiner, pickerel, brown trout from Seacoast brook

By KIMBERLEY HAAS
Union Leader Correspondent

GREENLAND — The U.S. Environmental Protection Agency has released data summarizing the results of recent fish tissue sampling conducted at Berry's Brook.

According to Kelsey Dumville in the public affairs office, under EPA and New Hampshire Department of Environmental Services oversight,

PFAS Continues to Make Headlines…



https://content.sierraclub.org/grassrootsnetwork/team-news/2018/08/another-reason-biosolids-should-never-be-used-fertilizer-pfas

PFAS Remediation Gets Global Attention

PFOS listed in Annex B

PFOA Recommended for listing

Annex B: "Parties must take measures to restrict the production and use of the chemicals listed under Annex B in light of any applicable acceptable purposes and/or specific exemptions listed in the Annex."

HEPA (Australia and New Zealand EPAs)

PFAS National Environmental Management Plan

JANUARY 2018

Adopts an Adaptive Management Approach

Guiding principles include *The Precautionary Principle*: "where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation."

Planning Response Actions

Basic Waste Site Remediation Tenants Apply

1. **Source Control** - Eliminate to the extent feasible the source of contaminant release

2. **Management of Migration** – Prevent or mitigate the spread of contaminants to unaffected areas or across media

3. **Risk Reduction** – Reduce levels of risk to human health and the environment down to acceptable levels in a timely manner

4. Helpful to remember the first tenant of the Hippocratic Oath *"primum non nocere"* – the cure should not be worse than the disease

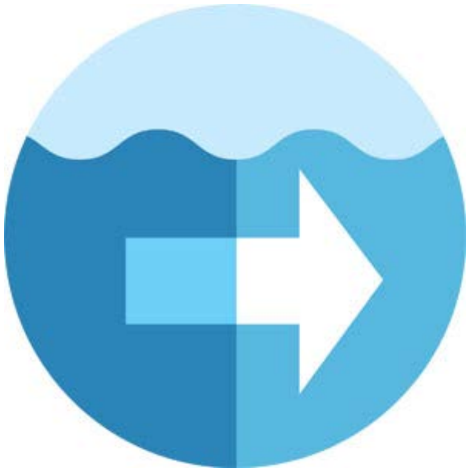
Source Control

- Source In?
  - WWTP Influent Testing
  - Testing for WWTP Customers – voluntary, requested, required by permit

Michigan DEQ is now requiring public wastewater treatment plants to identify industrial customers using PFAS, develop a monitoring plan, sample and work with companies, landfills or contaminated sites to reduce PFAS use or discharge.

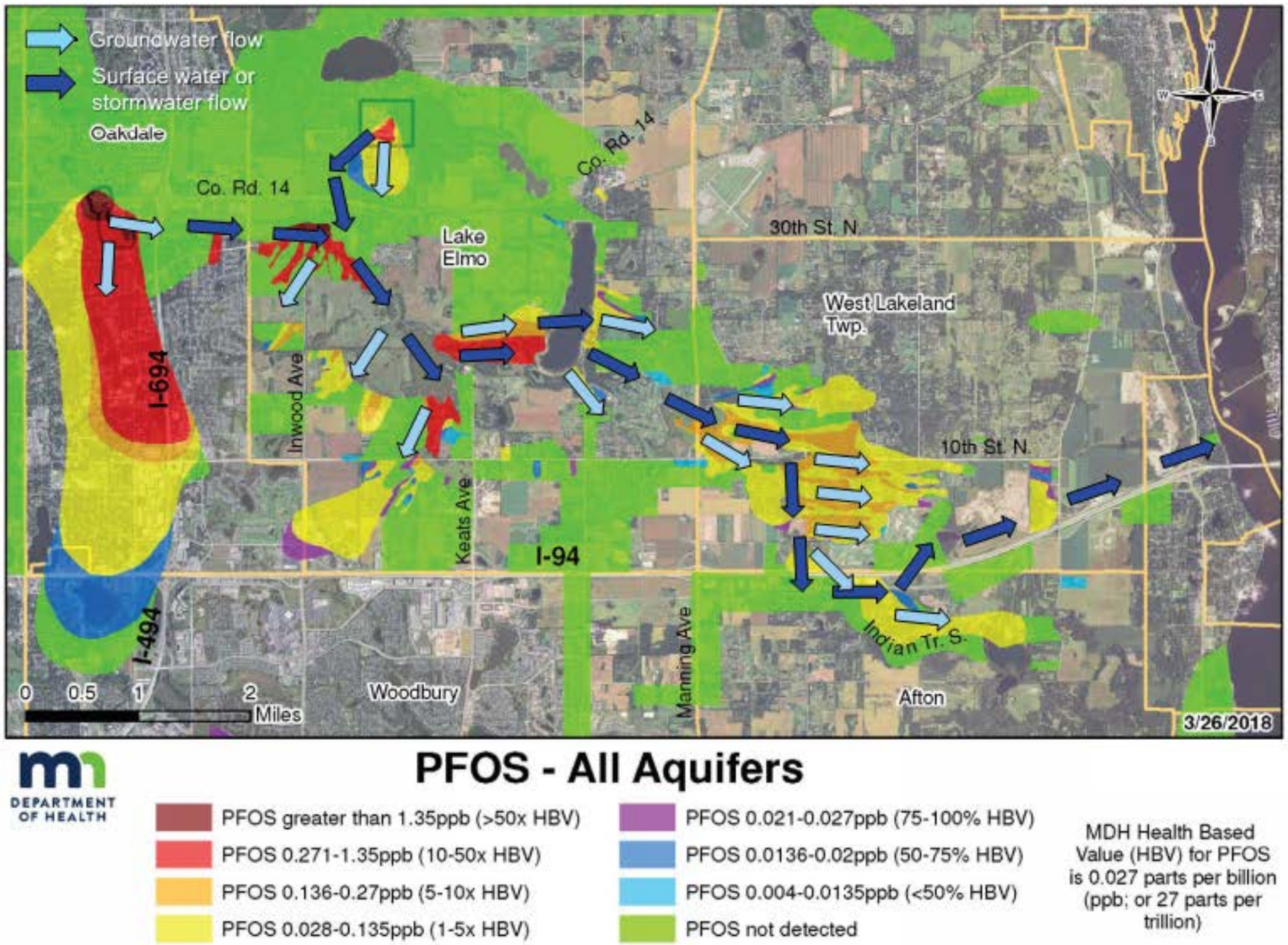
Source Control

- Source Out? Is it in your water discharge?
  - CWA/NPDES regulated
  - Discharge to surface water bodies – not degrading there
  - Migration to sediment and/or adjacent groundwater



Credit: Ginny Yingling, MN Department of Health

http://dels.nas.edu/resources/static-assets/besr/miscellaneous/Open-Session-Materials/AdHoc/SubsurfaceContaminants/Presentations/WSTB_Yingling.pdf



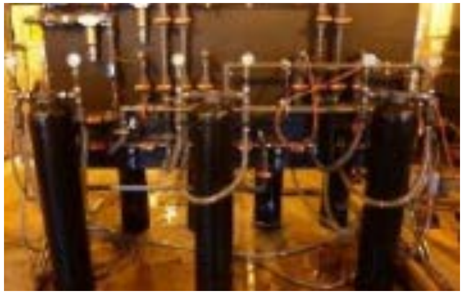
NOTES: Map combines data from all aquifers, actual concentrations in any area may vary; blank spaces indicate no sample data

Source Control

- Source Out? Where do you send your biosolids/sludge?
  - Incineration
  - Landfill
  - Agricultural Use/Land Application
- Each option has its own questions and risks

PFAS Management of Migration and Remediation Considerations

- Resists biodegradation
- Resists photolysis, hydrolysis
- Destroyed at ~1000˚C
- Water soluble, non-volatile and persistent
- Large dissolved phase groundwater plumes
- Sorption, solubility differences
- Common Co-contaminants



Helpful Available Remediation Resource -

Credit:

INTERSTATE TECHNOLOGY REGULATORY COUNCIL — ITRC

Remediation Technologies and Methods for Per- and Polyfluoroalkyl Substances (PFAS)

https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_remediation_3_15_18.pdf

- Published April 2018
- Upcoming Training (https://www.itrcweb.org/Training/Pfas)

Soil/Solids Remediation – Conventional Approaches

Incineration

- Destructive technology
- High temperature required
- Limited to permitted receiving facilities
- Commercially available
- High cost

Landfill Disposal

- Isolation technology
- Applicable to variety of PFAS
- Long term maintenance and liability
- Where does the landfill leachate go?
- Commercially available

Soil/Solids Remediation – Sorption/Stabilization Approaches

Carbon/Modified Carbon

- GAC and PAC common in water treatment; primarily pilot scale for soils
- Modified carbon (e.g. RemBind ®) range from test level to full scale applications
- Adsorption of full suite of PFAS and longevity of stabilization?

Minerals and Resins

- Modified minerals (e.g. amine modified organoclay MatCARE™) commercially available
- Other mineral formulations also being bench and pilot tested
- Adsorption of full suite of PFAS and longevity of stabilization?

Soil/Solids Remediation – Other Options on the Horizon?

Thermal Treatment

- Desorption with off-gas treatment
- Limited to ex-situ for now
- High energy consumption
- Air treatment, treatment residual management concerns
- Not full scale or commercially proven

Bioremediation

- Bacterial and fungal strains being tested for ability to biodegrade PFAS
- To date, little success has been demonstrated in literature, but research is ongoing and intensifying.

Remediation Technologies and Methods for Per- and Polyfluoroalkyl Substances (PFAS)

April 2018

Table 1. SOLIDS TECHNOLOGIES

REMEDIATION TECHNOLOGIES AND METHODS COMPARISON TABLE

This Table belongs with the ITRC PFAS Remediation Technologies and Methods fact sheet. The ITRC intends to update this table periodically as new information is gathered. The fact sheet user is encouraged to visit the ITRC PFAS web page (http://pfas-1.itrcweb.org) to access the current version of this file. Please see ITRC Disclaimer http://pfas-1.itrcweb.org/about-itrc/#disclaimer

In general, the technologies that are listed in the text of the fact sheet have been demonstrated ranging from bench- to full-scale and those descriptions are included in each technology's State of Development section. Additional technologies included in this supporting table are currently considered promising."

Remediation Technology			What PFAS demonstrated on?	Application (In Situ vs. Ex Situ)	Treatment Mechanism (Transformation or Separation)	Demonstration Maturity (Commercialized, Full-Scale, Field Pilot, Lab)	Strengths (Includes co-contaminants, sustainability, scalability)	Challenges/Limitations	Waste Management	Future Data Needs	References
Sorption and Stabilization	Carbon	GAC	PFOA, PFOS	In Situ	Separation		co-contaminants are remediated; is scalable	Surface area may become clogged by organic carbon in soil	N/A	understanding long term stability of contaminant	Yu et al. 2009 Du et al. 2014
		PAC	PFOA, PFOS	In Situ	Separation		co-contaminants are remediated; is scalable	Surface area may become clogged by organic carbon in soil	N/A	understanding long term stability of contaminant	Yu et al. 2009 Du et al. 2014
		CNT/modified CNT	PFOA, PFOS	Ex Situ	Separation		co-contaminants are remediated	Surface area may become clogged by organic carbon in soil	N/A	understanding long term stability of contaminant	Chen et. al 2011 Li et. al 2011 Kwadijk, Velzeboer, and Koelmans 2013
		Modified carbon	PFOS PFOA PFHxS PFBS PFBA	In Situ	Separation		co-contaminants are remediated; is scalable	Surface area may become clogged by organic carbon in soil; amendment dosage is high (>7%); Large volume, up to 10% by volume needs to be added to the soil	N/A	understanding long term stability of contaminant	Birk 2015
	Minerals	Minerals (iron oxide, goethite, high iron sand, clay/ organoclay)	PFOS PFHxS PFOA PFHxA	In Situ	Separation		Enhance sorption by modifying surface	Potential for desorption and leaching of PFOS off of surface; Influenced by soil chemistry (pH, ions and organic carbon content)	N/A	Potential for PFAS to leach from soil after treatment	Johnson et al. 2007 Zhao et al. 2014
		Modified minerals	PFOS	In Situ	Separation		Modified clay material	Amendment dosage is high (>7%); The soil moisture content needs to be 60% of soil water holding capacity	N/A	Potential for PFAS to leach from soil after treatment	Kambala and Maidu 2013
Isolation	Capping		All	In Situ	Separation	No projects found	Long term solution; accepted approach	Non-destructive; requires long-term maintenance	N/A	N/A	
Excavation and Disposal	to Landfill		All	Ex Situ	Separation		Long term solution; accepted approach	Non-destructive; requires long-term maintenance	Landfill disposal fees; long term liability of waste	N/A	Lang et al. 2017
	to Incinerator		All	Ex Situ	Transformation		Long term solution; accepted approach; destructive method	Cost; availability of permitted incinerator	N/A	N/A	Vecitis et al. 2008
Thermal	Desorption with off-gas treatment		PFOS/PFOA, 9 PFAS documented	Ex Situ	Transformation		Addresses VOCs, SVOCs, and PCBs co-contaminants, petroleum products, ultimately destructive	High energy solution, only ex situ for now, logistically difficult at some sites	Possible waste stream of condensate liquid	Mass balance to understand destructive mechanism; Documentation of air treatment removal and destruction mechanisms and end products for PFAS	Endpoint Consulting 2016 Enviropacific 2017

Commercialized / Implemented Full-Scale / Field Pilot tested / **Lab/Bench tested**

Commercialized / Implemented Full-Scale / **Field Pilot tested** / **Lab/Bench tested**

Commercialized / **Implemented Full-Scale** / **Field Pilot tested** / **Lab/Bench tested**

Commercialized / **Implemented Full-Scale** / **Field Pilot tested** / **Lab/Bench tested**

Carbon-based

Mineral-based

Landfill

Incineration

Soil/Solids Remediation

Source: Minnesota Pollution Control Agency

Water/Liquid/Groundwater Approaches

Activated Carbon

- GAC most common in water treatment
- Adaptable from point of use to large scale systems
- Spent carbon disposal or regeneration an added waste stream

Polishing/Separation

- Reverse osmosis
- Other membrane methods

Minerals and Resins

- Anion exchange resins
- Compound specific
- More costly than GAC

Specialty Coagulants

- Combined with solids dewatering
- Not tested at low ppt levels

Remediation Technologies and Methods for Per- and Polyfluoroalkyl Substances (PFAS)

Table 2. LIQUID TECHNOLOGIES

REMEDIATION TECHNOLOGIES AND METHODS COMPARISON TABLE

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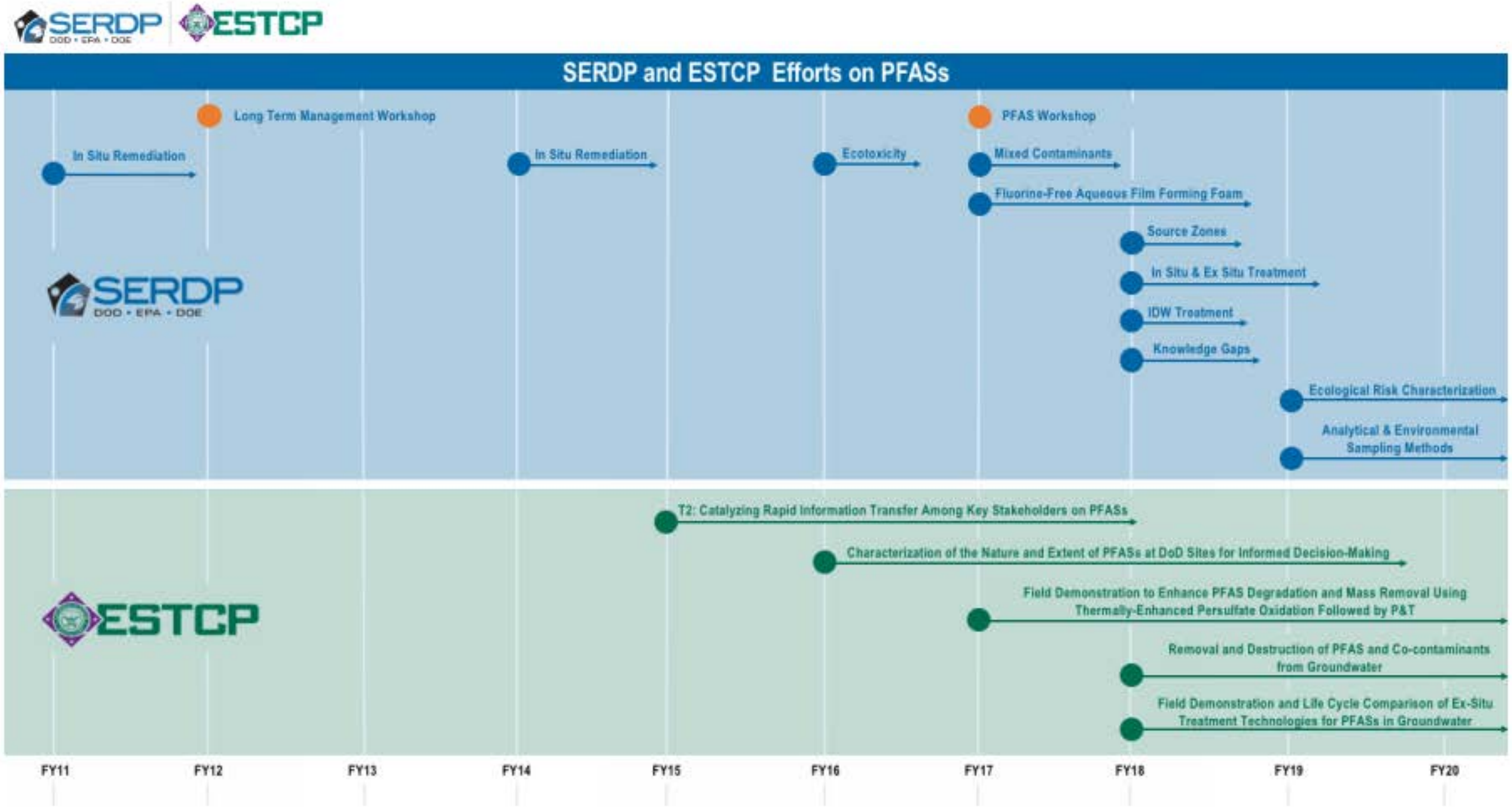
Remediation Group	Remediation Technology	What PFAS demonstrated on? What Concentrations?	Applicable Media (Groundwater, Drinking Water, Surface Water, Wastewater, Leachate)	Application	Treatment Mechanism (Transformation or Separation)	PFAS Demonstration Maturity (Lab, Field Pilot, Full-Scale, Commercialized)	Strengths (Includes co-contaminants, sustainability, scalability)	Challenges/Limitations (Includes co-contaminants, sustainability, scalability)	Waste Ma
Flocculation/Coagulation	Alum	PFOA/PFOS/Other PFAS = 1,000 µg/L, 1-5% removal PFOA = 8 µg/L, 20% removal PFOS = 236 µg/L, 40% removal	All	Ex Situ	Separation		Conventional technology. Used commonly for water treatment in other applications. Readily scalable	Current data show that alum is not effective f meeting health advisory (low ng/L). May best serve as initial treatment te Will likely require polishing.	
	Polyaluminum chlorides	PFOA/PFOS = 1,000 µg/L, 1-10% removal	All	Ex Situ	Separation		Conventional technology. Used commonly for water treatment in other applications. Readily scalable	Current data show that poly are not effective for meeting ng/L). May best serve as initial treatm Will likely require polishing.	
	Ferric salts	PFOA/PFOS = 1,000 µg/L, 10-50% removal PFOA = 8 µg/L, 15% removal PFOS = 236 µg/L, 30% removal	All	Ex Situ	Separation		Conventional technology. Used commonly for water treatment in ot applications. Readily scalable		
	Covalent bound hybrid coagulants	PFOA = 100 µg/L, 99% removal	All	Ex Situ	Separation		99.6% removal of PFOA was observed wit conditions.		
	Specialty coagulants	PFAS = 380-480 µg/L, 87-98% removal PFOA = 8 µg/L, 20% removal PFOS = 236 µg/L, 80% removal	All	Ex Situ	Separation		Application as coagulent in conventional treatment equipment is well known. Readily scalable.		
	Electrocoagulation	PFOA = 1,000-100,000 µg/L, up to 99% removal	All	Ex Situ	Separation		Can be improved by increasing current an decreasing pH. Improved by addition of H2O2 to promot advanced oxidation. Research shows zinc hydroxide electrode have better performance.		
	Activated carbon	Treatment demonstrated for all PFAS tested to date at part per trillion to part per billion concentrations for above-ground activated carbon treatment.	Groundwater, drinking water, wastewater, leachate	All Ex Situ	Separation		Treats all tested PFAS to date with high re prior to breakthrough. Design flexibility to increase removal. Simple to operate. Multiple vendors. Off-site reactivation/regeneration available for PFAS.	Competitive adsorptio Precursors and other P increase GAC loading an frequencies. No destruction of PFAS, u incinerated at high tempe	
	Activated carbon	Theoretically similar to above-ground carbon treatment, but not tested in situ to date.	All	Plume In Situ	Separation		Carbon commerically used for above-ground water treatment and for in situ barrier walls involving other contaminants. Can be effective for plume control while other in situ technologies are being developed.	Plume Stop™ only in situ p application evaluated for PF limited to one site with non-p Does not treat PFAS, only has plume migration. Will eventually become exhauste replenished in situ.	

Multiple pages-
Most technologies only at lab or bench scale testing stage

Additional Remediation Info:

https://clu-in.org/contaminantfocus/default.focus/sec/Per-_and_Polyfluoroalkyl_Substances_(PFASs)/cat/Remediation_Technologies/#8

Additional Remediation Info:



SERDP & ESTCP Efforts on Per- and Polyfluoroalkyl Substances (PFASs)

https://www.serdp-estcp.org/Featured-Initiatives/Per-and-Polyfluoroalkyl-Substances-PFASs

Essential to Stay Tuned –

State of the practice changes continually, and adaptive and new remedial approaches continue to be publicized

Thank you.

Questions?

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