US EPA's Research on PFAS: Managing PFAS End-of-Life Issues

Recycling , Landfills, Land Applications, and Incineration

Presentation overview

- Introduction to PFAS end-of-life issues
- Materials management
- Wastewater/Biosolids/Soil treatment
- Thermal treatment/Incineration
- Cross Agency technical support and collaboration

RCRA Waste Management Facilities:

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Overview – Materials Manageme

roblem: Lack of knowledge regarding end-of-life management of PFAS-ontaining consumer and industrial products

ction:

- Develop appropriate methods for appropriate media (e.g. liquids, solids, air/sta sampling)
- Characterize end-of-life PFAS recycle and disposal streams (e.g. municipal, industrial, manufacturing, recycled waste streams)
- Evaluate efficacy of materials management and remediation technologies (e.g. recycling, land application, landfilling, incineration, carbon regeneration) to ma end-of-life disposal
- Evaluate performance and cost data with collaborators to manage these mater and manage environmental PFAS releases

esults: Development/assessment of technologies, data and tools to manag nd-of-life streams

mpact: Responsible officials will be able to manage effectively end-of-life isposal of PFAS-containing products

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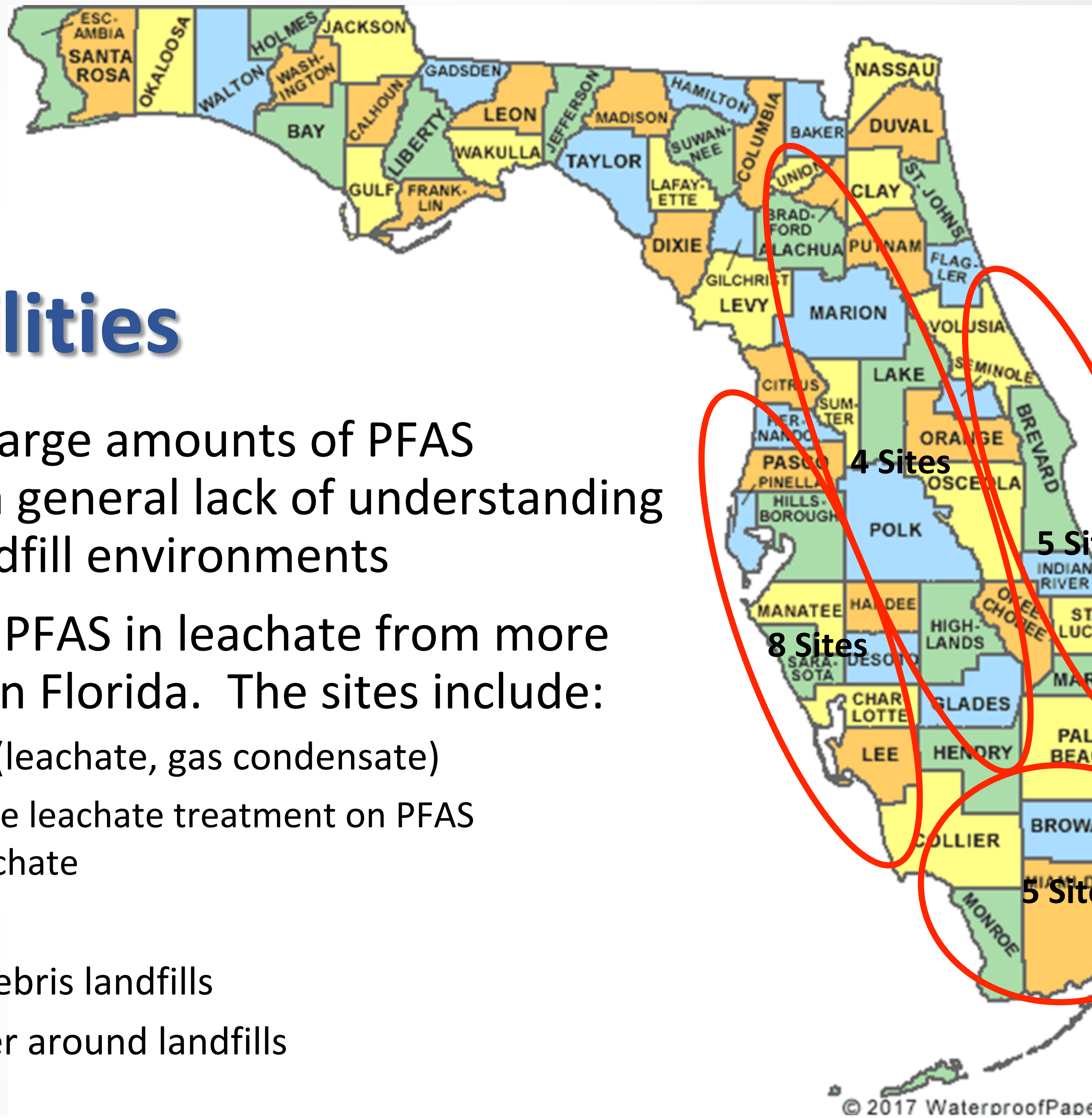
CRA Waste Facilities

oblem: Landfills receive large amounts of PFAS ntaining waste, there is a general lack of understanding fate and transport in landfill environments

ction: collect and analyze PFAS in leachate from more an 20 RCRA landfill sites in Florida. The sites include:

- Municipal solid waste landfills (leachate, gas condensate)
  - Examine the impact of onsite leachate treatment on PFAS concentration in landfill leachate
- Ash monofills (Leachate)
- Construction and demolition debris landfills
- Groundwater and surface water around landfills



Future Work: RCRA Waste

- eachate sampling to expand to other regions of the United States.
  - In discussion with Waste Management Inc and The Solid Waste Association of North America (SWANA) to provide site access for sample collection
  - Include total oxidizable precursors analysis
- ate, transport, and transformation of PFAS simulated landfill environments
- FAS transport through earthen and an-made liners
- FAS concentration in MSW ash and flue gas
- FAS flow and concentrations through e MSW recycling processes including omposting

Wastewater and Land Application of Biosolids/Wastes

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Wastewater treatment and Land Application of Biosolids/Wastes

roblem: Lack of knowledge regarding end-of-life management of PFAS ontaining consumer and industrial products in wastewater

ction:

- Characterize wastewater and relate discharge streams (e.g. municipal and industrial wastewater, land applied waste streams)
- Evaluate efficacy of existing management technologies to manage end-of life disposal (e.g. land application of biosolids)
- Evaluate performance and cost data to manage these waste streams and environmental PFAS releases

esults: Provide technologies, data, and tools to manage wastewater treams

mpact: Responsible officials will be able to manage PFAS-containing vaste streams

PFAS in Biosolids

	PFOA (ng/g dry wt)	PFOS (ng/g dry wt)
Navarro, 2016	1 - 14	4 - 84
Sepulvado, 2011	8-68	80-219
Venkatesan, 2013	12-70	308-618
Washington et al, 2010, 2011	50-320	30-410
Mills, Dasu (in prep)	10-60	30-102

- Does not include other PFAS and precursors that can be degraded over time to more stable PFAAs
- PFAAs end products do not degrade and do bioaccumulate
- Many more PFAS compounds present and more being introduced
- Lindstrom et al, 2011 found there may be a relationship between land applied biosolids and contamination in wells in Decatur, AL

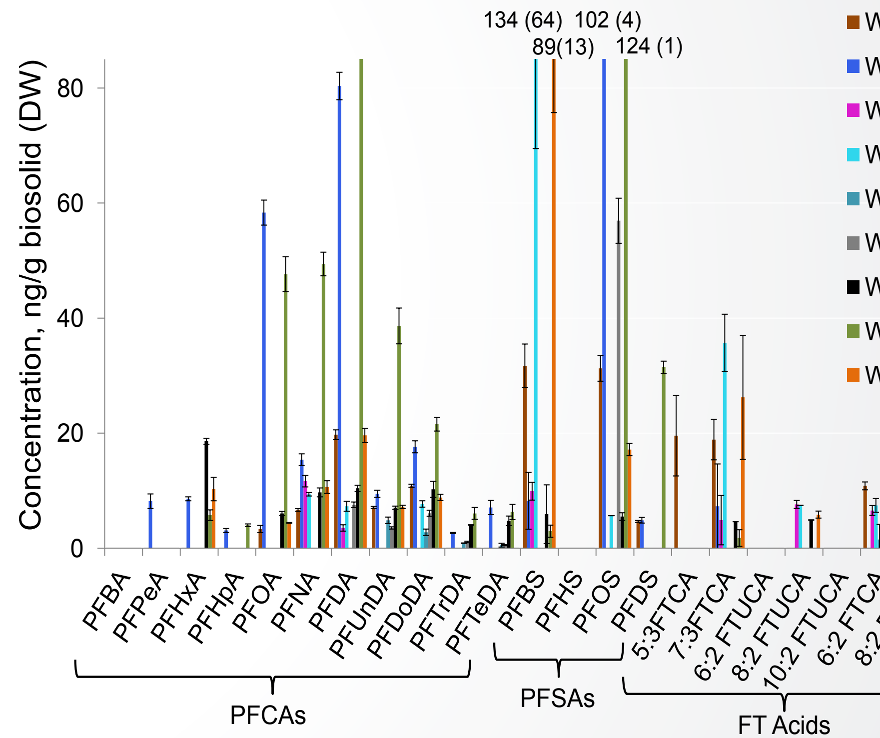
PFAS in wastewater residuals

onjunction with Region 6

ction: Nine wastewater treatment ants were sampled seasonally

- The solids treatment included anaerobic digestion and aerobic digestion
- Solid residuals and effluent were analyzed for PFAAs, precursors, and transformation products.

esults: PFAS and PFAS precursors of arying distributions were found



PFAAs concentrations in biosolids collected during
sampling

Land Application of Biosolids

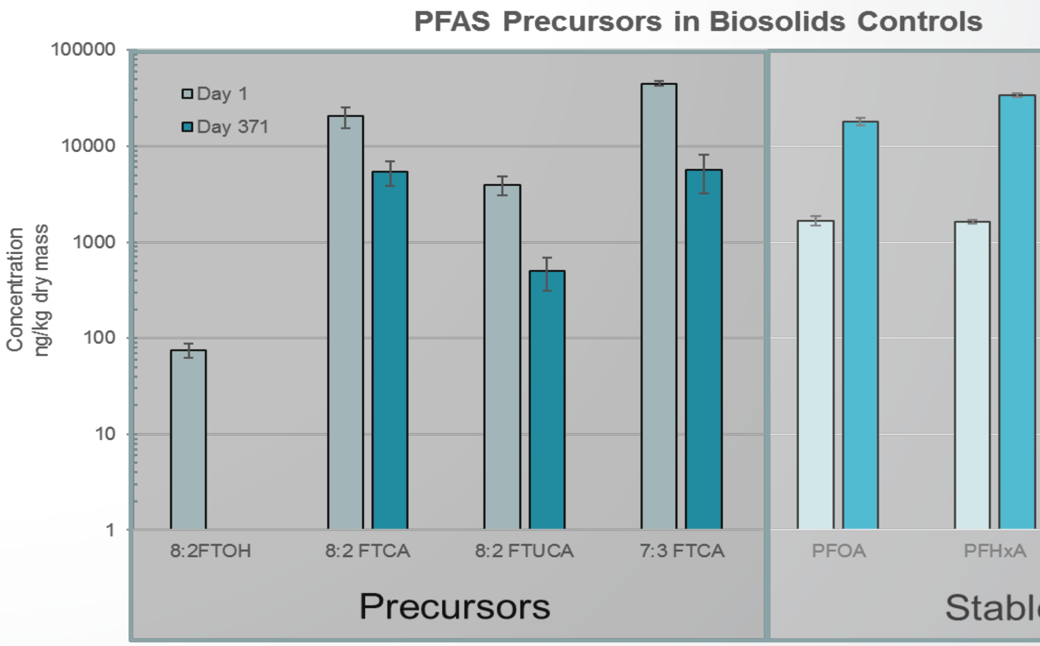
: Evaluate application methods for liquid and solid biosolids and
re the natural attenuation for various analytes including PFAS

s

Precursor concentrations were similar to PFAA concentrations

Precursor concentrations decreased with time

Stable PFAAs increased over 371 days commensurate to the expected metabolic pathways from precursor material



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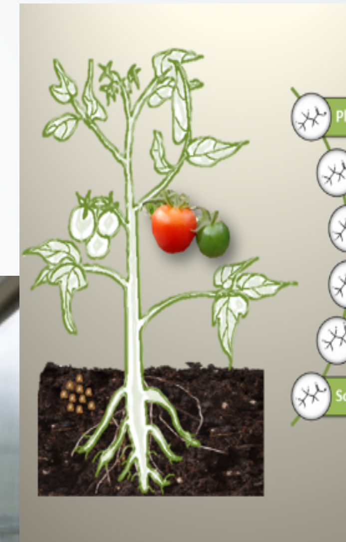
Land Application of Biosolids: PFAS uptake into edible plants

njunction with Region 5

- **n:** A variety of food crops were grown in soil ded with biosolids.
  - The biosolids contained PFAAs
  - PFAA concentrations in edible portion of the plant were measured.

ts

- The edible portion had measurable levels of PFOA, among other PFAS
- Further research needed to characterize uptake in more crops under varying conditions
- Research needed to assess plant uptake as a route of human and ecological exposure



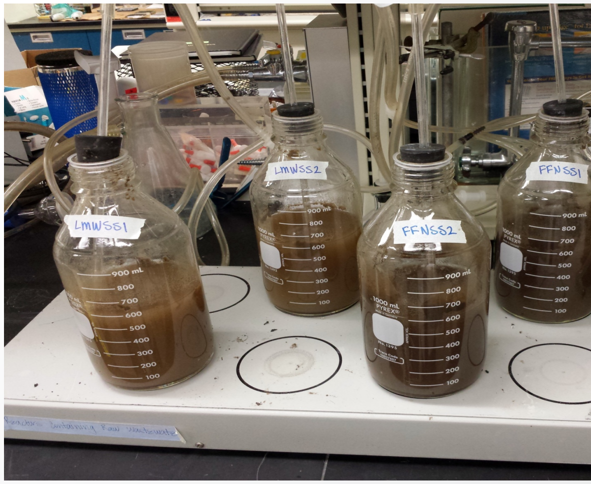
- Blaine, et al (2013). ES&T 47(24): 1
- Blaine, et al (2014). ES&T 48(14): 7

Future research: Wastewater Treatm

em: Wastewater Treatment Plants are a source of PFAS

n: Develop research to support:

- More robust and expanded analytical methods
- Bioassays to better understand if treatments are effective and to identify risks
- Evaluation of WWTP conventional and advanced unit operations to manage PFAS
- Evaluate air emissions from unit operations (e.g. activated sludge, biosolids drying, sewage sludge incineration)
- Evaluate biosolids treatment (e.g. land application under wide range of soil types, biosolids, and management strategies).
- Evaluate pretreatment technologies to address "sources" to wastewater as a more cost effective approach



Immobilization Technologies for PFAS-Contaminated Soils

isting technologies have limitations

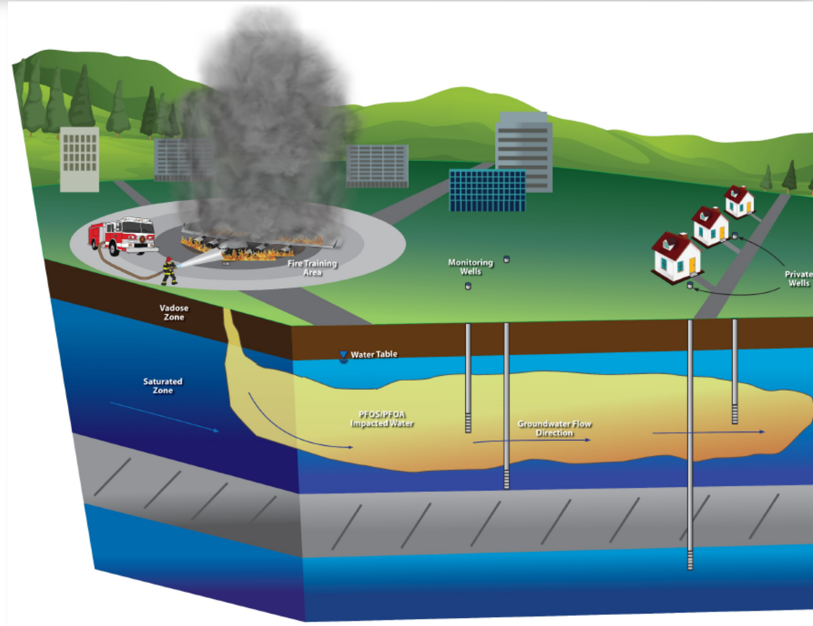
- Excavation and thermal treatment
- Capping

-situ strategies

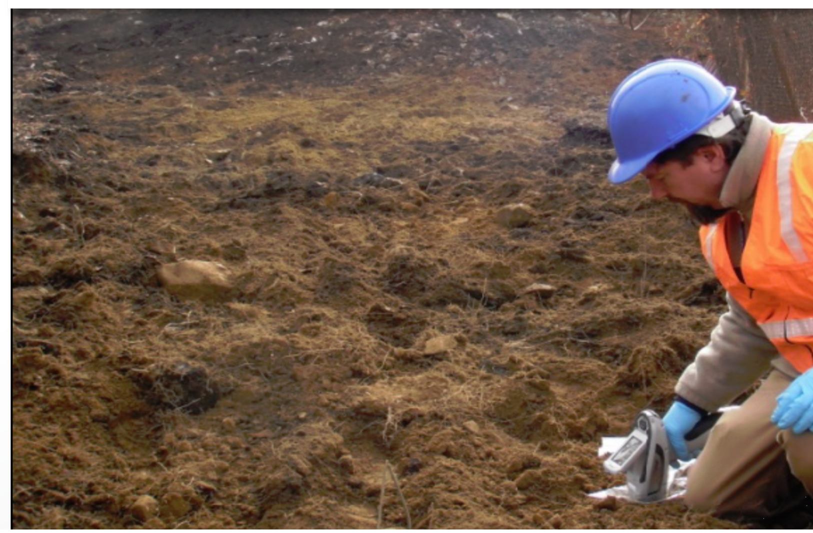
- Treatment
- Stabilization/Immobilization

ere has been limited research on PFAS abilization

- Stabilization well studied for some legacy contaminants
- No comparable data available for PFAS



NOT TO SCALE



Thermal treatment

Thermal treatment of PFAS

e strength of the C-F bonds require temperatures above 1,000 °C for
eater than 1 second.

- For example, CF_4 requires 1400 °C
- Information is lacking in the literature and in practice
- Its decomposition product, HF, is easily monitored

oducts of Incomplete Combustion (PICs) are more likely formed with F radicals tha
her halogens such as Cl

- Sufficient temperatures, times, and turbulence are necessary to ensure destruction
- PIC data from incineration studies are lacking
- The effect of mixed halogens in the waste stream introduces more unknowns
- Measurement methods for PICs are under development at ORD

tiating collaborative projects with DoD and industry partners to evaluate existing
chnologies:

- Thermal treatment system for PFAS contaminated soils in Alaska
- Fate of PFAS during GAC reactivation from treatment systems

Future work: Thermal treatment

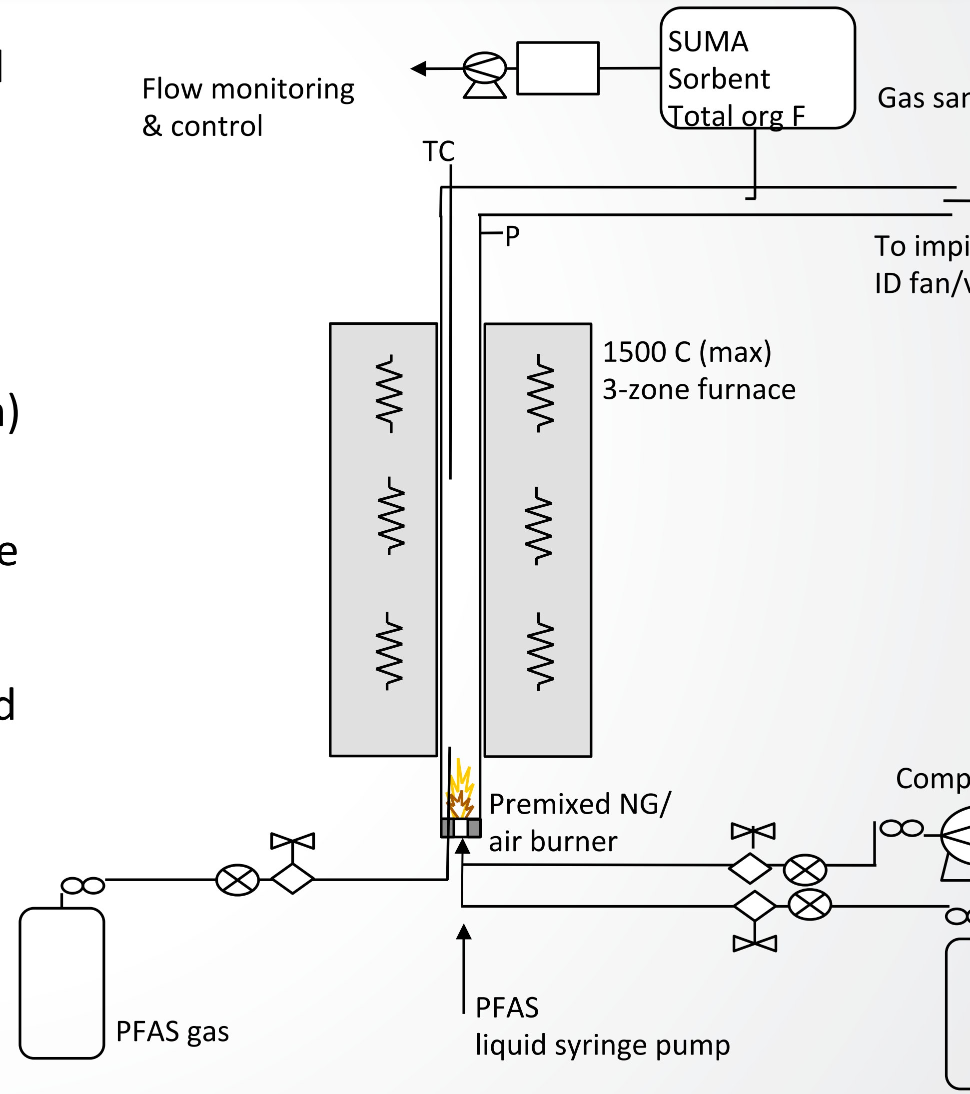
blem: There are many sources of materials that may need be incinerated

- Manufacturing wastes
- Biosolid sludges
- Municipal waste
- Obsolete flame retardants
- Spent water treatment sorbents (resins/activated carbon)

minimum conditions (temperature, time) are needed to ately destroy PFAS and what are the products of incomplete stion?

ion: Conduct bench- and full-scale incineration studies and deling to evaluate:

- Impact of source material
- Impact of temperature on degree of destruction
- Impact of calcium
- PFAS releases from incineration systems



Technical Support

has knowledge and expertise related to the analysis and
ment of PFAS for various medias. As more interest is
sed on PFAS, ORD is a resource for states, Program
es, Regions, Tribes, and Communities as they face these
enges.

Examples:

dwater and Engineering Technical Support Centers providing
ical input to a variety of Superfund sites regarding PFAS issues

ed States in stack sampling to evaluate emissions from PFAS
facturing facilities

le technical assistance regarding QA and data analysis for Federal
es sites characterizing PFAS contamination.

of the science synthesis of sampling techniques for sampling
stituted AFFF foams from groundwater migration to surface waters

EPA actively partnering with Federal, State, Trib and Communities

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- EPA serves on their technical advisory group that oversees DoD's PFAS research
- DoD and EPA developing analytical methods for characterizing PFAS exposure and site characterization
- Partnering with industry to evaluate thermal treatment systems for managing contaminated soi and reactivation of GAC
- EPA cost and performance models are being adapted with DoD for site remediation and cleanup
- Evaluating treatment technologies for site remediation and managing emergency response wast streams

A and FDA

- Initiated cross agency workgroups to focus on analytical methods, charactering exposure, and treatment/remediation

E

- Joint project with academia to evaluate E-beam treatment of PFAS in water

es/Tribes/Communities

- Stack sampling of emissions from manufacturing facilities
- State workgroups to assess drinking water and contaminated sites

For More Information

Speth – *Drinking water treatment, GAC regeneration*
c Mills – *Remediation, analytical methods*
s Impellitteri – *Analytical methods, biosolids*
bet Tolaymat – *Landfills, materials management*
olyn Acheson – *Biosolids*
Linak - *Incineration, thermal treatment*

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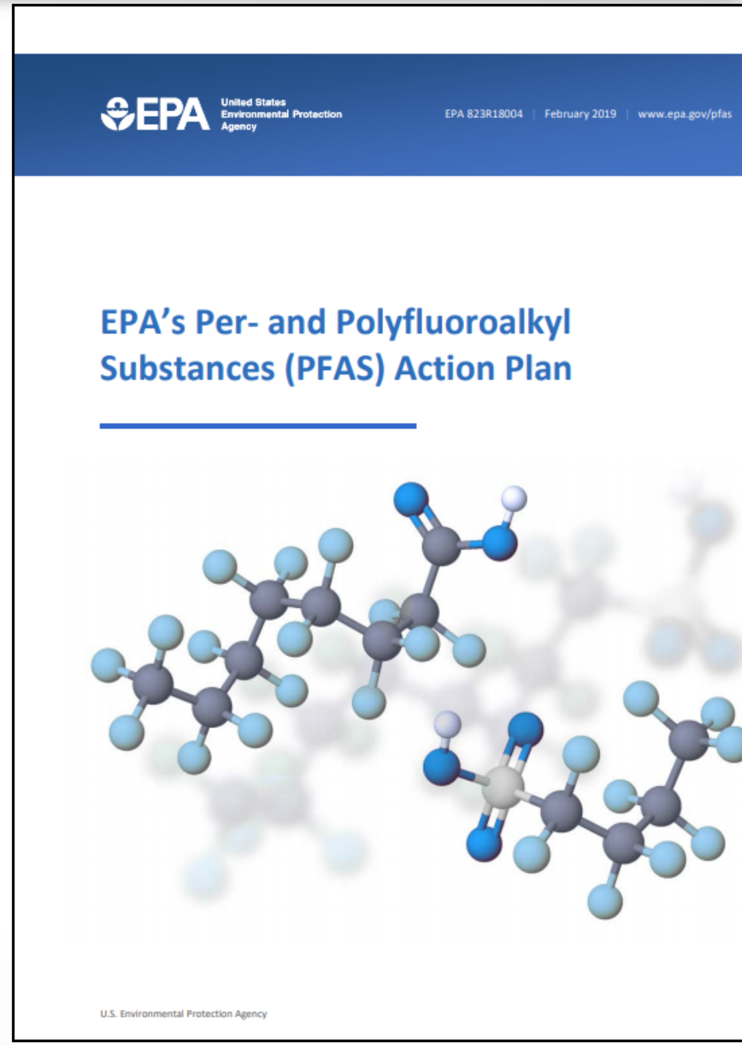

EPA United States Environmental Protection Agency
EPA 823R18004 | February 2019 | www.epa.gov/pfas

EPA's Per- and Polyfluoroalkyl Substances (PFAS) Action Plan

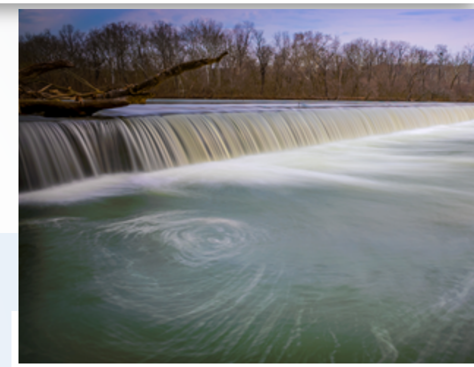
U.S. Environmental Protection Agency

Methods for detecting, identifying PFAS different end-of-life materials:

Precursors, Degradates, and Terminal PFAS

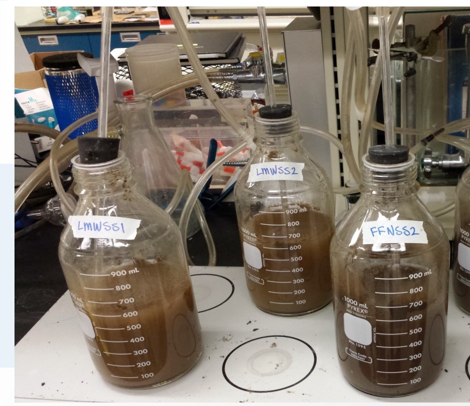
EPA

Non-Drinking Water Methods:
SW-846 Method 8327—Direct Injection



AS target analytes

- Inclusive of target analytes in EPA Method 537
- Commercially available standards (“neat” and isotopically labeled)



t injection method based on EPA Region 5 SOP

- Similar to ASTM Method D7979
- Multi-laboratory validation study completed in 2018
- Method is currently available for comment through 23 Aug 2019

drinking water matrices

- Cleaner matrices e.g surface water, groundwater, wastewater effluents

t Quantitation Limits: 10 nanogram/L

Non-Drinking Water and Solids Meth

Isotope Dilution

complex method relative to direct injection

- More robust and accounts for complex matrices through isotopically labelled standard recoveries;
- Meets DoD requirements, which are optional at non-DoD affiliated sites.

24 PFAS analytes plus GenX chemical (HFPO-DA) with 10 ng/L MDLs

drinking water and solid matrices

- Non-drinking waters (e.g. surface water, groundwater, wastewater, landfill leachate).
- Solids (e.g. soils, sediments, biosolids, tissues).

atory internal validation started, ten lab external validation study planned

- ORD has internally demonstrated the method on limited matrices.
- DoD is funding single and multilaboratory validation studies with input from EPA.
- Goal is to submit the results of the methods studies to OW 1600 series and OLEM SW846 series.

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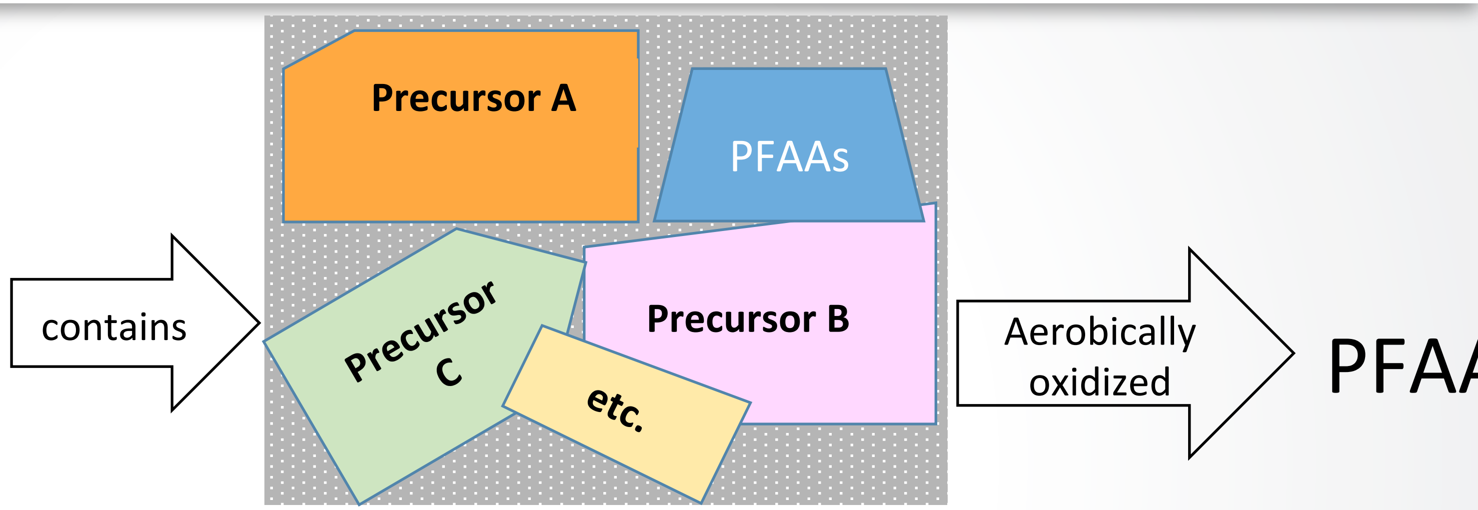
PFAS Precursors



measure Precursors

ducts are often broad mixtures of PFAS

ble & persistent PFAAs (e.g. PFOS) are most commonly ntified

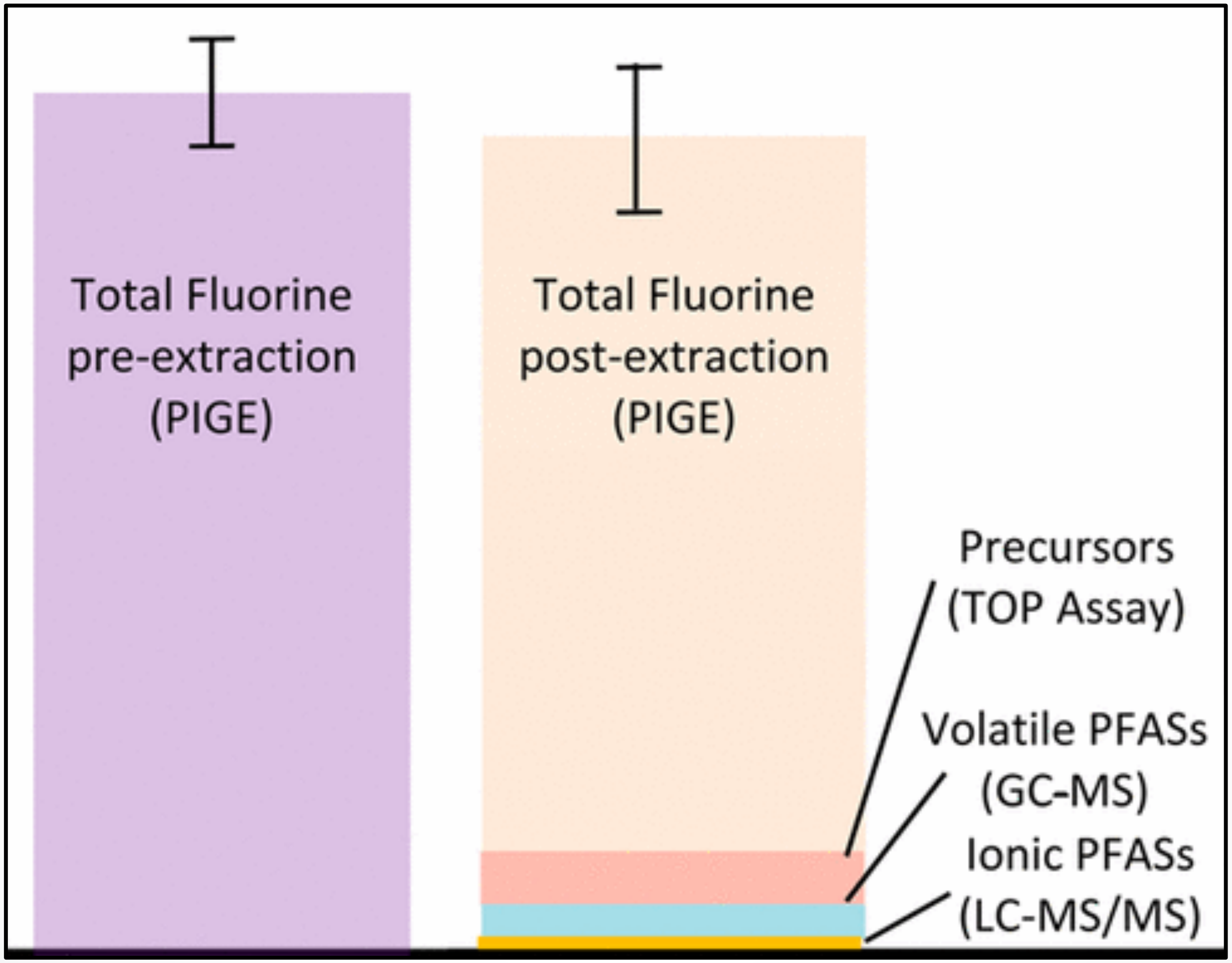
cursors mass may be substantial component of the l product mass

cursors degraded to PFAAs over time naturally or ing oxidative treatment

How do we measure/account

- Total oxidizable Precursor Assay (TOP Assay)
- Total Organofluorine analysis using combustion i chromatography (TOF-CIC)

For example… a mass balance for Pl



Mass balance based on total fluorine in textiles and papers.

Robel et al