PFAS 101:

An Introduction to Per- and Polyfluoroalkyl Substances

Amber Batson, PE

7/26/2019

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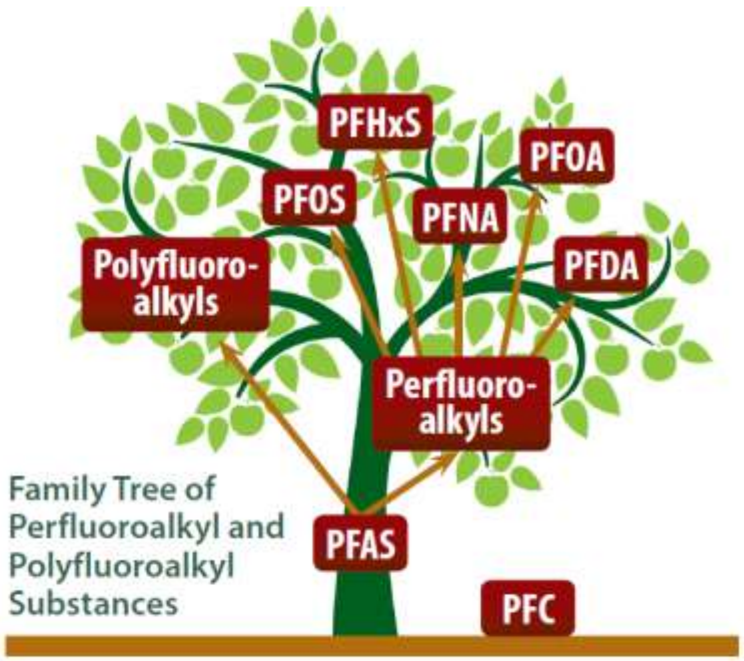
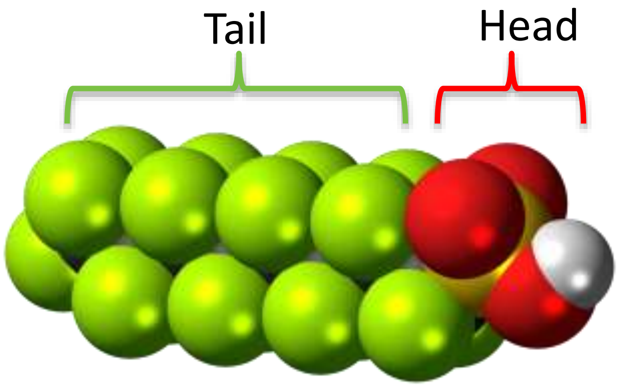
Questions We Will Cover Today…

- So what are PFAS?
- Are there regulations driving this?
- How are PFAS released into the environment?
- What are the treatment options?
- Is there more research being done?
- What can a Texas utility do?

There are over 4,000 Different Per- and Polyfluoroalkyl Substances (PFAS)!



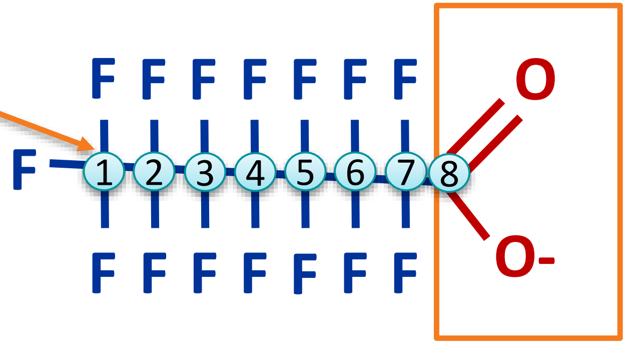
https://www.atsdr.cdc.gov/docs/17_278160-A_PFAS-FamilyTree-508.pdf



PFOA and PFOS

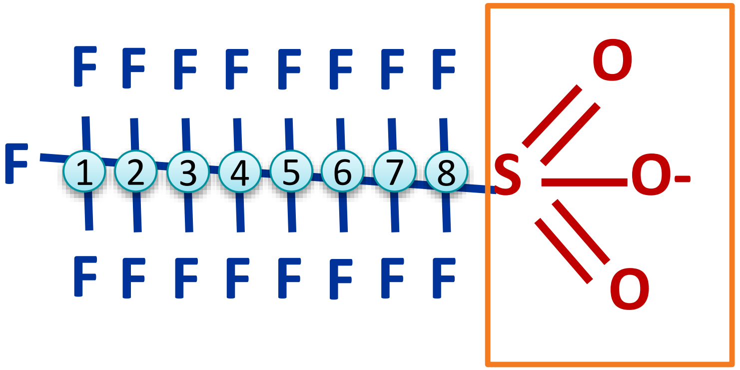
- ***P***er***F***luoro***O***ctanoic ***A***cid (PFOA)

Strong carbon & fluorine bond



Carboxylate

- ***P***er***F***luoro***O***ctane***S***ulfonic Acid (PFOS)



Sulfonate

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They Are In Our Living Environment....

- Large class of fluorosurfactants with unique chemical & physical properties that make many of them extremely persistent and mobile in the environment
- Used since late 1940s in wide range of consumer and industrial applications

http://www.defence.gov.au/Environment/PFAS/pfas.asp

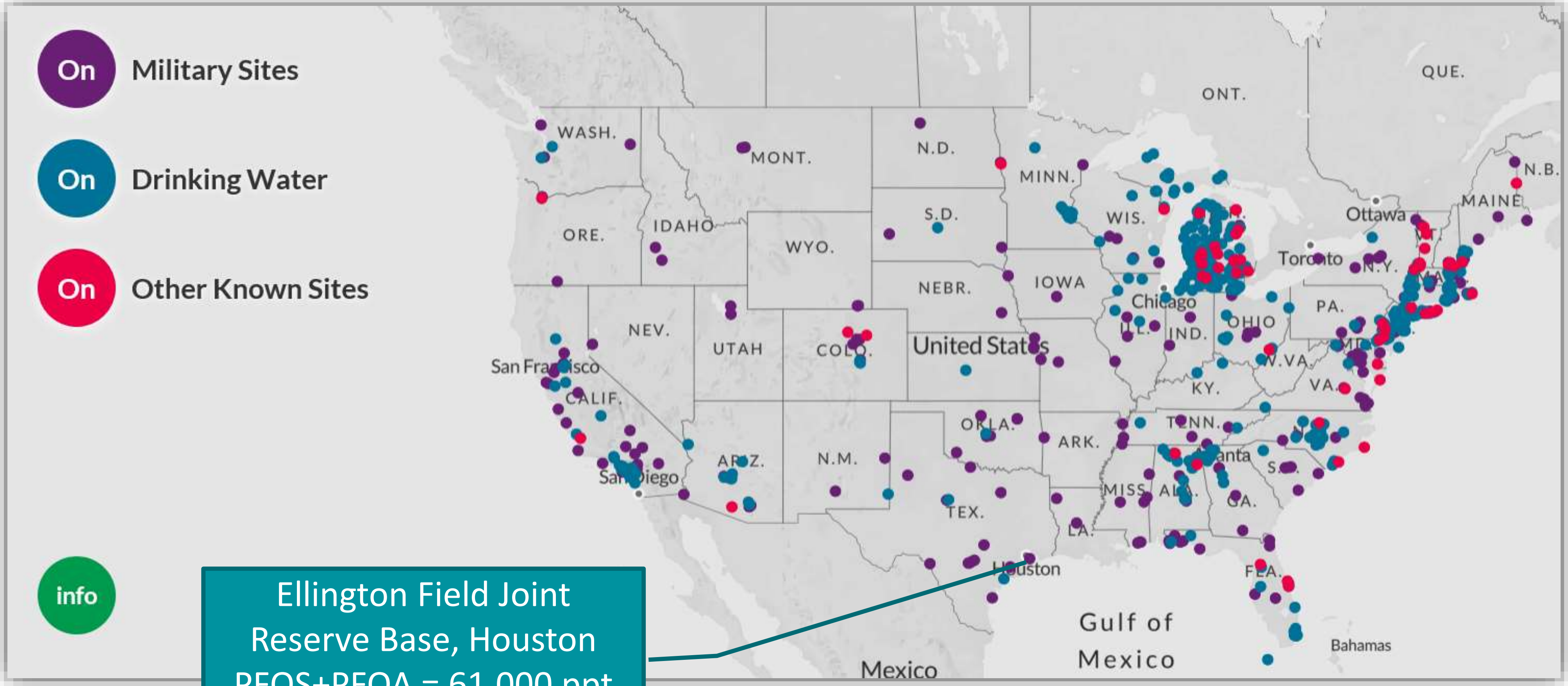
Detection of PFAS Contamination

Source: EWG

NOTE:

- Standard methods only exist for drinking water for a small number of PFAS.
- Many PFAS cannot be detected via SM.
- There is no standard method for how to detect in soils, wastewater, or sludge (some labs have developed their own modified version of SM)

How Much PFAS Contamination Have We Found Today?



Ellington Field Joint Reserve Base, Houston
PFOS+PFOA = 61,000 ppt (2018)

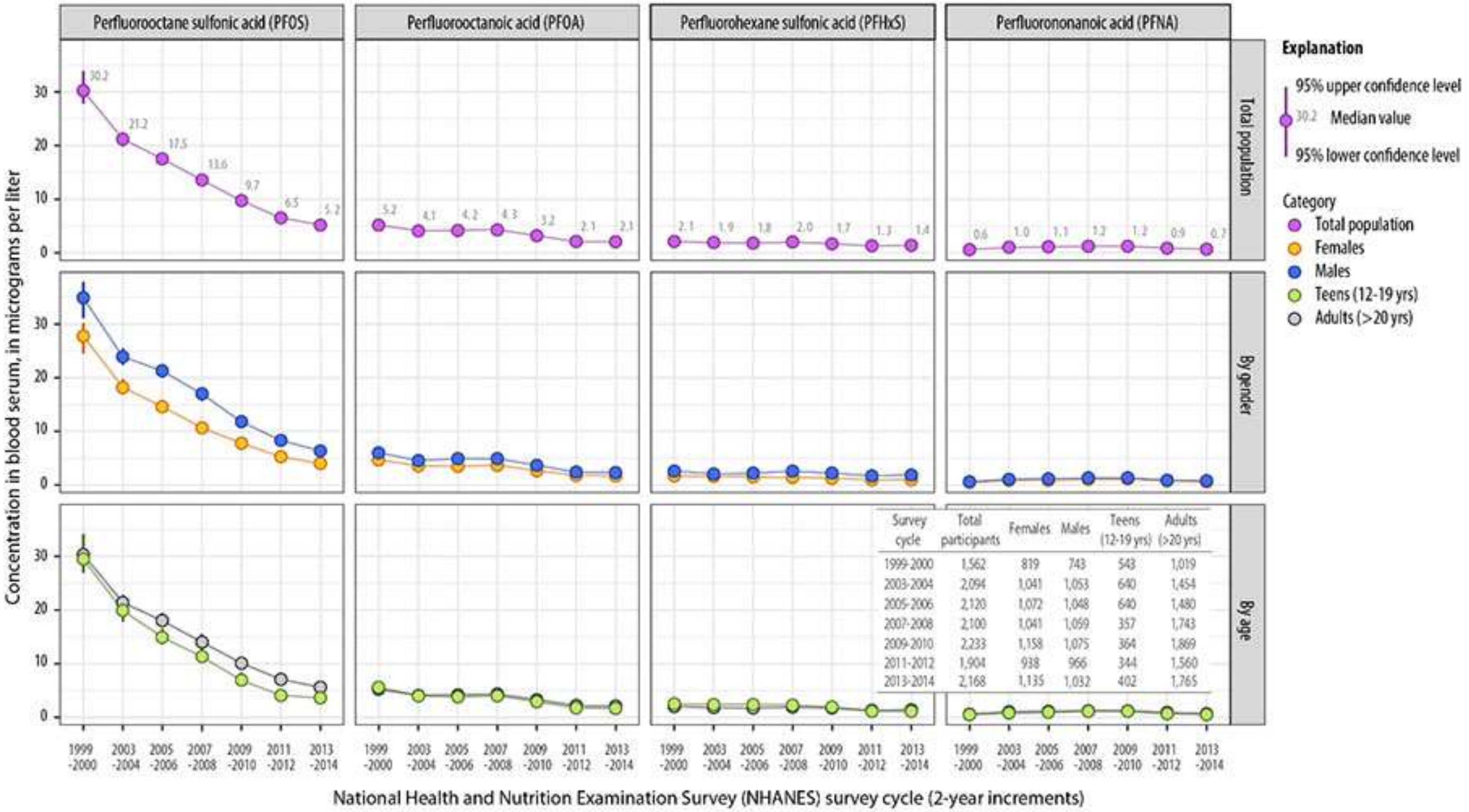
Source:

The Current Scientific Understanding of PFAS Health Impacts

- Research is on-going
- Having PFAS exposure or PFAS in your body does not mean you will necessarily have health problems now or in the future.
- Most people in health studies do not have health effects, even when exposed to high amounts of PFAS.
- Some health studies have found health effects linked to some PFAS such as:
  - Decreased chance of a woman getting pregnant
  - Increased chance of high blood pressure in pregnant women
  - Increased chance of thyroid disease
  - Changed immune response
  - Increased cholesterol levels
  - Increased chance of cancer, especially kidney and testicular cancers

PFAS is Likely in All of Us…

Median concentration of selected per- and polyfluoroalkyl substances (PFAS) in blood serum (1999-2014) in the United States



Survey cycle	Total participants	Females	Males	Teens (12-19 yrs)	Adults (>20 yrs)
1999-2000	1,562	819	743	543	1,019
2003-2004	2,094	1,041	1,053	640	1,454
2005-2006	2,120	1,072	1,048	640	1,480
2007-2008	2,100	1,041	1,059	357	1,743
2009-2010	2,233	1,158	1,075	364	1,869
2011-2012	1,904	938	966	344	1,560
2013-2014	2,168	1,135	1,032	402	1,765

Data source: Centers for Disease Control and Prevention. Fourth Report on Human Exposure to Environmental Chemicals, Updated Tables, (January 2017). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. https://www.cdc.gov/exposurereport/.

Note: In January 2006, the eight major PFAS manufacturing companies in the U.S. voluntarily committed to a 95% reduction of emissions and product content for PFOA and selected related PFAS species by 2010 and a complete elimination of these chemicals from emissions and products by 2015 (USEPA. 2010/2015 PFOA Stewardship Program). The major US producer of PFOS phased out production of PFOS precursors by 2002 (Prevedouros et al. ES&T 2006, 40:32-44) .

Revised 2017.06.22 ATSDR/DCHI/SSB/ba

Science Support Branch
data organization, analysis, visualization

Source: CDC

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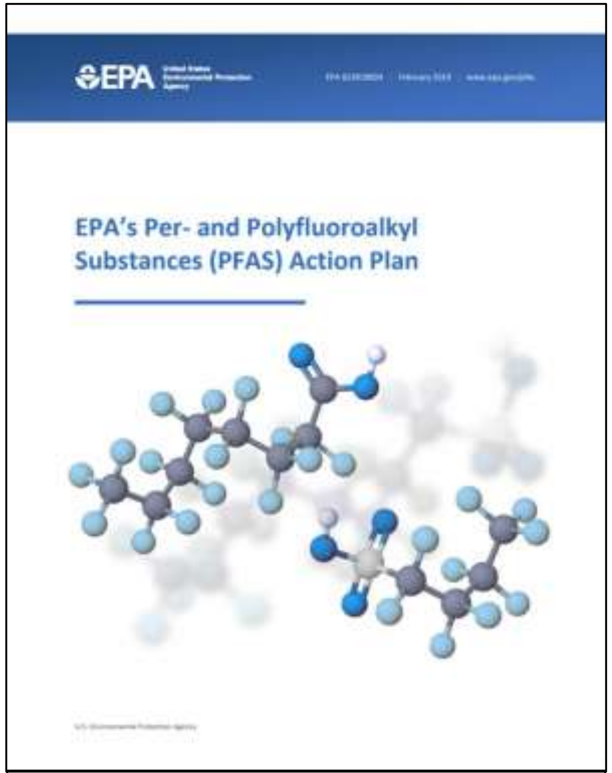
Regulatory History

- Concerns originated in **1999**
  - By **2002**, 3M phased out PFOS production
  - By **2008**, 3M phased out PFOA production
- USEPA OSWER established Health Advisory Levels for PFOS (200 ppt) & PFOA (400 ppt) in **2009**
- USEPA included 6 PFAS in UCMR3 in **2012**
  - By **2015**, all manufacturers phased out PFOA production
- USEPA revised health advisory levels (PFOS: 70 ppt and PFOA: 70 ppt, PFOA+PFOS: 70 ppt) in **2016**
- USEPA held community outreach meetings in **2018**
- USEPA published PFAS Action Plan on **2/14/2019**
- USEPA published draft screening levels of 40 ppt and preliminary remediation goals (PRGs) of 70 ppt for PFOS and PFOA for groundwater that is a current or potential source of drinking water on **4/25/19**
- USEPA public meeting for UCMR5 including PFAS, **7/16/2019**


EPA

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

- Drinking water
- Cleanup
- Toxics
- Research
- Enforcement
- Risk Communications

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No Fed MCLs

Health advisory levels and MCL continue to evolve at state level

- **USEPA** – Lifetime Health Advisory Levels
  - 70 ppt – PFOA, PFOS, PFOA + PFOS
- **Alaska** action levels for groundwater and surface water
  - 70 ppt – PFOS + PFOA + PFNA + PFHxS + PFHpA
  - 2 ppb – PFBS
- **California** drinking water (July 2019)
  - 6.5 ppt PFOS – Notification level
  - 5.1 ppt PFOA – Notification level
  - 40 ppt PFOA, 10 ppt PFOS- Response level
- **Connecticut and Massachusetts** Screening Criteria
  - 70 ppt – total of PFHxA + PFHpA + PFOA + PFNA + PFOS
- **Michigan** Proposed drinking water standards (regulated by 2020)
  - PFNA: 6 ppt
  - PFOA: 8 ppt
  - PFHxA: 400,000 ppt
  - PFOS: 16 ppt
  - PFHxS: 51 ppt
  - PFBS: 420 ppt
  - GenX: 370ppt

(June 2019)

- **Minnesota** Action Levels
  - 35 ppt – PFOA ; 27 ppt – PFOS
- **Montana Water Quality Standard (DEQ-7)**
  - 70 ppt – PFOA, PFOS
- **New Jersey** Drinking Water MCL
  - 13 ppt PFNA – MCL (effective 9/4/2018)
  - 14 ppt PFOA – Proposed MCL
  - 13 ppt PFOS – Proposed MCL
- **New York**
  - 10 ppt-PFOA, PFOS (may be effect in 2019)
- **North Carolina**
  - 140 ppt – GenX
- **NH DES** Final proposed MCL and AGQS (June 2019)
  - 12 ppt – PFOA
  - 15 ppt – PFOS
  - 18 ppt – PFHxS
  - 11 ppt – PFNA
- **Vermont** Drinking Water Standard
  - 20 ppt – PFHxA + PFHpA + PFOA + PFNA + PFOS

Be aware of state specific PFAS investigation plan

Characterization of Different PFAS Releases

- Aqueous Film Forming Foams
- Manufacturing Emissions
- Landfill Leachate
- Wastewater Effluent, Biosolids

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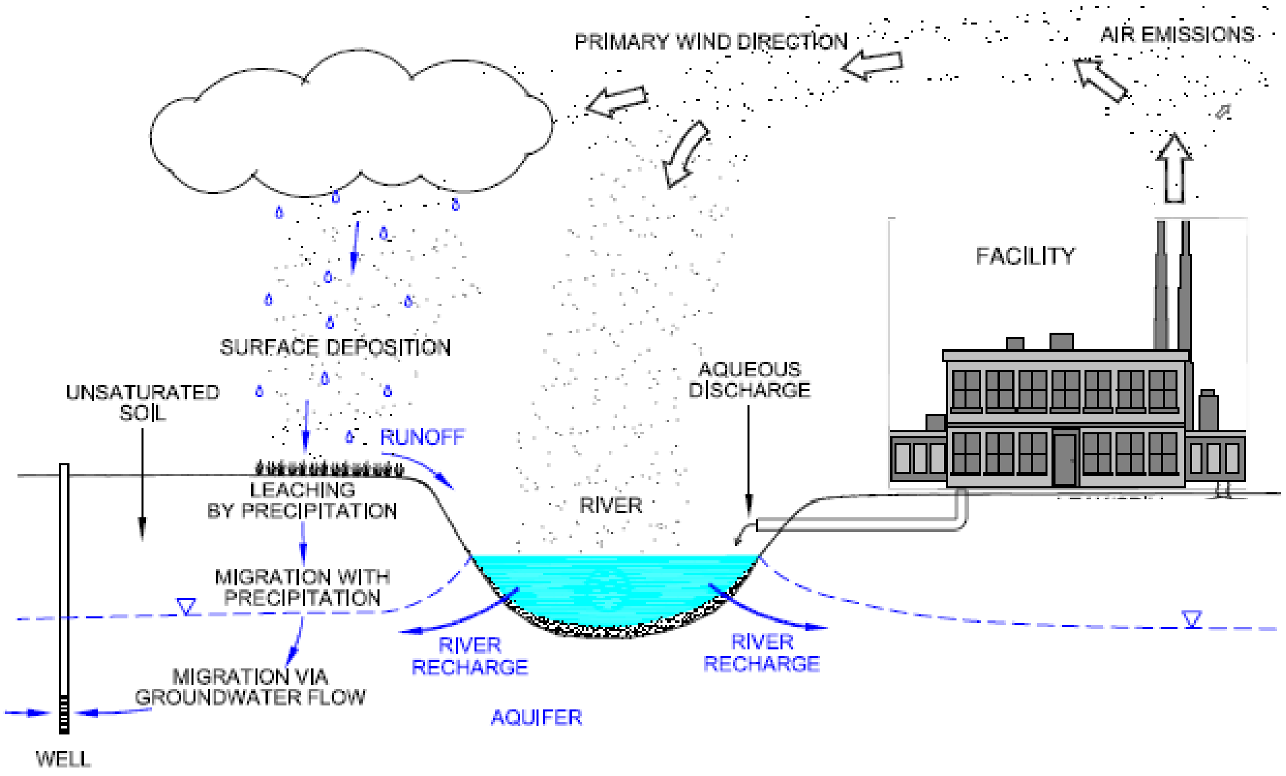
Aqueous film forming foam (AFFF)

- Complex, proprietary mixtures
- PFAS a few % in mixture but still g/L levels
- Mixed uses of different AFFFs at most sites
- PFAS precursors can be biotransformed to more toxic constituents of PFAS (e.g., PFOS, PFOA)

Source: Houston Chronicle (ITC Fire)

PFAS Emissions/Discharges from Manufacturing Sources

- Wind directions and atmospheric deposition play key roles on transporting PFAS
  - PFAS can be detected in soil and water upgradient and downgradient from the manufacturing facility

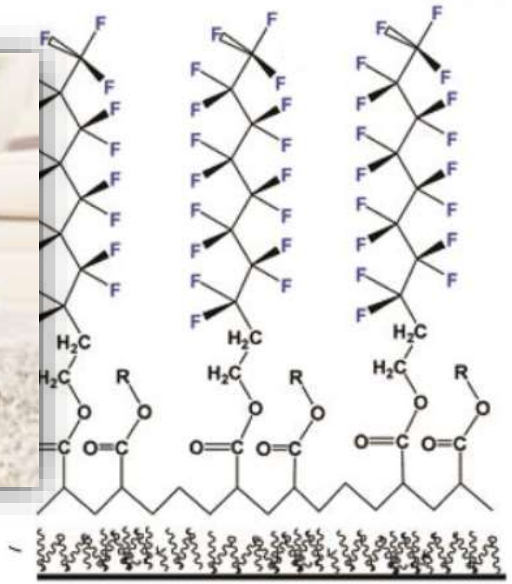


Most known case studies associated with manufacturing emissions are primarily associated with PFOA, PFNA or Gen-X. PFAS compositions in manufacturing emissions are different from AFFF sources and less complex.

PFAS in Landfills

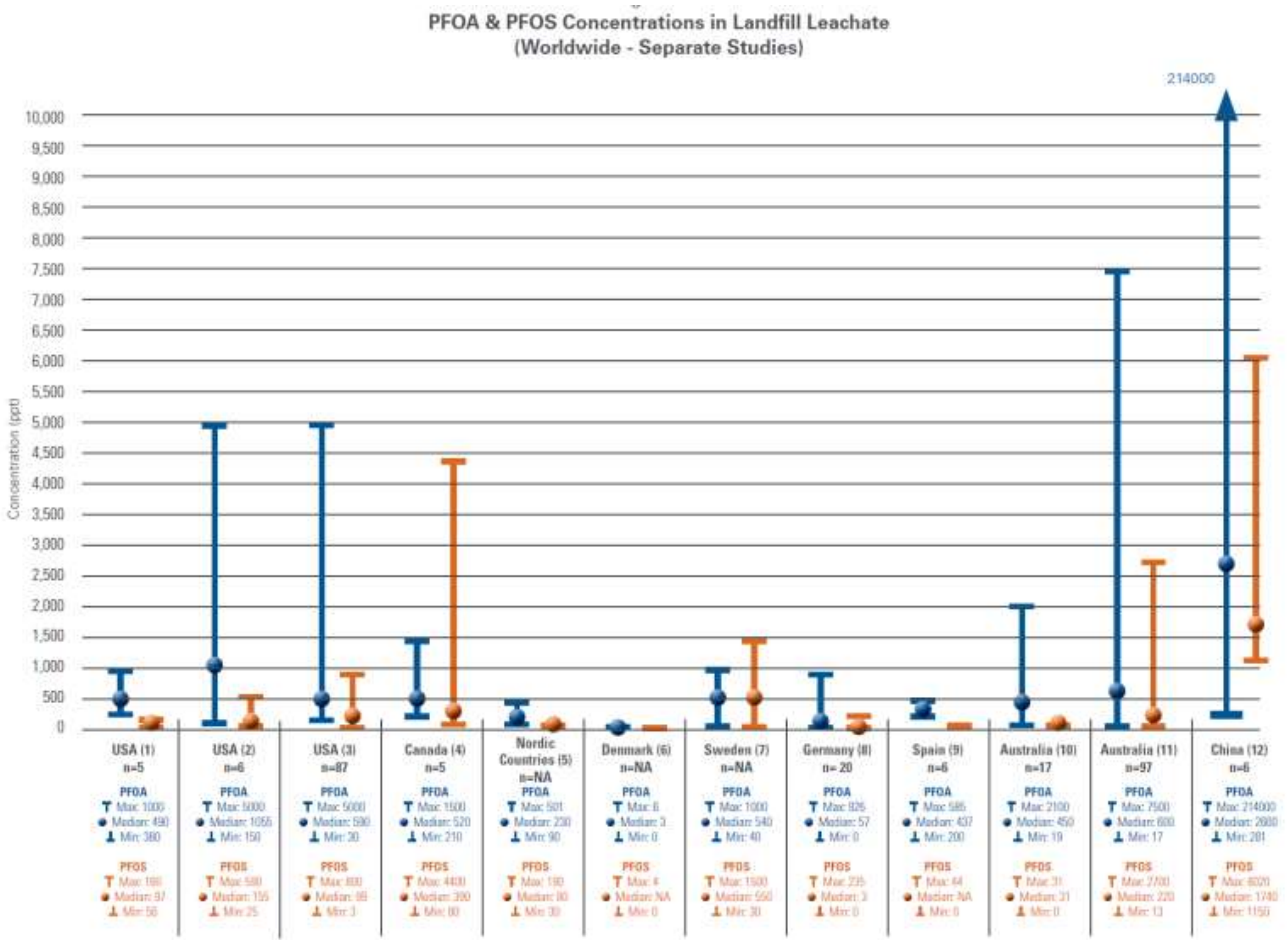
Fate of landfill leachates:

- Leach into groundwater with no treatment (if unlined)
- Recirculated back to landfill
- Discharged to POTW
- Pretreatment before discharge



Carpet Treatment

PFOS and PFOA in Landfill Leachate



Michigan Waste & Recycling Association, Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent TECHNICAL REPORT, March 2019

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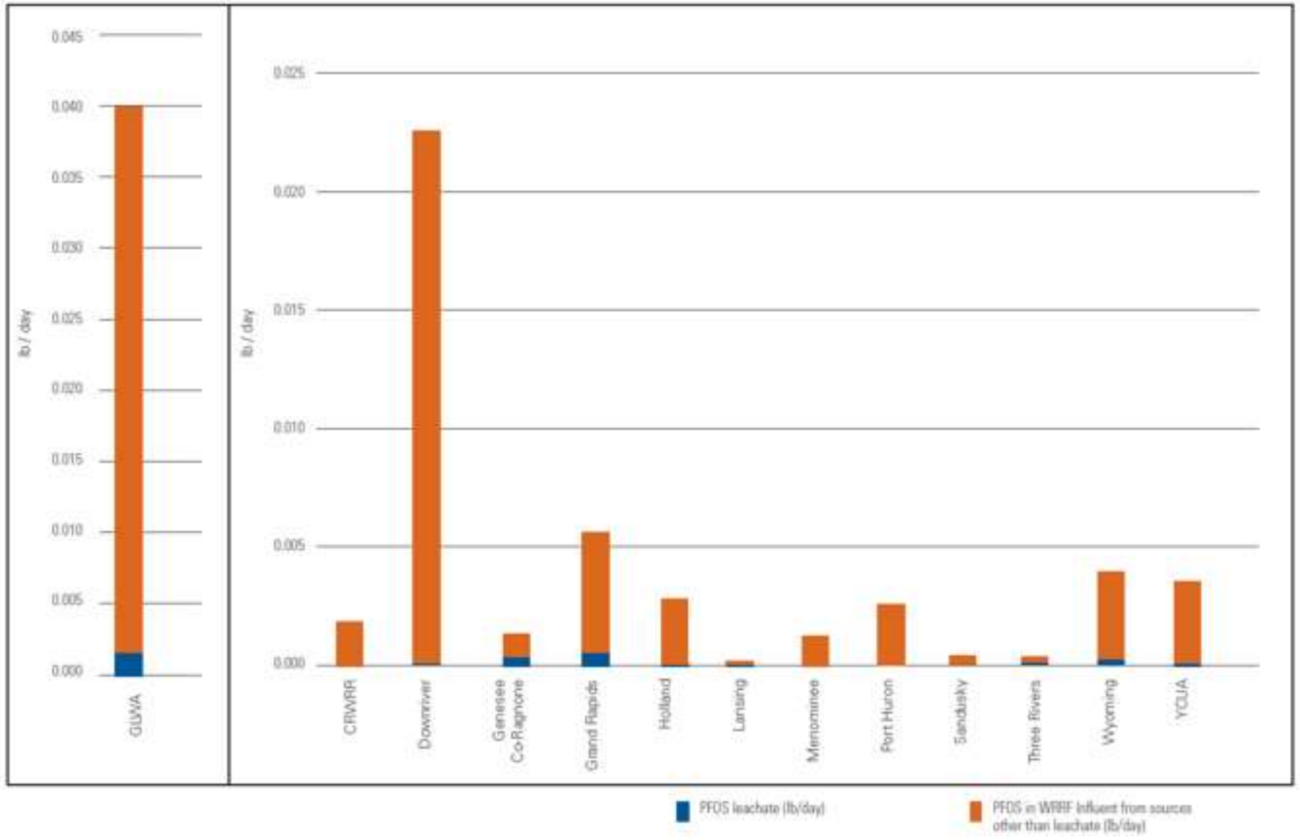
PFOS in Landfill Leachate Fed into POTW

PFOS Mass: Influent Leachate vs. Overall WRRF Influent



Note : Blue shading represents active Type II landfill leachate loading for PFOS mass at each WRRF. This graph includes a total of 13 WRRFs utilized by 26 landfills. Eleven of the WRRFs treat 24 active landfills (23 which were sampled as part of this study and South Kent landfill). Two of the WRRFs are utilized by two additional active landfills that were not sampled as part of this study. PFOS influent concentrations were unavailable for the WRRFs that treat other active Type II landfills. The mass represents a calculated value on a single sample, permitted discharge volume, and average daily leachate discharge.

Michigan Waste & Recycling Association, Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent TECHNICAL REPORT, March 2019

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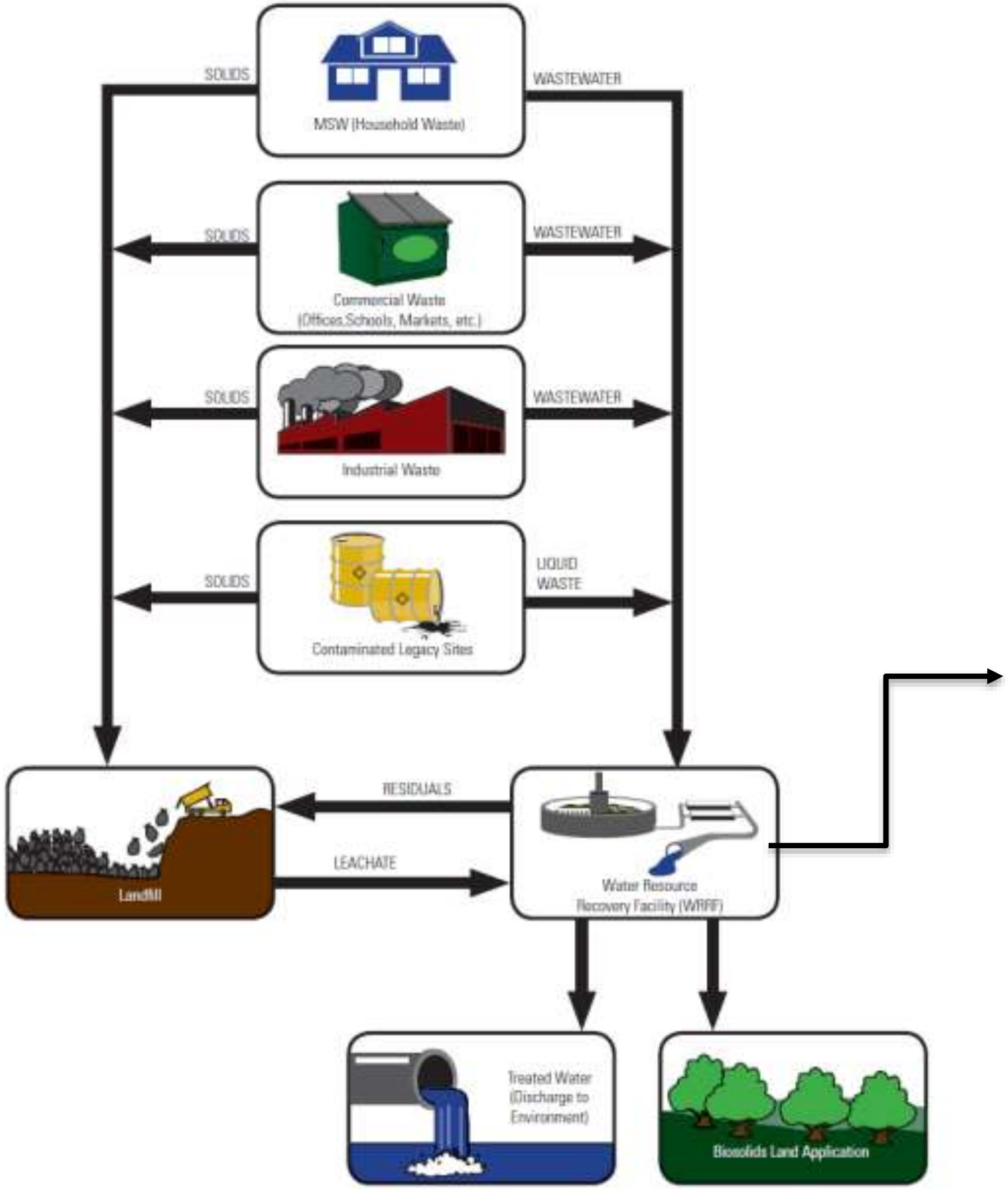
PFAS in Wastewater



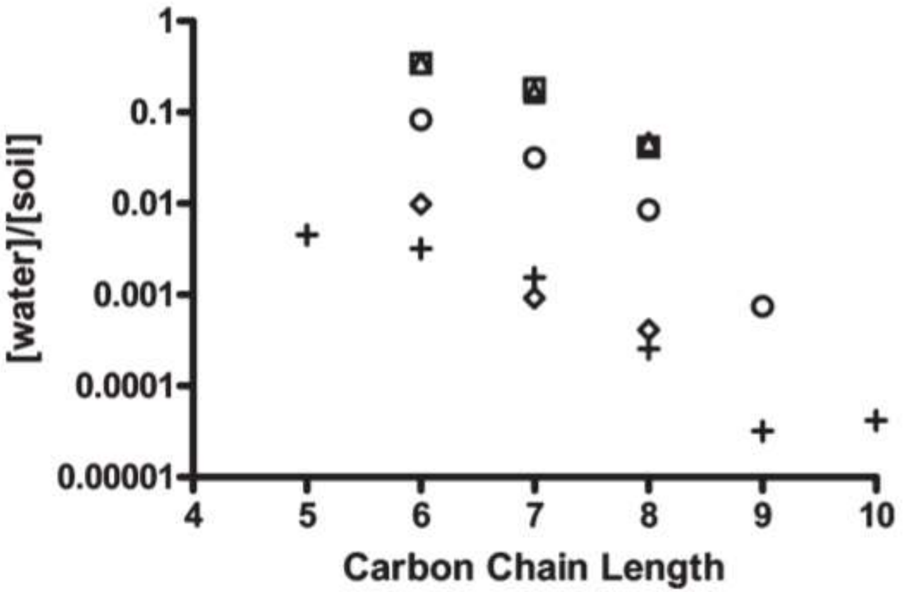
- Negligible treatment at WWTP, <5% removal
- **Most removal via sorption to wastewater sludge, particularly for long chain PFAS**
- Short chains get discharged into the environment
- Depending on influent compositions, typically effluent concentrations slightly lower than influent, but some documents effluent higher than influent

Michigan Waste & Recycling Association, Statewide Study on Landfill Leachate PFOA and PFOS Impact on Water Resource Recovery Facility Influent TECHNICAL REPORT, March 2019

PFAS Fate in Biosolids

- PFAS are in biosolids because they have been widely used for decades and persistent in the environment
- PFAS mobility can be influenced by
  - Chain length
  - Organic carbon content
  - pH
  - Cation concentrations
  - Clay content
  - Types of soil minerals
- Uncertainty on public health risk
  - Presence of PFAS in biosolids is not evidence of risk or significant exposure

PFAS in Biosolids



(Lindstrom et al, 2011)

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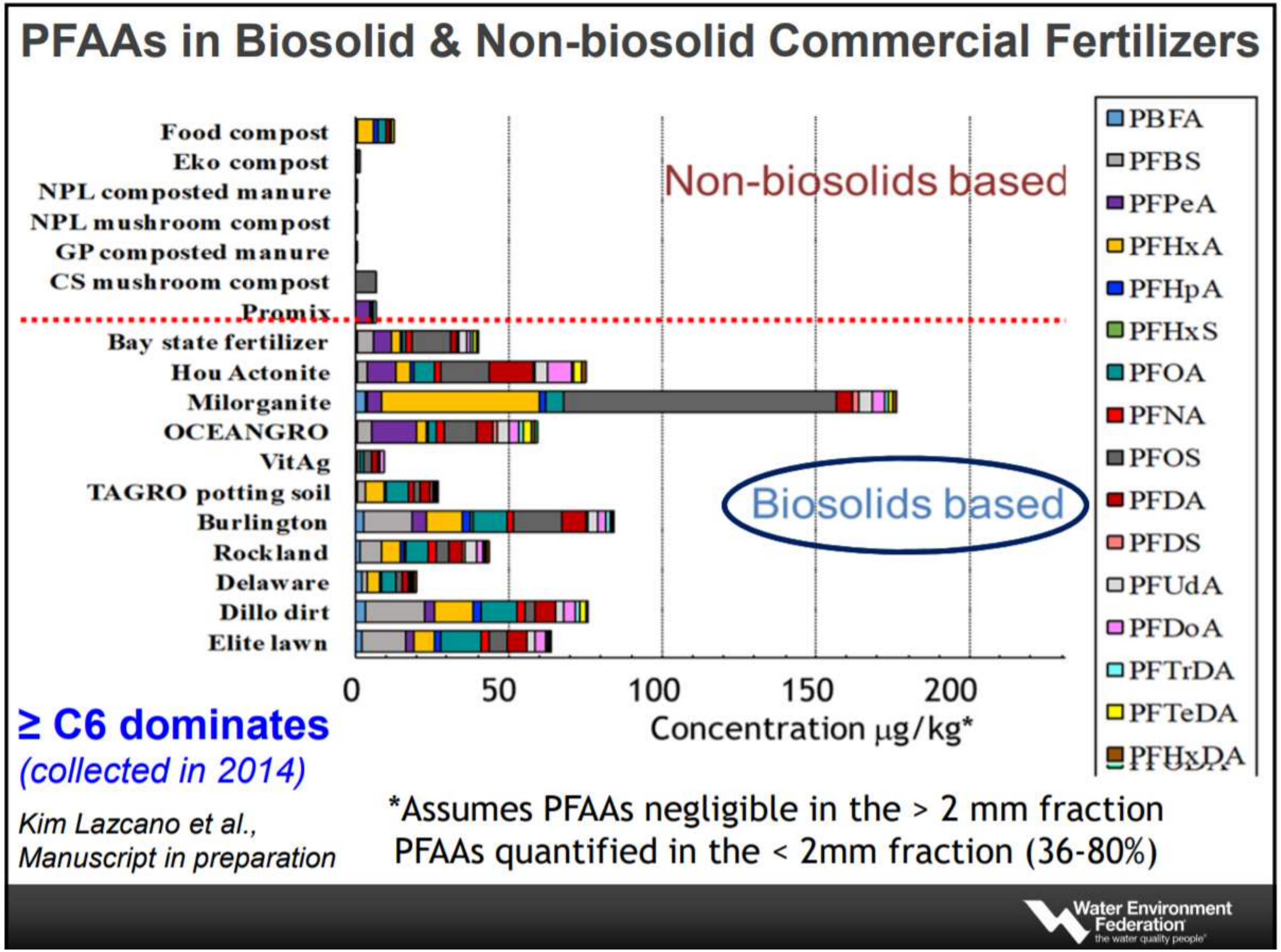
PFAS in Commercial Fertilizers (Data Date: 2014)



Research Underway for PFAS in Biosolids

Title: Assessing Poly- and Perfluoroalkyl Substance Release from Finished Biosolids

Investigators: Dr. Charles Schaefer (CDM Smith), Dr. Linda Lee (Purdue University), Ned Beecher (North East Biosolids and Residuals Association (NEBRA))

Objectives: The overall goal of this proposal is to assess poly- and perfluoroalkyl substance (PFAS) release from finished biosolids. Specifically, this release will be examined as a function of PFAS loading in the finished biosolids, the post-digestion processing of the biosolids, and the age of the biosolids (freshly produced vs. field-aged). Specific objectives will be to:

- Quantify PFAS levels, including potential perfluoroalkyl acid (PFAA) precursors, in finished biosolids from multiple water resource recovery facilities (WRRFs)
- Assess the impacts of anaerobic digestion on PFAS levels and potential for release from finished solids
- Determine the extent to which PFAS release from biosolids occurs (both dissolved and colloidal) and the fraction of PFASs which remain irreversibly sequestered to the biosolids
- Determine the impacts of field-aging (which likely will facilitate precursor transformation and sequestration) on the fraction of PFAS that is released
- Develop preliminary guidelines or rules of thumb for mitigating PFAS levels and release in biosolids

Three Mainstream PFAS Treatment Technologies

Granular Activated Carbon (GAC)

Ion Exchange Resin

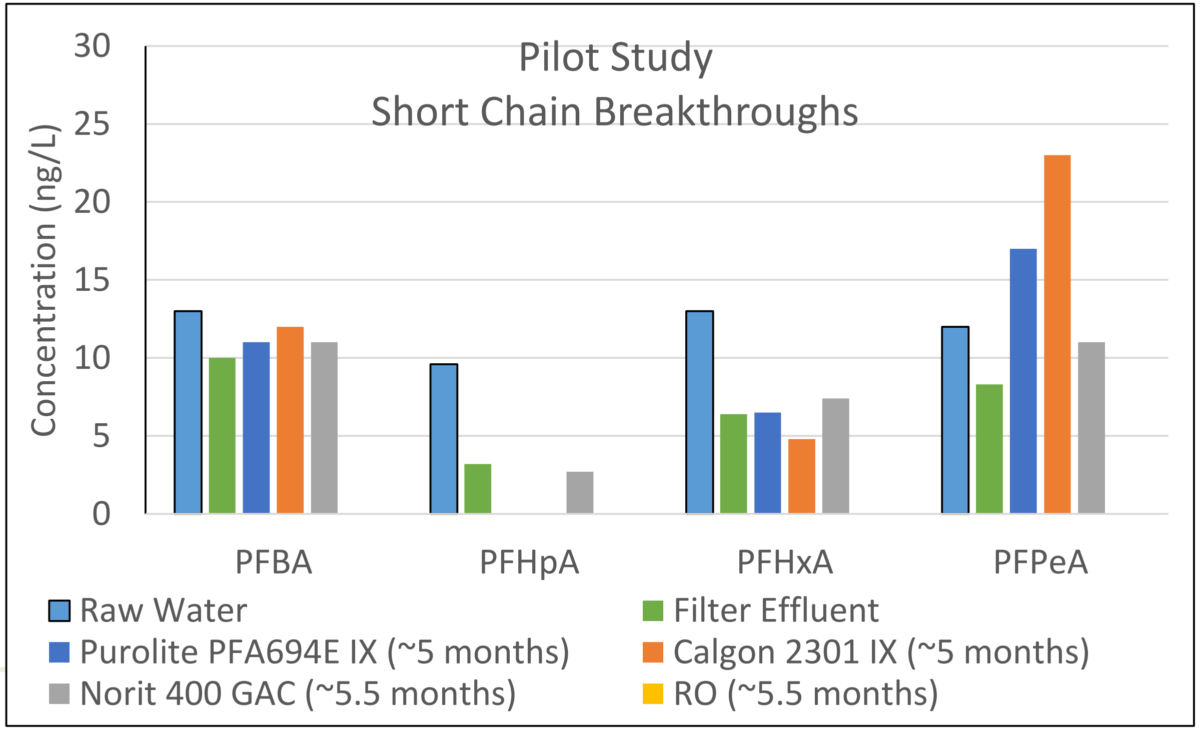
High Pressure Membrane

Implementing a PFAS Removal System

Engineering evaluation
- System upgrades
- New system to remove PFAS

Check on PFAS treatability

Pilot testing treatment effectiveness



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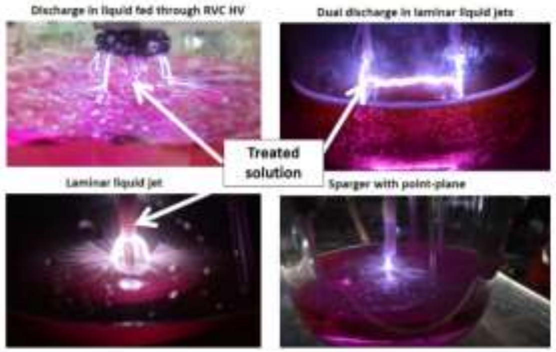
PFAS Treatment Considerations

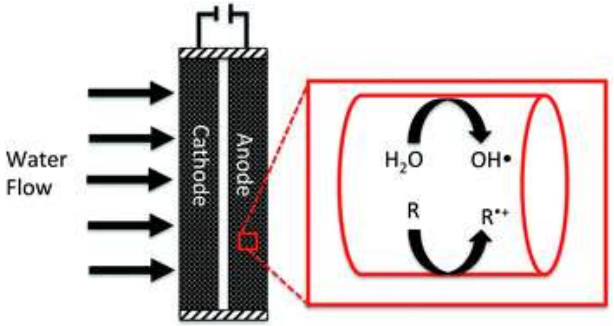
- Sense of scale is important
- PFAS treatment in drinking water is a young practice: Do not generalize or assume. Be wary of citing other treatment results on other waters. Consider site specific water chemistry!
- Long chain PFAS can be removed efficiently using filtration technologies
- Short chain PFAS are highly mobile and more difficult to be removed using GAC or ion exchange resin
- Biological and oxidation processes can increase PFAS concentrations in the effluent
- Pretreatment may be needed at WWTP

CDM Smith Water Research and Testing Laboratory

PFAS Destruction Is Possible

- PFAS are mineralized to F- and CO2 on site
- PFAS destruction requires high energy to break C-F bond
- Most recognized destruction technologies under development
  - Plasma treatment
  - Electrochemical oxidation (EO)
  - Sonication
- Based on promising bench scale data, pilot scale studies were funded
- Significant progress has been made on understanding EO treatment effectiveness





Research Underway for PFAS Treatment in Water and WW

- Evaluation and Life Cycle Comparison of Ex-Situ Treatment Technologies for Poly-and Perfluoroalkyl Substances (PFASs) in Groundwater
  - DoD project led by WRF
  - Research Team: Colorado School of Mines, North Carolina State University, University of Colorado –Boulder, CDM Smith

- WRF 4913: Investigation of Treatment Alternatives for Short-Chain Poly and Perfluoroalkyl Substances
  - Research Team:

THE Water Research FOUNDATION

NC STATE UNIVERSITY

AMERICAN WATER

HAZEN AND SAWYER Environmental Engineers & Scientists

CDM Smith

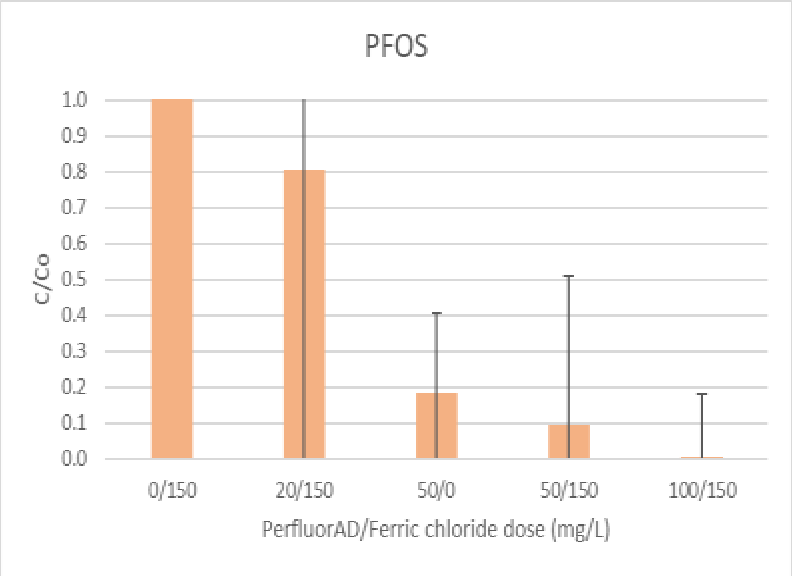
Southern Nevada Water Authority

SCHOOL OF MINES COLORADO 1874

CITY OF ANN ARBOR MICHIGAN

R&D: Potential WWTP Pre-Treatment PerfluorAd

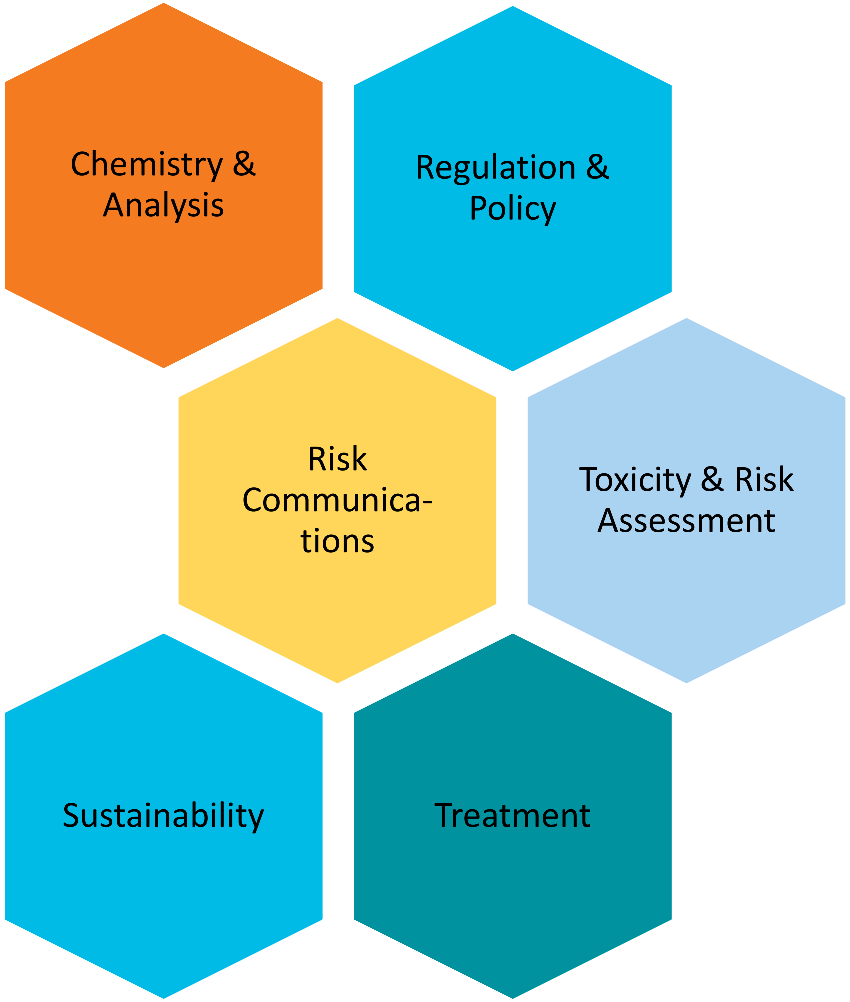
- It is liquid and biodegradable
- It interacts with PFAS only
- It does not interact with other organics or inorganics
- Low dosage requirement
- Low volume of micro flocs will be generated
- Micro floc is also biodegradable
- PFAS in biodegraded micro floc has potential to be destructed
- Large scale pilot tested in Europe and commercially available in the US
- Only simple mixing process is required
- Low reagent cost



Treatment of PFAS in landfill leachate

The PFAS is Realm Changing Daily – What Can We Do?

- Monitor the ongoing arguments on toxicity effects
- Follow regulation and policy developments; advocate for scientifically-based policy
- Understand your risks: Do some homework!
  - Identifying potential sources
  - Establish influent/effluent/biosolids levels
- Develop risk communications for the public
- Consider PFAS when going through treatment process selection or evaluating potential future liabilities
- Participate in R&D and help foster innovation



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THANK YOU

Find more insights:
www.cdmsmith.com/pfas

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