PFAS Introduction & Overview

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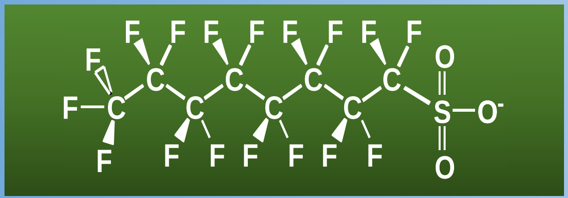
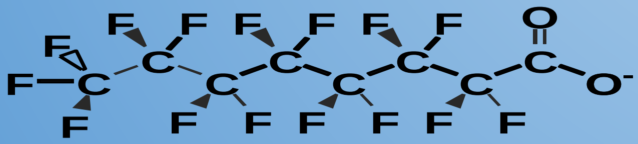
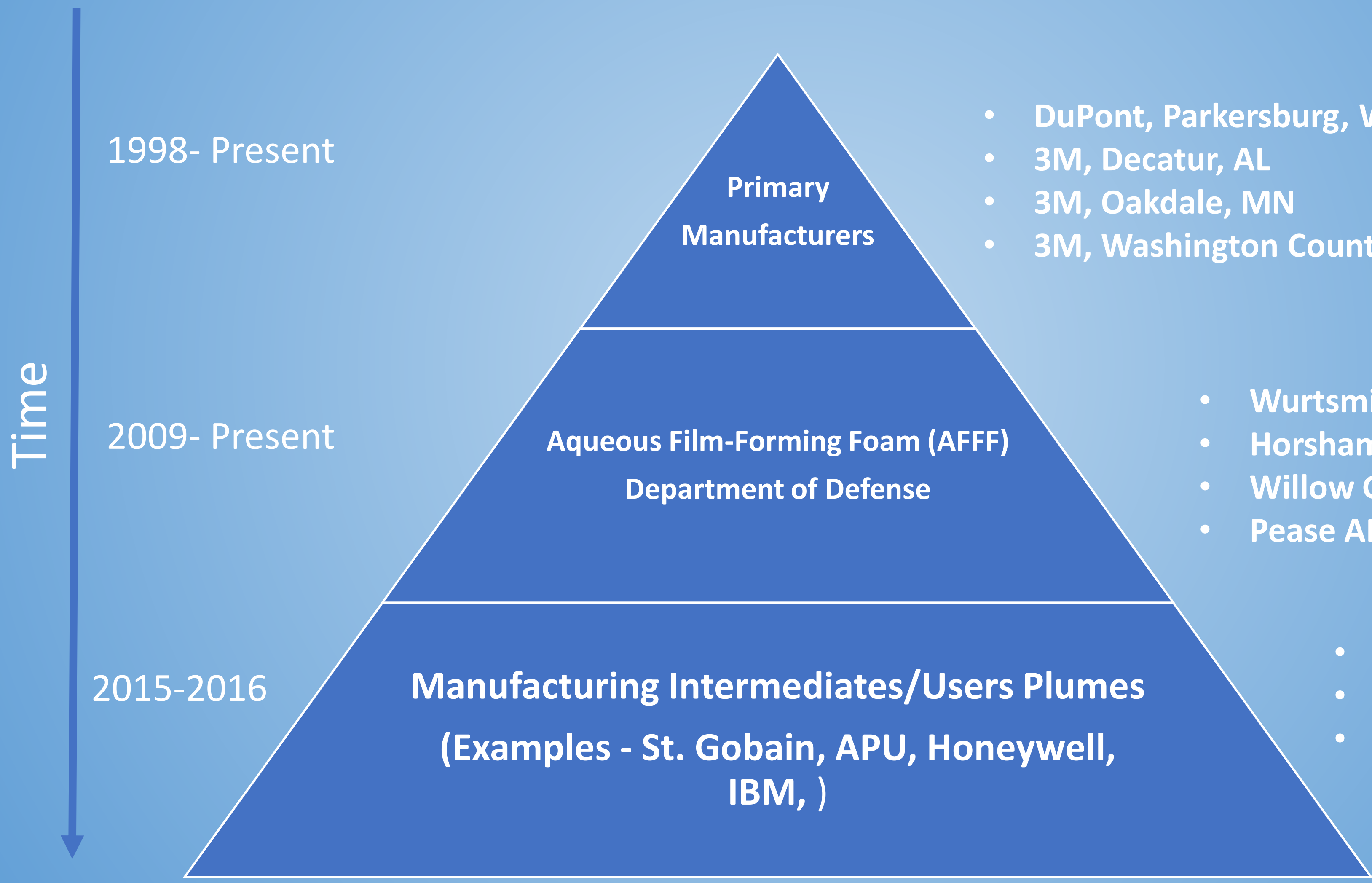
What are PFAS compounds?





- PFAS are a class of synthetic compounds containing thousands of chemicals formed from carbon chains with an attached fluorine.
- The C-F bond is the shortest and the strongest bond in nature and is responsible for most of the unique and useful characteristics of these compounds.
- PFAS are surfactants that repel oil and water, reduce wear or surface adhesion
- Introduced as early as 1948 (Teflon or PTFE polymer) with increasing use in the late 1960s and 1970s.
- At low concentrations, many have significant water solubility.

How we got here



- **DuPont, Parkersburg, WV**
- **3M, Decatur, AL**
- **3M, Oakdale, MN**
- **3M, Washington County Landfills, MN**

- **Wurtsmith AFB, MI**
- **Horsham AGS, PA**
- **Willow Grove NASJRB, PA**
- **Pease AFB, NH**

- **Hoosick Falls, NY**
- **Bennington, VT**
- **Pownal, VT**

UCMR 3 Data and Results

- No enforceable federal drinking water standards have been established for PFAS. The EPA is currently working on drinking water data from UCMR3 to determine if establishing a Maximum Contaminant Level (MCL) is warranted under the Safe Drinking Water Act.

- 2013-2015: EPA conducts the third Unregulated Contaminants Monitoring Rule (UCMR3) study. Six analytes were monitored at the Reporting Limits specified by the Rule.
  - PFBS 90 ng/L, PFHxS 40 ng/L, PFOS 30 ng/L
  - PFHpA 40 ng/L, PFOA 20 ng/L, PFNA 20 ng/L

EPA Health Advisory Levels

- EPA 2011 Provisonal Drinking Water Health Advisory Levels.
  - PFOS, 200 ng/L
  - PFOA, 400 ng/L
- EPA 2016 Drinking Water Health Advisory Levels.
  - EPA guidance level for PFOA or PFOS, 70 ng/L
  - EPA guidance level PFOA + PFOS, 70 ng/L
- Not legally enforceable, but new Health Advisory Levels may be given weight in state regulation and in litigation.

Potential PFAS Sources

MANUFACTURING

- Aerospace
- Automotive
- Chemical
- Electronics
- Metal Coatings & Plating
- Textiles

FIREFIGHTING

- Airports and Aviation Facilities
- Military Bases and Training Centers
- Petroleum Refineries and Terminals
- Petrochemical Production Facilities

NON-INDUSTRIAL

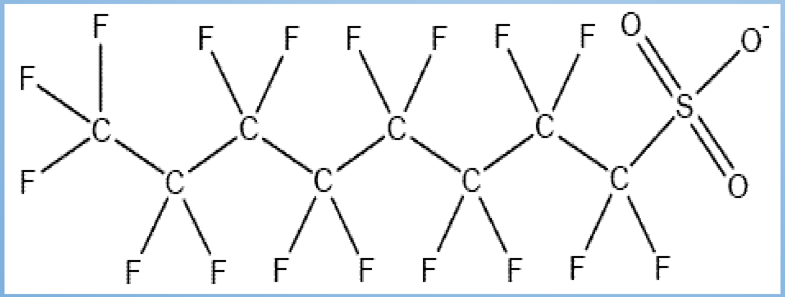
- Waste Disposal Facilities
- Wastewater Treatment Plants
- Biosolids Application for Agriculture


Fate and Transport

Fate and Transport Processes

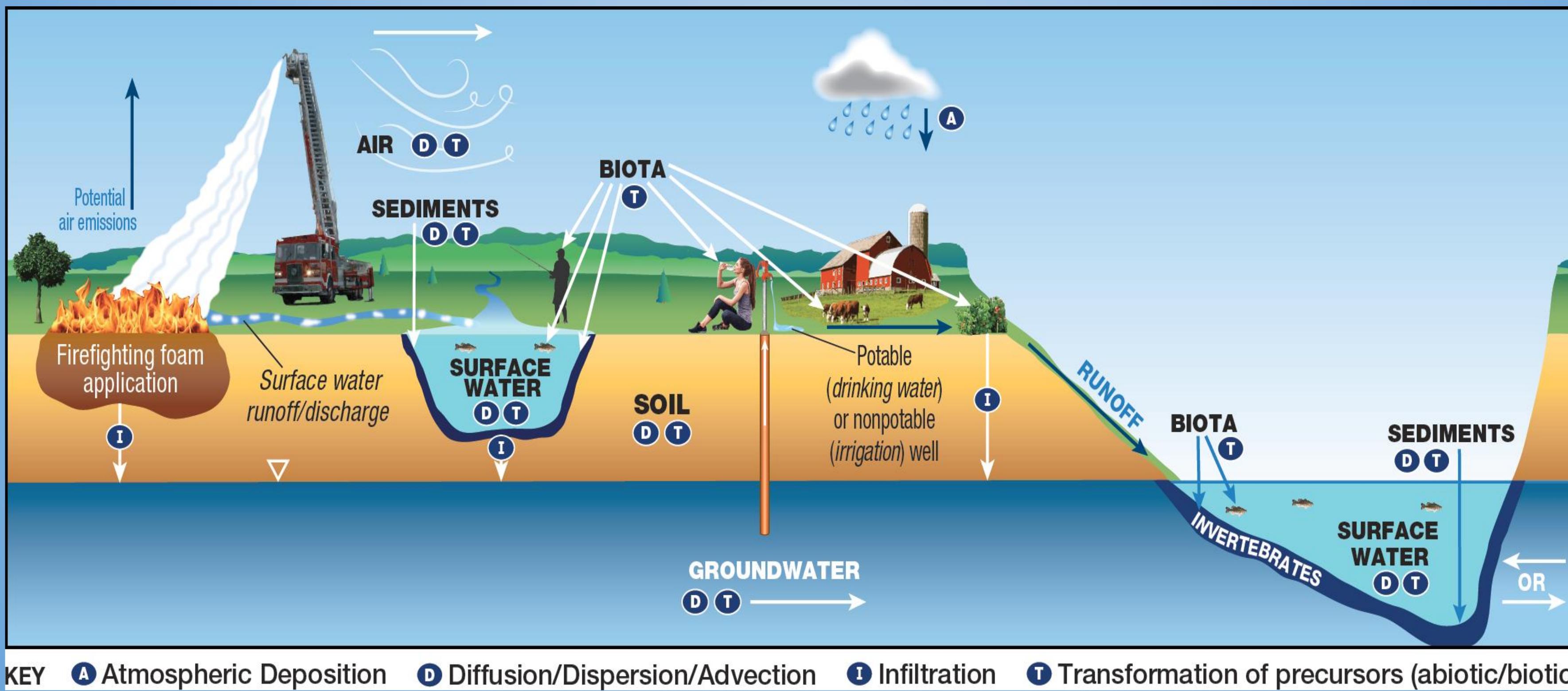
Partitioning:

- Hydrophobic & Lipophobic
- Sorption:
    - PFSA > PFCA
    - Longer chain > Shorter chain
    - Koc
- Mobility
    - Short chain > Long chain
    - Low volatility
    - Airborne particulates



Conceptual Site Model

- From ITRC Fate and Transport Fact Sheet (March 16, 2018)



Ubiquity

Human Exposure

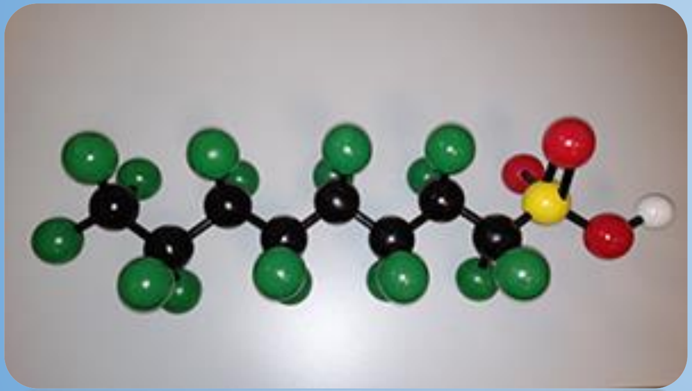
- Food and packaging
- Drinking Water
- House Dust

Serum Level (ppb)	PFOS (C8)	PFOA (C8)	PFHxS (C6)
Production Workers	1500-2000	500-1000	~500
NHANES 99-00	30.4	5.2	2.1
NHANES 03-04	20.7	3.9	1.9
NHANES 13-14	5	1.9	1.4

Persistent

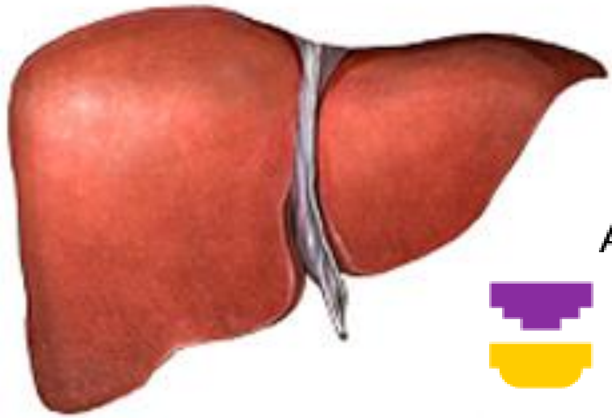
Human Serum Half-lives		
Compound	No. of Carbons	Half-life
PFOS	8	4.3-5 years
PFOA	8	2.1-3.8 years
PFHxS	6	8.5 years
PFHxA	6	32 days
PFBS	4	28 days
PFBA	4	2-4 days

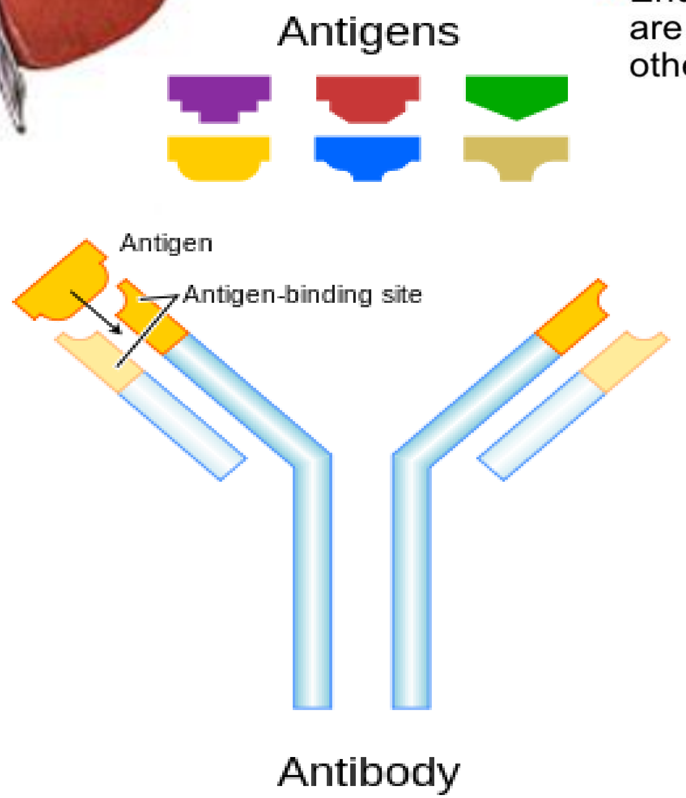
Distribution

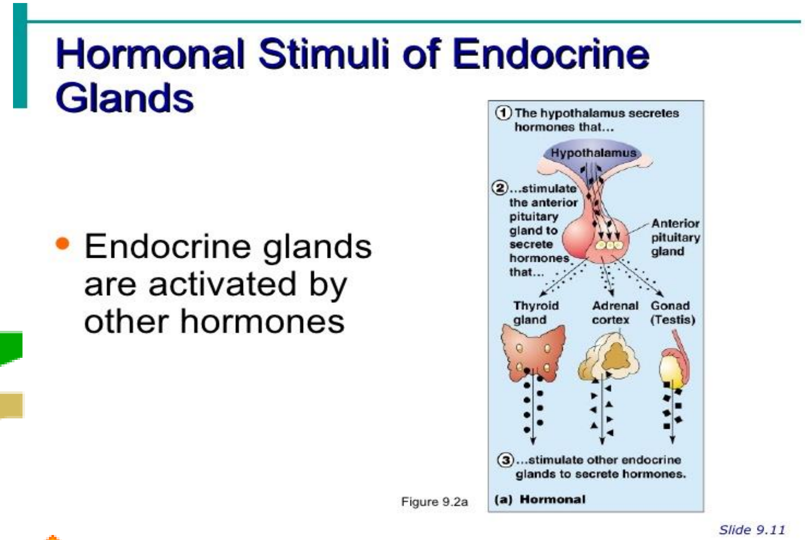


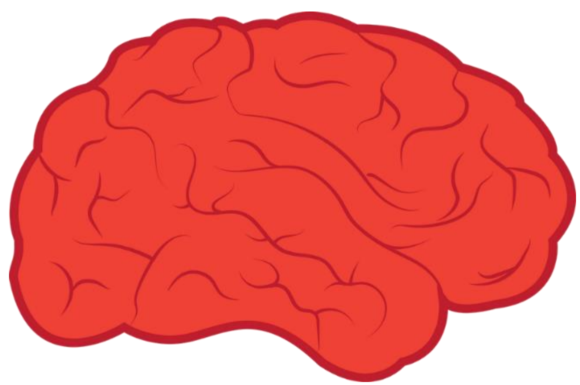
- Low affinity to fat
- Binds to proteins
  - Cell membrane surfaces
  - Highly perfused tissues
- Minimally in muscles
- Cross the placenta
- Men have higher levels than women
- Very little metabolism of PFOS and PFOA

Systemic Toxicities









Phase I Environmental Site Assessments (ESAs)

- ASTM E1527-3 – Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process
  - Identify recognized environmental concerns (RECs)
  - Petroleum products and "hazardous substances"
  - "Hazardous substances" defined by CERCLA
    - PFAS not currently a hazardous substance under CERCLA
    - EPA may designate PFOA and PFOS as "hazardous substances"
  - In the meantime, the All Appropriate Inquiries (AII) rule also states "pollutants" and "contaminants."

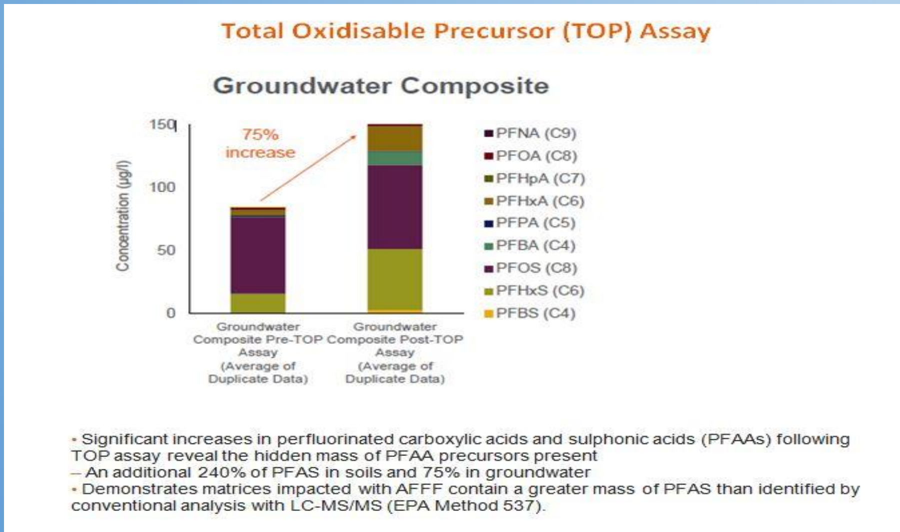
How to Sample for PFAS

- PFAS can be found in many consumer products including sampling and analytical equipment.
- Special care must be taken to avoid sample contamination.
- Need very low reporting limits.

Methods

- Method Development and Validation
  - EPA 537 Drinking Water Method Released 2008 Modified method used for other matrices.
  - ASTM D7968-14 Standard Test Method for in Soil
  - ASTM D7979-15 Standard Test Method for Water, Sludge, Influent, Effluent and Waste Water
  - Various documents, research papers, vendor application notes
  - DoD QSM 5.0 Table 15 and QSM 5.1 Table B-15.
- New methods under development for non-drinking water matrices. EPA and DoD are working on these.

Total Oxidisable Precursors Assay



- Process of transforming PFAS precursors in a sample to measurable perfluorinated carboxylic acid which can be measured.
- Sample + persulfate + heat converts precursors to terminal PFCAs and PFSAs
- LC MS/MS analysis without conversion (before) + conversion (after) + LC MS/MS analysis
- Delta is converted precursors

New and Upcoming

- **SPLP (1312) and LEAF (1315)**
  - Bottle extractor HDPE
  - Filtration apparatus stainless steel
  - Waste characterization impact analysis
- **Air**
  - Various media: impinger fluids, particulate filter, XAD-2 Resin
  - Media prepared by lab and batch tested,
  - Prep procedures modified for various media
- **PFAS Forensic**
  - Custom projects – project needs clear definition, information on products and site, and an investigative plan.
  - Matching the fingerprints of a source or product (composition or degradation products) with the fingerprints at an area with PFAS concerns.
  - Analysis of products and consumer goods (PFAS and TOP) vs field results to determine sources found in field.


Remedial Approaches
FORGED STEEL

Characteristics of PFASs

- **Issues**
  - ***Detection***
  - ***Precursors*** → ***Compounds of concern***
- **Recalcitrant**
  - ***Strong C-F bond***
- **Low volatility**
- **High solubility**
  - ***Long plumes***

Remedial Technologies - PFAS Treatment

- Groundwater Remediation
  - Granulated Activated carbon
  - Ion Exchange resins
  - Filtration/reverse osmosis
  - In-situ Treatment
    - In situ injectable carbon-based systems
    - In situ chemical oxidation
      - Various high energy oxidant systems
      - Creating reductive and oxidative radicals
- Biotransformation
  - Not for C-F bond?
  - Possible in time?
- "Other"
  - High temperature > 1,100 C

GAC

- Proven effective multiple sites – viable option
- Low sorption of PFAAs- GAC consumption and costs higher
- Higher costs than conventional contaminants
- Lower capacity than Ion exchange
- May be ineffective on short chain PFASs
- Regeneration, at high temperature: “destroys” PFASs but may reduce capacity
- Can be more cost-effective, but site-specific analysis required

Ion Exchange

- Number case studies increasing
- High capacity for PFAS adsorption
- Working on resins for improving short chain PFAS removal
- Can be more cost-effective, but site-specific analysis required
- Regeneration and PFAS destruction research/demonstration is ongoing

Treatment of Solids- PFASs

- Chemical Fixation/ Immobilization
  - *Commercially available*
    - *RemBind*
- Isolate in place
  - *Capping*
  - *Landfill reconstruction*
- Incineration
  - *Proven technology*
  - *Generally for lower Volume, higher concentration materials*
- Landfill
  - *Commercially available vs. special construction*
  - *Leachate management & treatment considerations*

Common Client Approaches

- **If water, then GAC**
- **If solids** (typically lower concentration, higher volume), **then isolation**
- **If solids** (high concentration, low volume), **then incineration**

Treatment Technology Summary

- Excavation & landfilling and isolation in place are the best current solids treatment options
  - Commercially available additives such as RemBind^{TM} and MatCARE^{TM}.
- Pump & Treat
  - Using GAC is the best current water treatment option
  - Ion exchange is also commercially available
- In-Situ Options
  - Oxidation technology- emerging
  - Injection of activated carbon- emerging

PFAS Resources

- www.epa.gov/pfas

EPA
United States
Environmental Protection
Agency

- www.dep.pa.gov/Citizens/My-Water/drinking_water/Perfluorinated Chemicals-PFOA and PFOS-Pennsylvania

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

ITRC PFAS Team

- Includes >350 members: industry, academia, DOD, regulatory, consulting, analytical labs and vendors
- Seven PFAS Fact Sheets:
  - AFFF Introduction
  - History and Use
  - Naming Conventions and Chemical Properties
  - Regulations and Guidance
  - Fate and Transport
  - Site Characterization, Sampling, Lab Methods
  - Remediation Technologies and Methods
- 2019 – Technical Guidance Document

www.itrcweb.org

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