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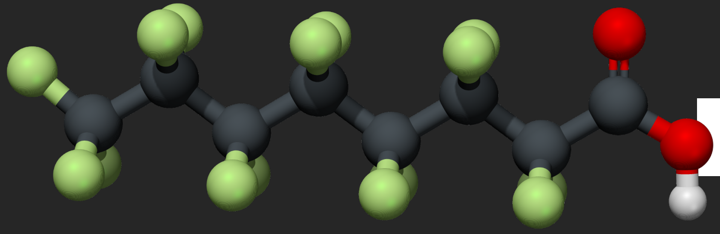
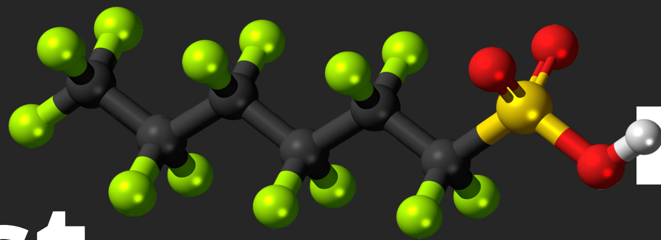
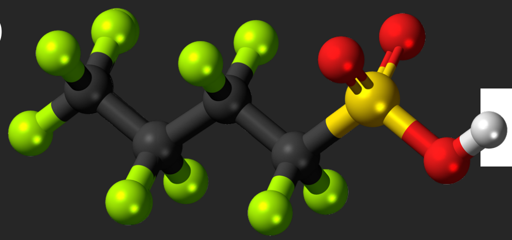


PFOA

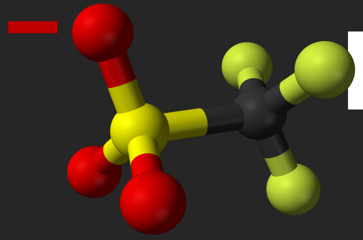
# PFAS Background, Regulatory Horizon, Best Available Technologies



PFHxS



PFBS



Triflate


**ZAID CHOWDHURY, PHD, PE, BCEE**

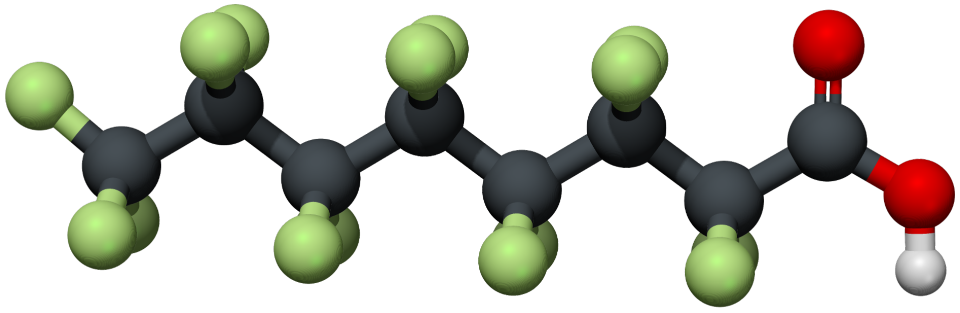
***WATER PRACTICE LEADER***


MSSC Conference
February 24, 2022
Las Vegas, NV

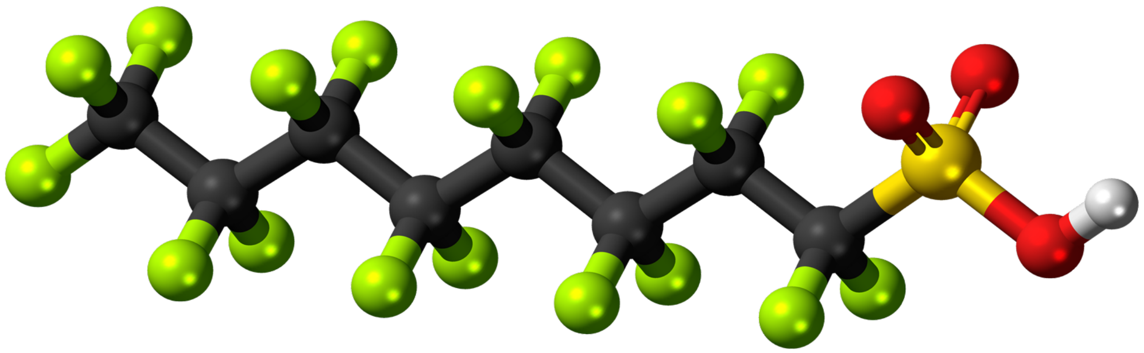
# AGENDA

- Background
- Regulatory Activities
- Treatment Technologies

# What is PFAS?



**Perfluorooctanoic Acid** (PFOA)



**Perfluorooctanesulfonic Acid** (PFOS)

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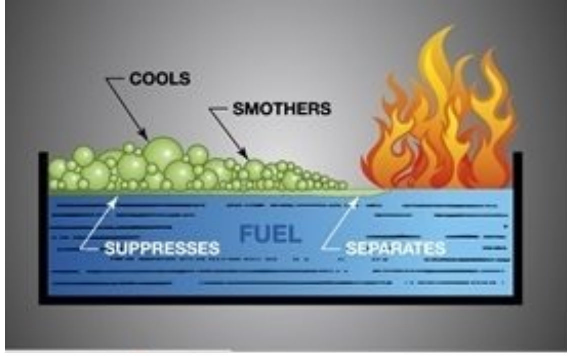
# PFAS are man-made chemicals used to make a variety of water-, heat-, and oil-resistant products

- ~ 5,000 synthesized
- ~ 500 used in the last decade
- Aqueous Film Forming Foams (AFFF)
- Other Industrial Uses






Teflon Industrial Coatings DUPONT

GUARANTEED TO KEEP YOU DRY GORE-TEX PRODUCTS GORE

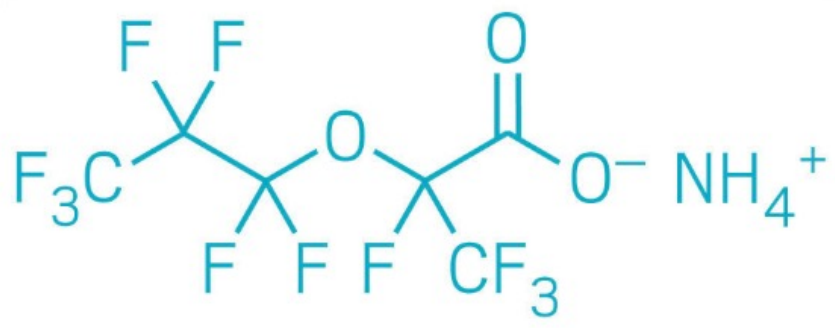
SCOTCHGARD PROTECTOR 3M

For Leather

SIMONIZ®

STAINMASTER Live Well

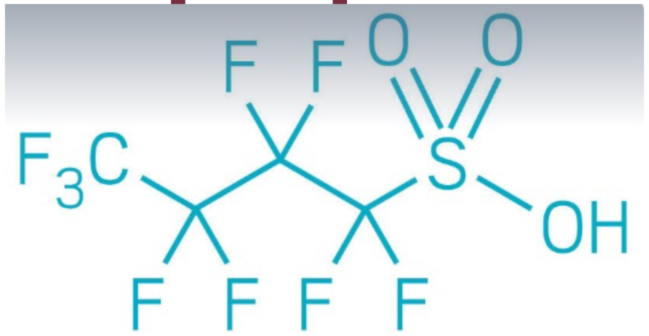
# The new generation of PFAS compounds retains some of their beneficial properties




### Gen X

- A technology to form high performance fluoropolymers in lieu of PFOA
- Ammonium salt
- Found in waters in some areas
- Also associated with health issues

&




### PFBS

- Replacement of PFOS
- Found in waters in some areas
- Also associated with health issues

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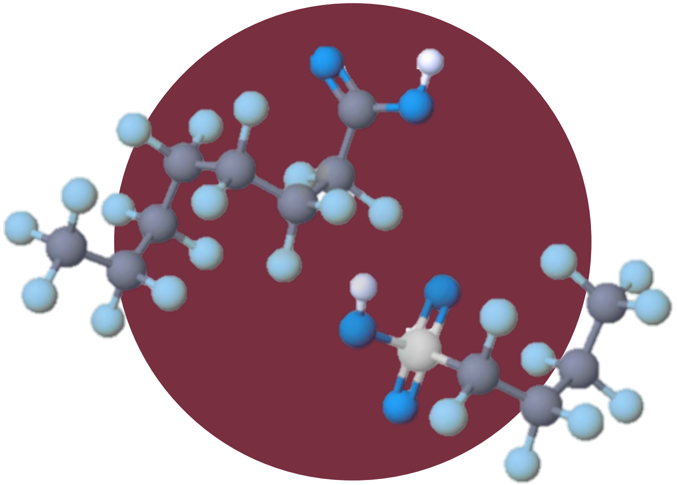
# PFAS Presents several Health-Related Challenges



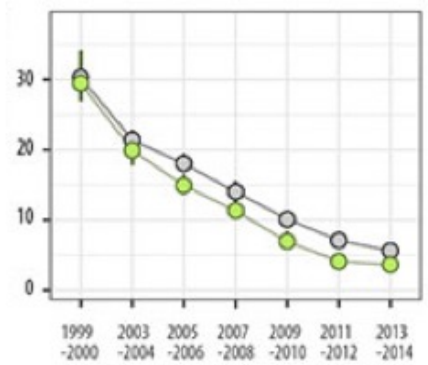
**Strong C-F bonds are hard to break down**

**PFAS compounds bioaccumulate and persist in the bloodstream**

*PFAS found in ~95% of people tested*

**Stays in the body anywhere from 2-9 years**

# 70 years of PFAS at a glance




- **1949** — 3M produces PFOS
- **1967** — FDA allows use in packaging
- **1999** — NHANES blood results
- **2002** — PFOS phased out
- **2005-2013** — C8 Study
- **2008** — PFOA phased out
- **2012** — NHANES blood results
- **2015** — PFOA production stopped / UCMR3
- **2016** — EPA issues Health Advisory
- **2019** — EPA's Action Plan

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# The C8 Study (2005 to 2013) resulted in some significant headlines

LIVE

DuPont Facility Contaminates Drinking Water

BREAKING NEWS

LIVE

More than 70,000 People in the Mid-Ohio Valley Area Impacted by PFAS

BREAKING NEWS

LIVE

Court Orders Further PFAS Study and Treated Water Delivery Requirements

BREAKING NEWS

LIVE

PFAS in Blood Serum Found to be More than 20 Times National Average

BREAKING NEWS

LIVE

Probable PFAS Links Established with Various Health Endpoints

BREAKING NEWS

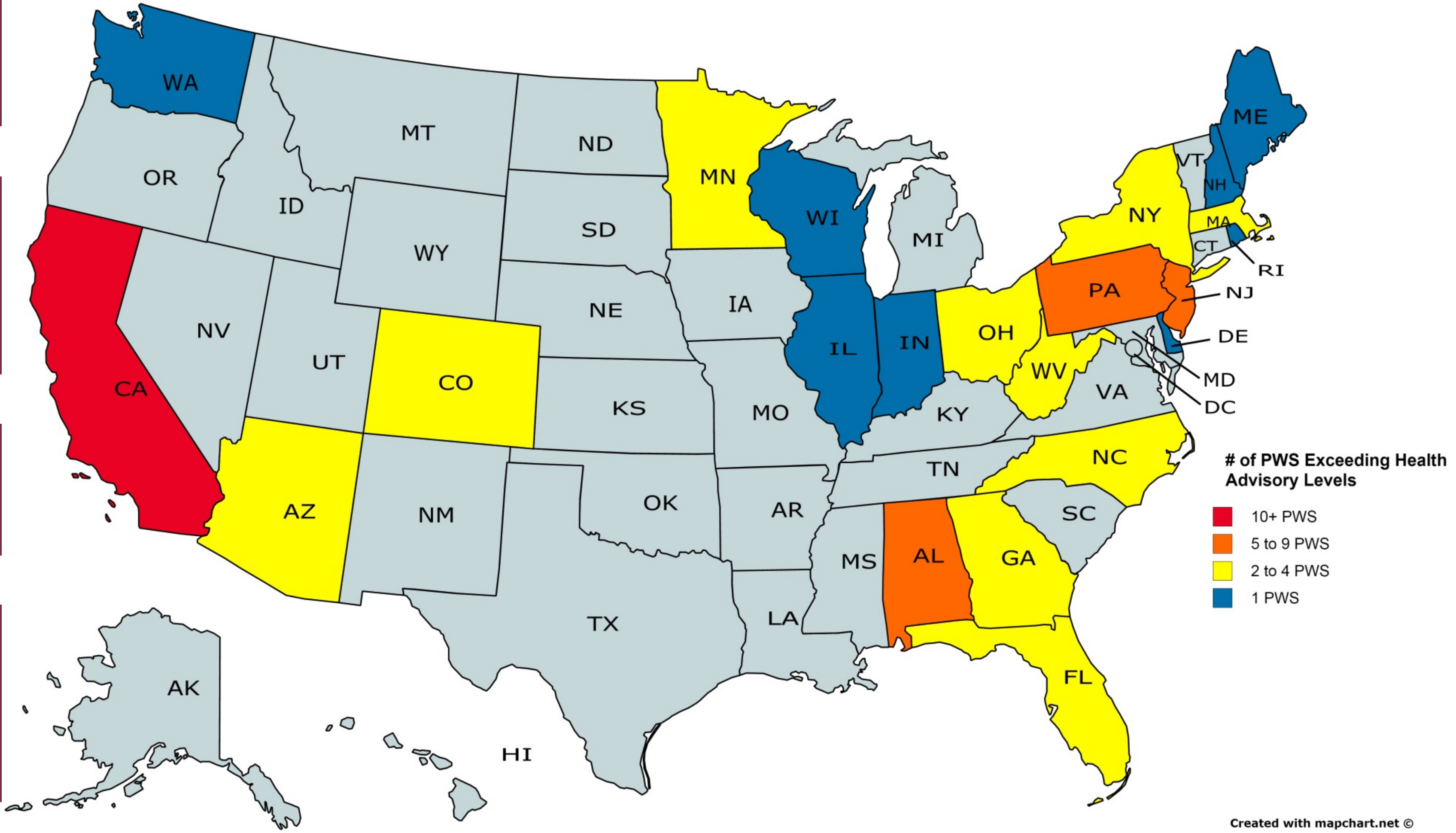
# The UCMR3 (2013-2015) monitored for PFAS in the US and found widespread occurrence in drinking water

36,000 samples collected from 5,000 systems

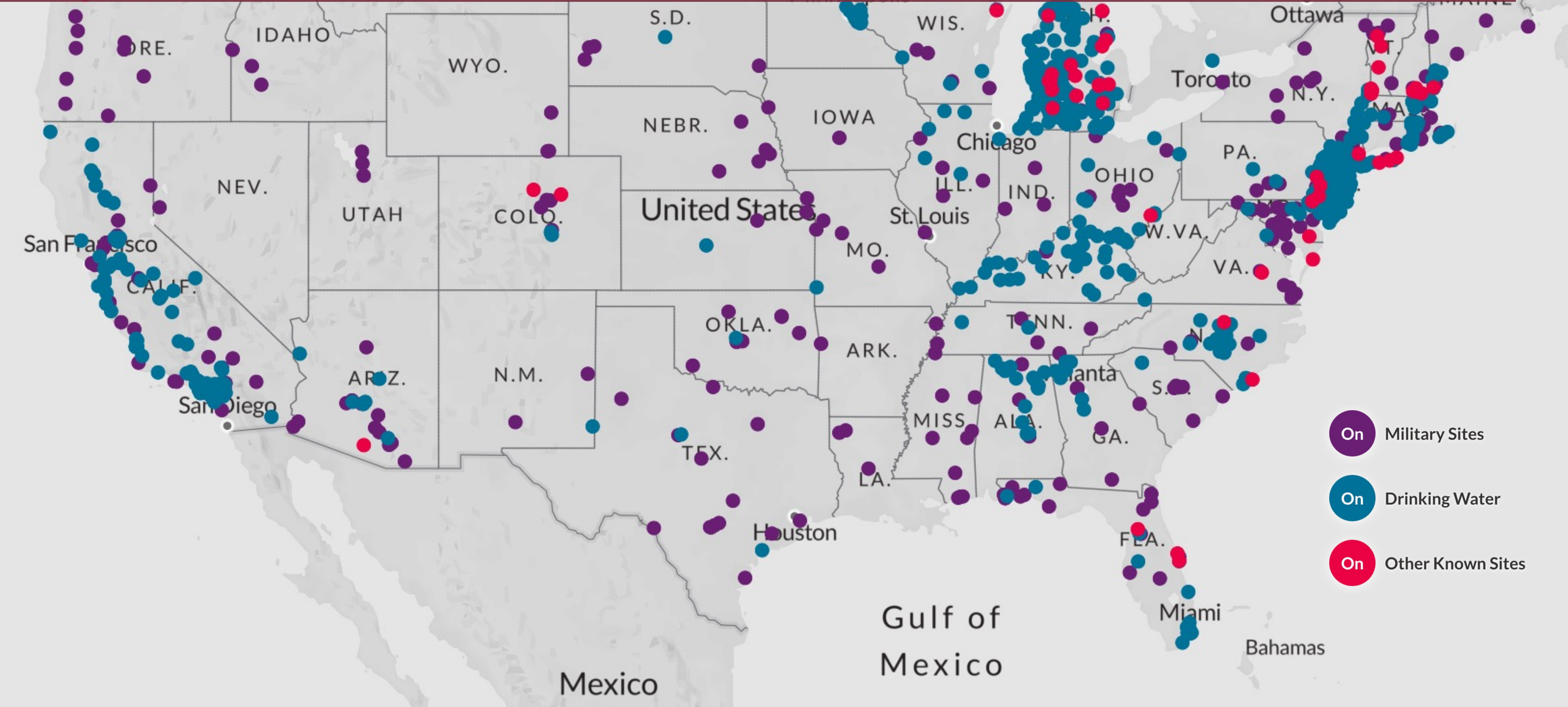
Included Six PFAS ( PFOA, PFOS, PFBS, PFNA, PFHpA, and PFHxS), MRLs - 20 to 90 ng/L

3.9% of the systems detected PFAS while 1.3% exceeded HAs

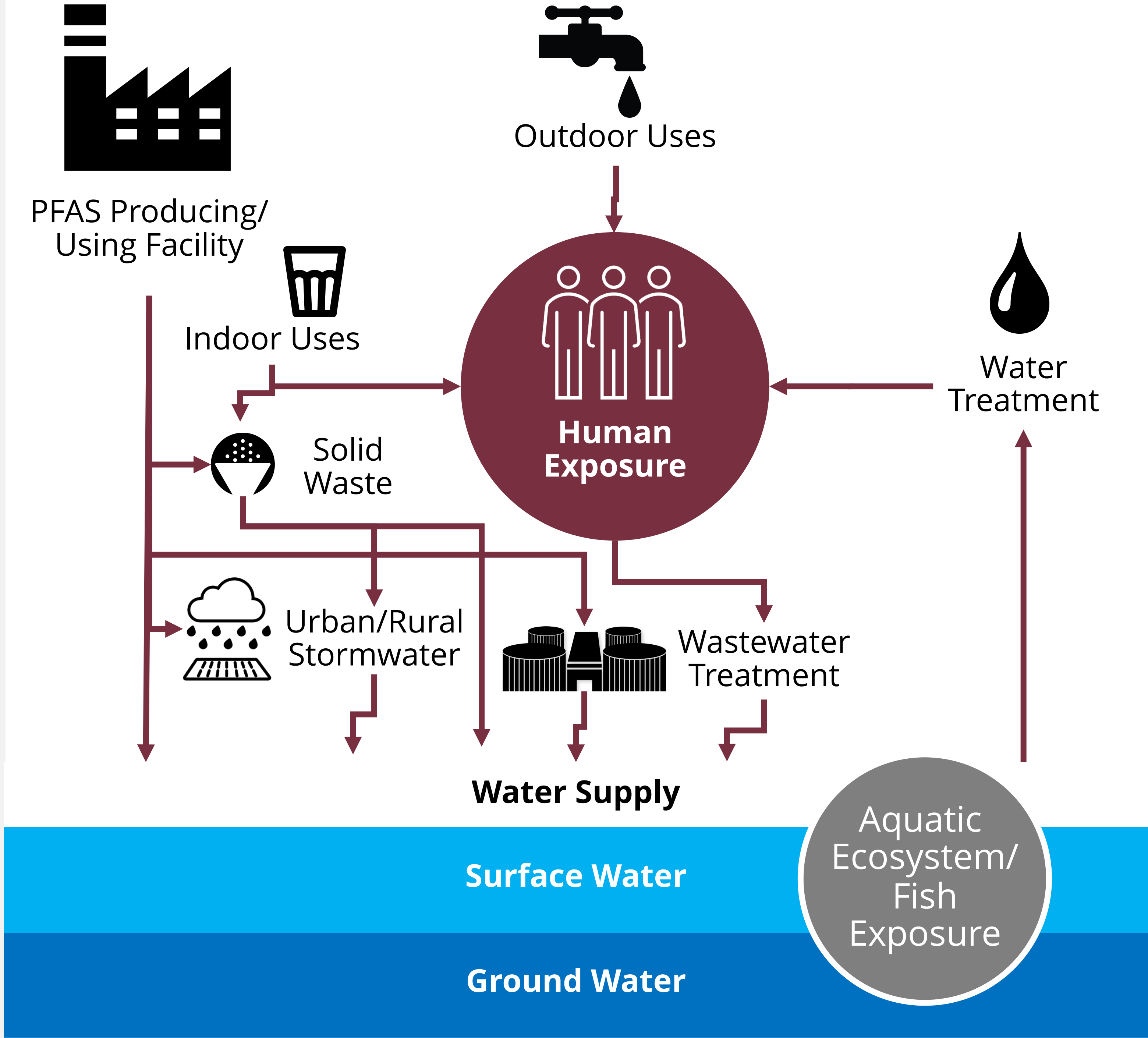
Current MRLs are 10 to 20 times lower for larger number of PFAS



# The Environmental Working Group (EWG) used available data to show PFAS occurrence in the nation



# We can be exposed to PFAS in a lot of different ways




**Remember:** The USEPA has set PFAS drinking water Health Advisory at 70 parts per trillion (PPT)

*Source: NRDC*

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# AGENDA

- Background
- **Regulatory Activities**
- Treatment Technologies

# A brief look at PFAS regulatory activities

**2009 Provisional Health Advisory**
- PFOS 200 ng/L
- PFOA 400 ng/L

**2013-2015 UCMR3 Monitoring**

**2016 Lifetime Health Advisory**
- PFOS 70 ng/L
- PFOA 70 ng/L
- PFOA+PFOS 70 ng/L

**2019 Action Plan**
- March 2021: PFOA/PFOS positive regulatory determination

**2021 Strategic Roadmap**
- Fall 2021: Finalize UCMR5 with 29 PFAS
- Fall 2021: toxicity assessment of GenX and PFBS
- After Fall 2021: toxicity assessment of PFBA, PFHxA, PFHxS, PFNA, and PFDA
- Fall 2023: Final PFOA/PFOS Rule (MCL)

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EPA
United States
Environmental Protection
Agency

**PFAS Strategic Roadmap:**
**EPA's Commitments to Action**
**2021–2024**

# EPA has published a new 'strategic roadmap' for PFAS on October 18, 2021

| Key Steps and Milestones from USEPA Office of Water | | 2022 | | | | 2023 | | | | 2024 | | | | 2025 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| UCMR5 to include 29 PFAS | Final Rule | | | | | → | → | → | → | → | → | → | → | → | → | → | → |
| PFOA/PFOS Regulation (MCL) | | | | | Proposed Rule | | | | Final Rule | | | | | | | → | → |
| Toxicity Assessment of GenX and 5 additional PFAS Compounds | Study/Report/Guidelines | | | | | | | | | | | | | | | | |
| Health Advisories for GenX and PFBS | | | Final Rule | | | | | | | | | | | | | | |
| Decisions about PFAS Industrial Effluent Limitation Guidelines | | | | | Study/Report/Guidelines | | | | | | | | | | | | |
| Leverage NPDES Permitting to Reduce PFAS Discharge | | Proposed Rule | | | | | | | | | | | | | | | |
| Validated Analytical Method for 40 PFAS | | | | | Final Rule | | | | | | | | | | | | |
| Updated PFAS Analytical Method for Drinking Water | | | | | | | | | | | | | Final Rule | | | | |
| Ambient Water Quality Criteria for PFAS (Aquatic Life) | | Final Rule | | | | | | | | | | | | | | | |
| Ambient Water Quality Criteria for PFAS (Human Health) | | | | | | | | | | | | | Final Rule | | | | |
| PFAS Monitoring in Fish Tissue | | | | | | | | Study/Report/Guidelines | | | | | | | | | |
| PFAS in Fish Advisory | | | | | | | Final Rule | | | | | | | | | | |
| Risk Assessment for PFOA and PFOS in Biosolids | | | | | | | | | | Final Rule | | | | | | | |

Legends:
- Final Rule
- Proposed Rule
- Study/Report/Guidelines
- → Monitoring

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**Recent developments have led to a flurry of legislative activity—some of it useful**

Toxicity Assessments

National Defense Authorization Act 2022

Groundwater Cleanup Guidance

Other Federal Actions

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# Toxicity assessment of some PFAS compounds have been completed and others are in process

| Date | Status | Contaminant | Reference Dose (mg/kg/day) |
|---|---|---|---|
| 2016 | Final | PFOA/PFOS | 0.00002 |
| 2021 | Proposed | PFOA<br>PFOS | 0.0000000015<br>0.0000000079 |
| April 2021 | Final | PFBS | 0.00003 |
| October 2021 | Final | GenX | 0.000003 |
| 2021 | In Peer Review | PFBA | 0.01 |

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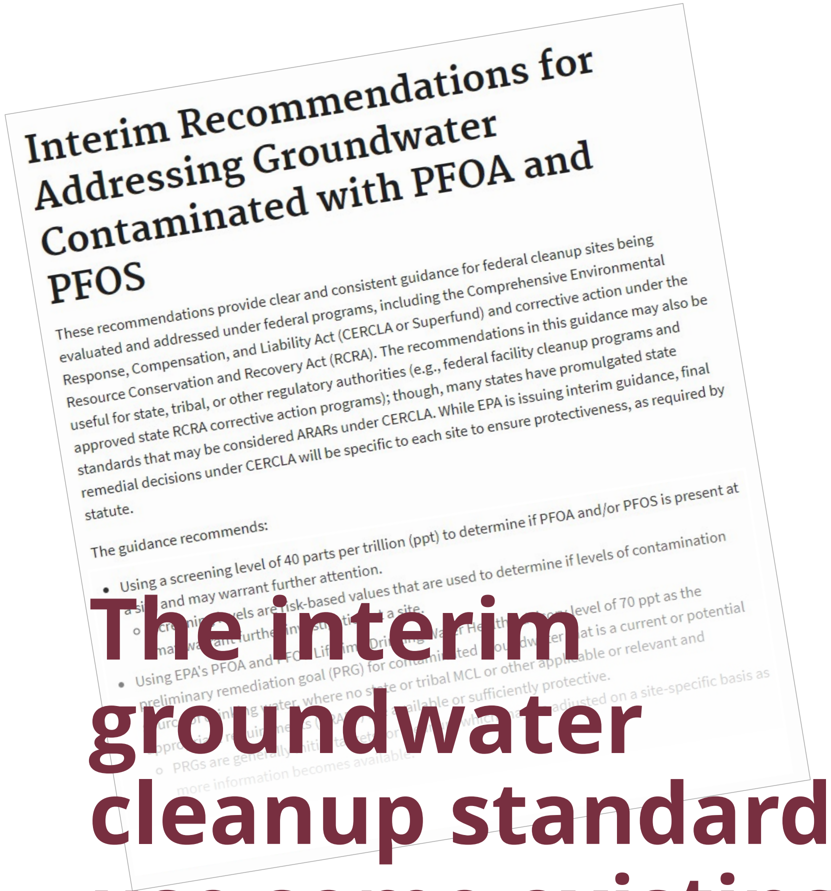
# National Defense Authorization Act 2022 covers four PFAS actions

NDAA
NATIONAL DEFENSE AUTHORIZATION ACT

1. Temporary moratorium on incineration of PFAS until DOD guidance or FR notice by EPA
2. Creation of task force to identify PFAS alternatives
3. Requires GAO audit of DOD procurement in order to screen and avoid PFAS
4. Requires remediation schedule within 270 days of PFAS contaminated site identification

# CERCLA and RECRA

- PFOS and PFOA designated as hazardous substances under CERCLA:
  - Proposal – January 2022
  - Final – Summer 2023
- PFOS, PFOA, PFBS, and GenX are identified as hazardous constituents under RECRA




# The interim groundwater cleanup standards use some existing standards as a template

**Applicable to Federal cleanup**

**Serves as a guide for State level cleanup**

**Covers sites under CERCLA and RECRA**

**PFOS/PFOA Screening level 40 ng/L**

**Remediation goal: 70 ng/L**

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# Other Federal Actions

- Effluent Limit Guidelines (ELG):
  - Propose PFAS limits for plastics, chemicals, and fibers by Summer 2023
  - Propose PFAS limits for crome electroplating and metal finishing industries by Summer 2024
- Toxic Substances Control Act (TSCA) will require PFAS reporting
- Four new PFAS chemicals are included for Toxic Release Inventory (TRI)
- Some PFAS related exemptions may be removed from TRI reporting after completing litigations

## Drinking Water Regulations

Risk-based Rule Making

PFOS/PFA MCL

UCMR

Health Advisories

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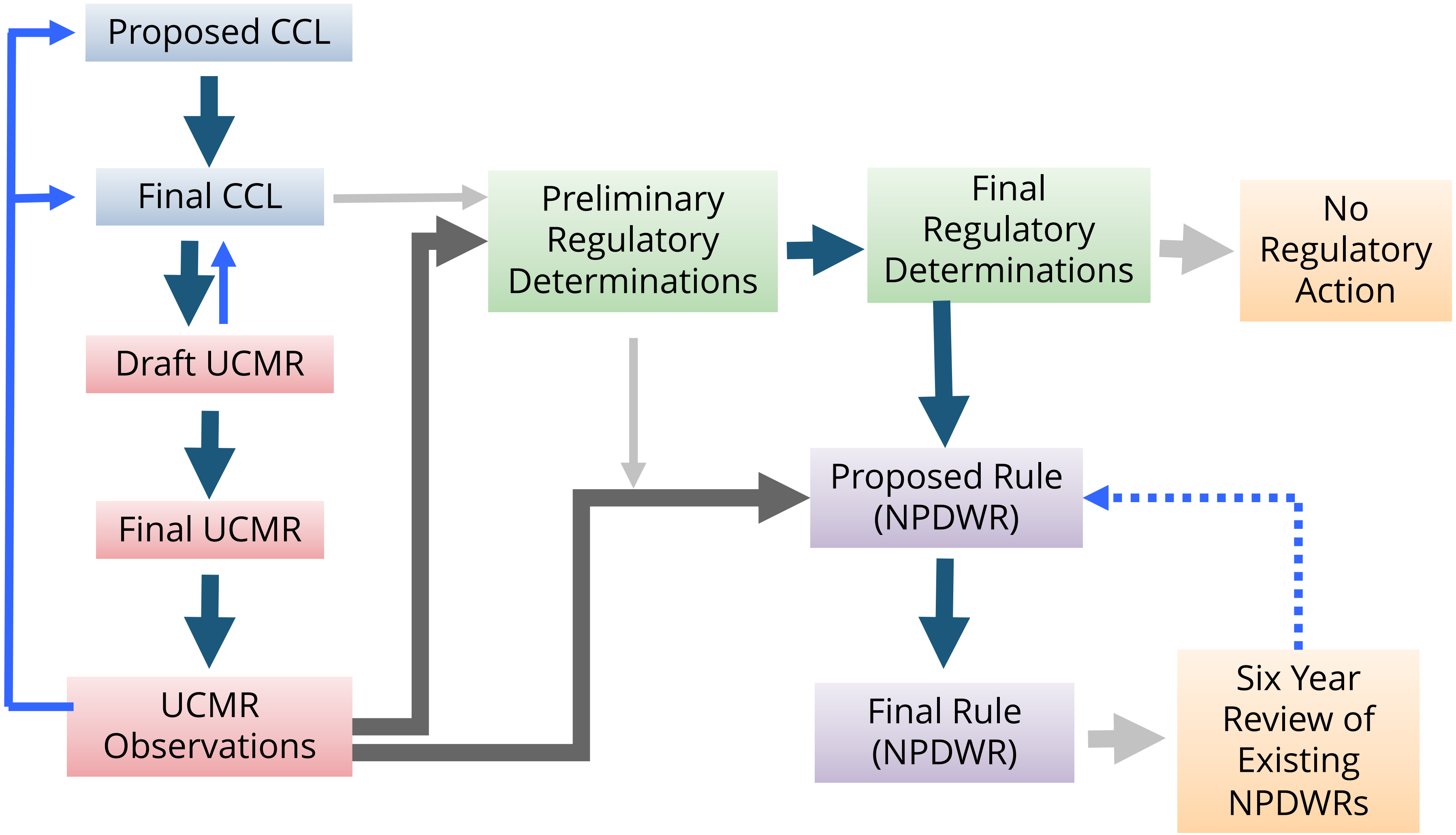
# Risk-based rule making process



# UCMR5 includes 29 PFAS

**March 11, 2021**
Proposal

**December 2021**
Final

**2023-2025**
Monitoring

# PFOA/PFOS MCL is expected in short order

**March 3, 2021**
Re-issued Positive Reg-Det from Feb 2020

By **Fall 2023**
Final Rule

**Summer 2024**
Compliance Date

**Legislative actions may shorten the time**

# Some states are setting their own regulatory standards in anticipation of federal limits

| State | Compound | Level (ng/L or ppt) |
|---|---|---|
| Connecticut | Sum of PFDOA, PFOS PFNA, PFHxS, PFHpA | 70 |
| Maine | Sum of PFDA and PFOS | 70 |
| Minnesota | PFOA<br>PFOS<br>PFHxS | 35<br>27<br>27 |
| New Hampshire | Sum of PFDA and PFOS | 70 |
| New Jersey | PFNA<br>PFOA | 13<br>14 |
| North Carolina | GenX | 140 |
| Vermont | Sum of PFDA and PFOS | 20 |
| West Virginia | Sum of PFDA and PFOS | 70 |

# PFAS – What to expect next?

PFOA/PFOS MCL expected by Fall 2023. The MCL could be at or below the current HAL of 70 ppt

MCLGs for 3 additional PFAS are expected

The new rule may have some streamlined path to add more PFAS

New health advisories may come out to cover additional PFAS

The health end point will possibly be based on reproductive and endocrine impacts

# AGENDA

- Background
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- **Treatment Technologies**

# What do we do if there are PFAS in our water?

## Remove

- Adsorption with GAC
- Anion exchange
- High-pressure membrane filtration
- Thermal/electrolytic destruction (experimental)
- Chemical reduction (experimental)

## Alternative Sources

- Abandon contaminated wells
- Alter blending conditions

## Proactive Communication

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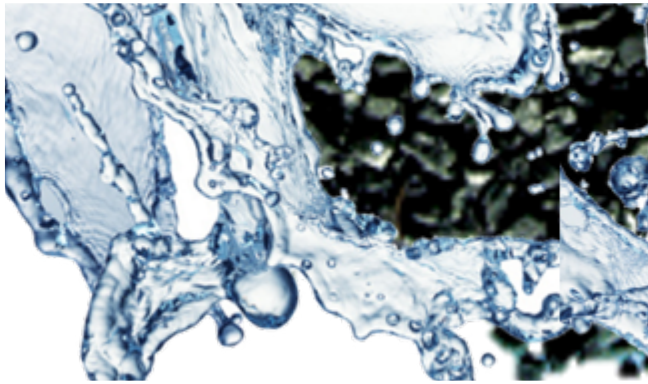
# Adsorption on Granular Activated Carbon (GAC) is considered one of the best available technology for PFAS removal

**GAC is the leading technology for  removal of PFAS from water**

- GAC has been used for more than 15 years in over
  40 large installations for both drinking water and remediation PFAS applications
- Over 1,000 POE GAC systems are in use treating residential well sites

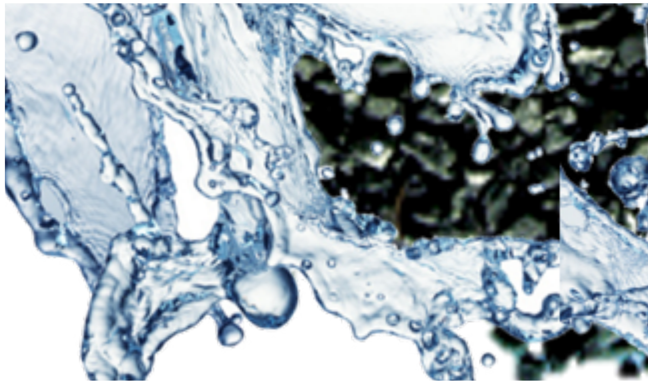
**GAC is economically viable for water treatment**

- Simultaneous removal of other organic compounds.
- Already online in many “new” PFAS-contaminated sites.

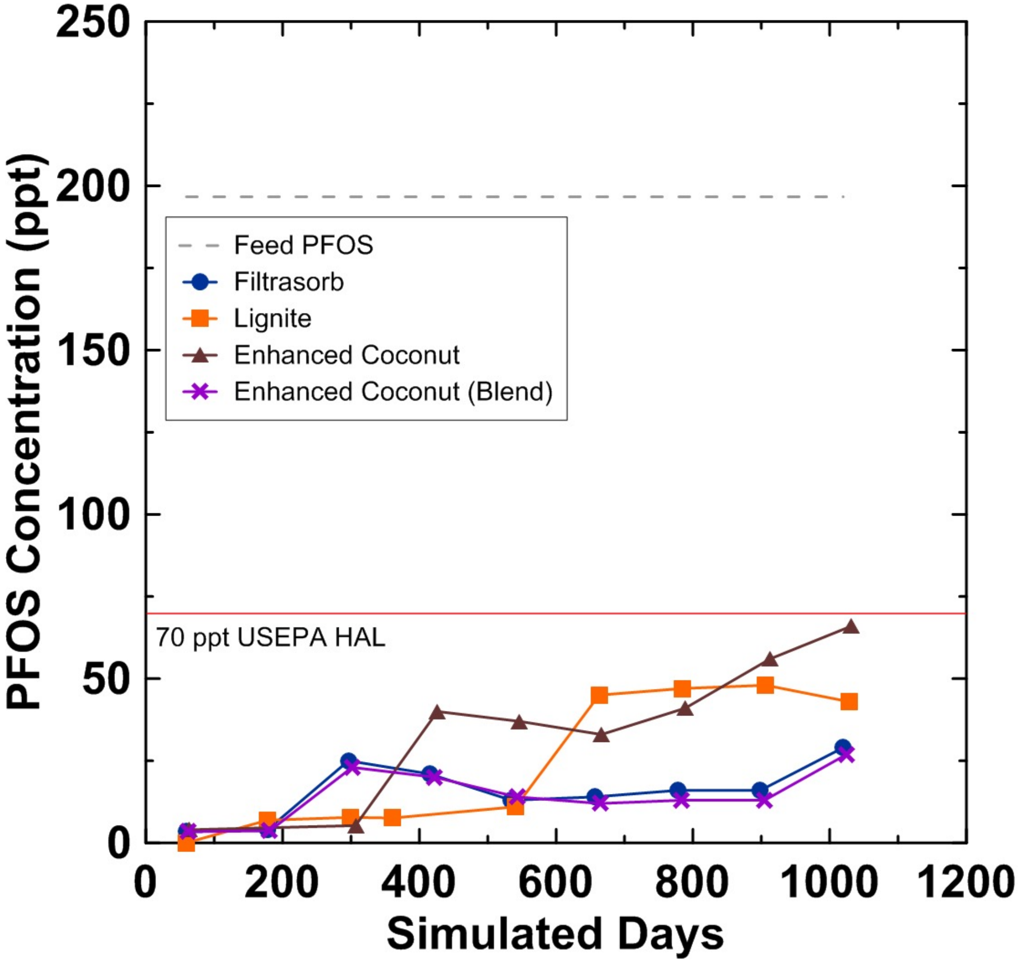
# A research study compared the performance of four different types of GAC for PFAS removal

| Carbon | Apparent Density, Oven (g/cc) | Ash (%) | Iodine Number (mg/g) |
|---|---|---|---|
| Reag. Bituminous | 0.561 | 7.8 | 999 |
| Lignite | 0.377 | 12.4 | 616 |
| Enhanced Coconut | 0.414 | 4.1 | 1291 |
| Enhanced Coconut (Blend) | 0.388 | 6.9 | 1070 |

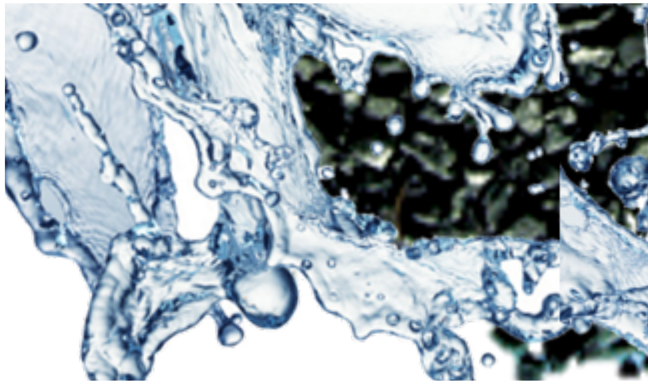



*Source: Eli Townsend, Calgon Carbon, Corp.*

# All of the tested GAC worked well for PFOS removal







*Source: Eli Townsend, Calgon Carbon, Corp.*

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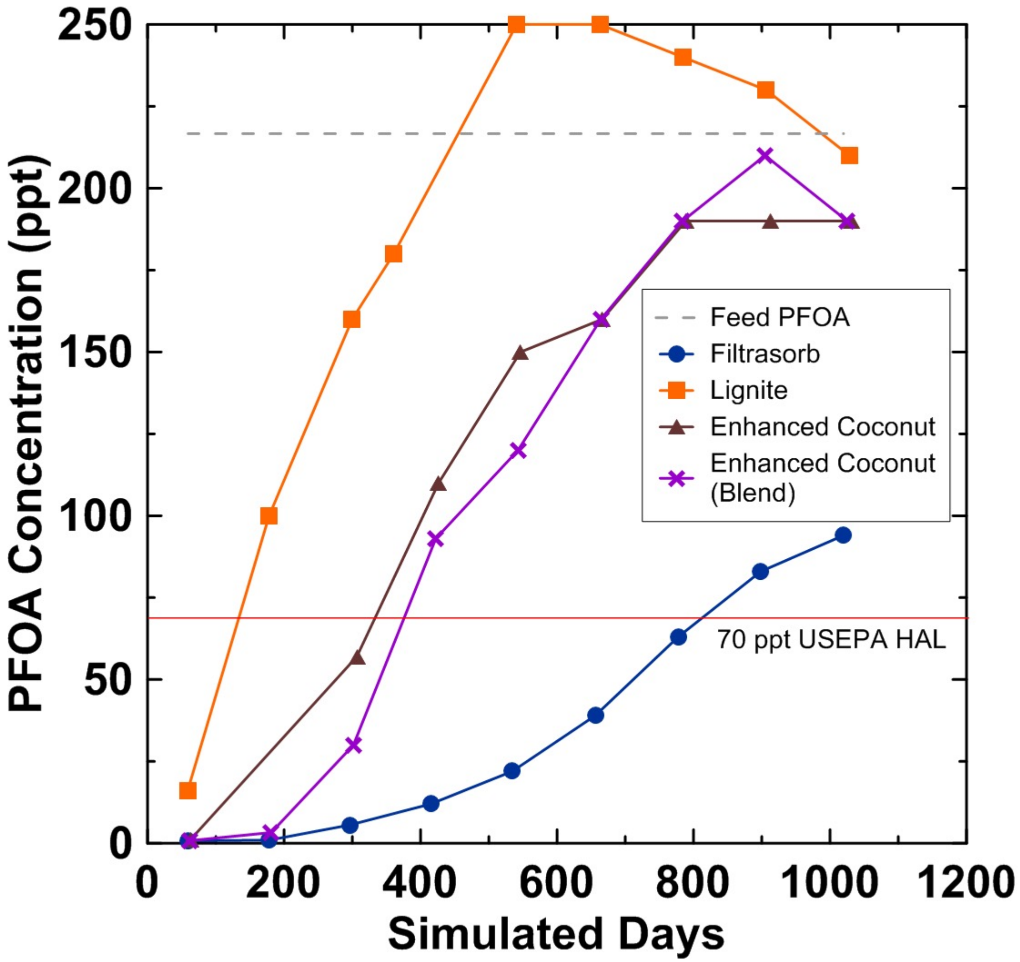
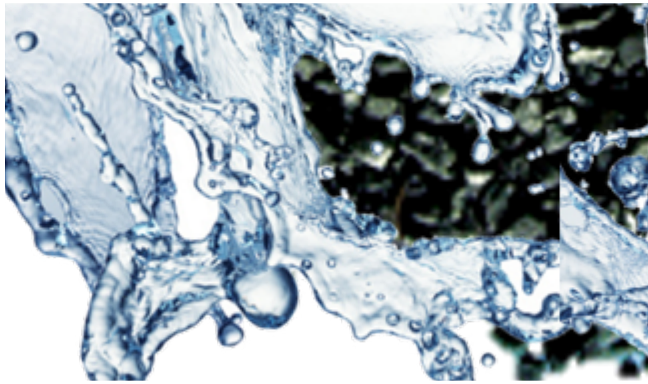
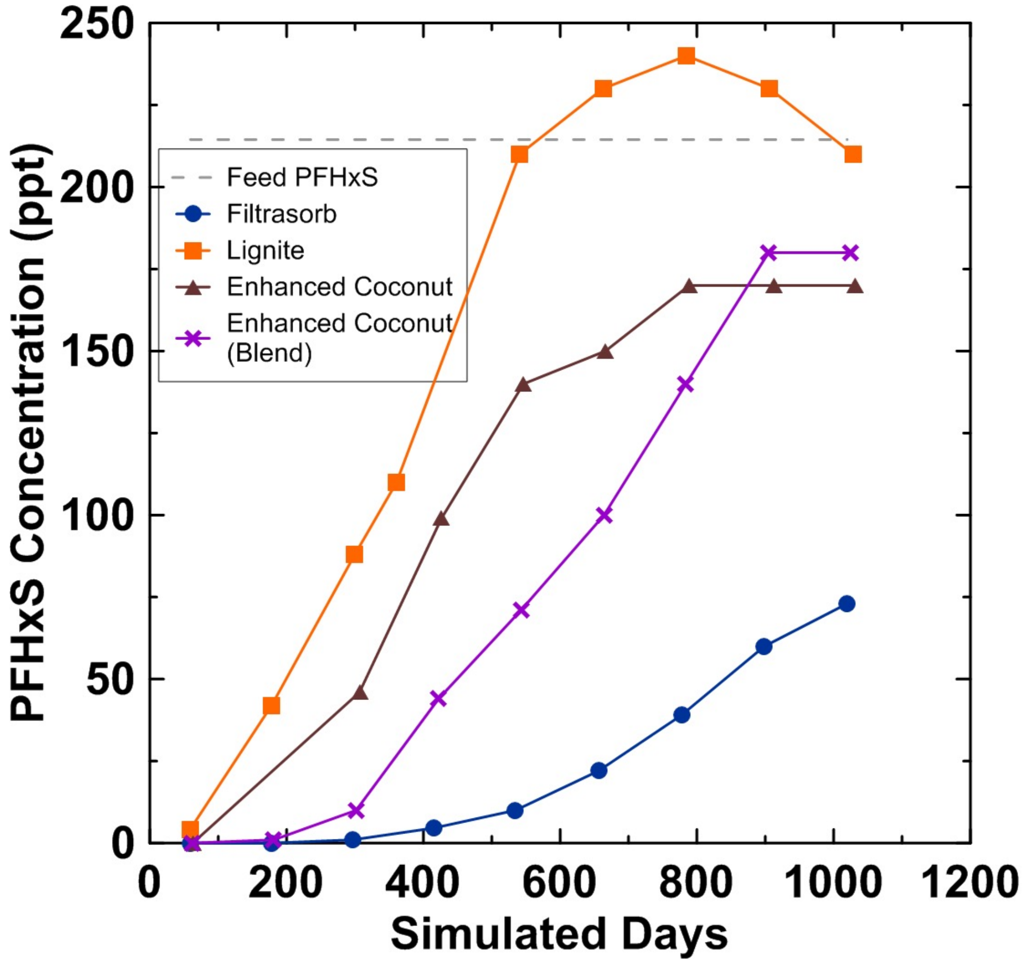
# Re-agglomerated bituminous GAC showed the best performance for PFOA removal



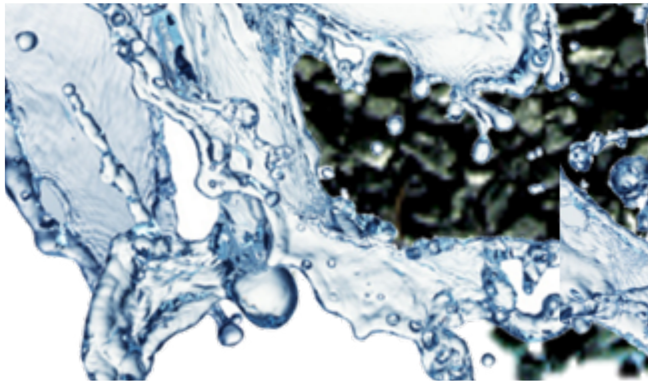




# The same carbon also worked better for PFHxS removal

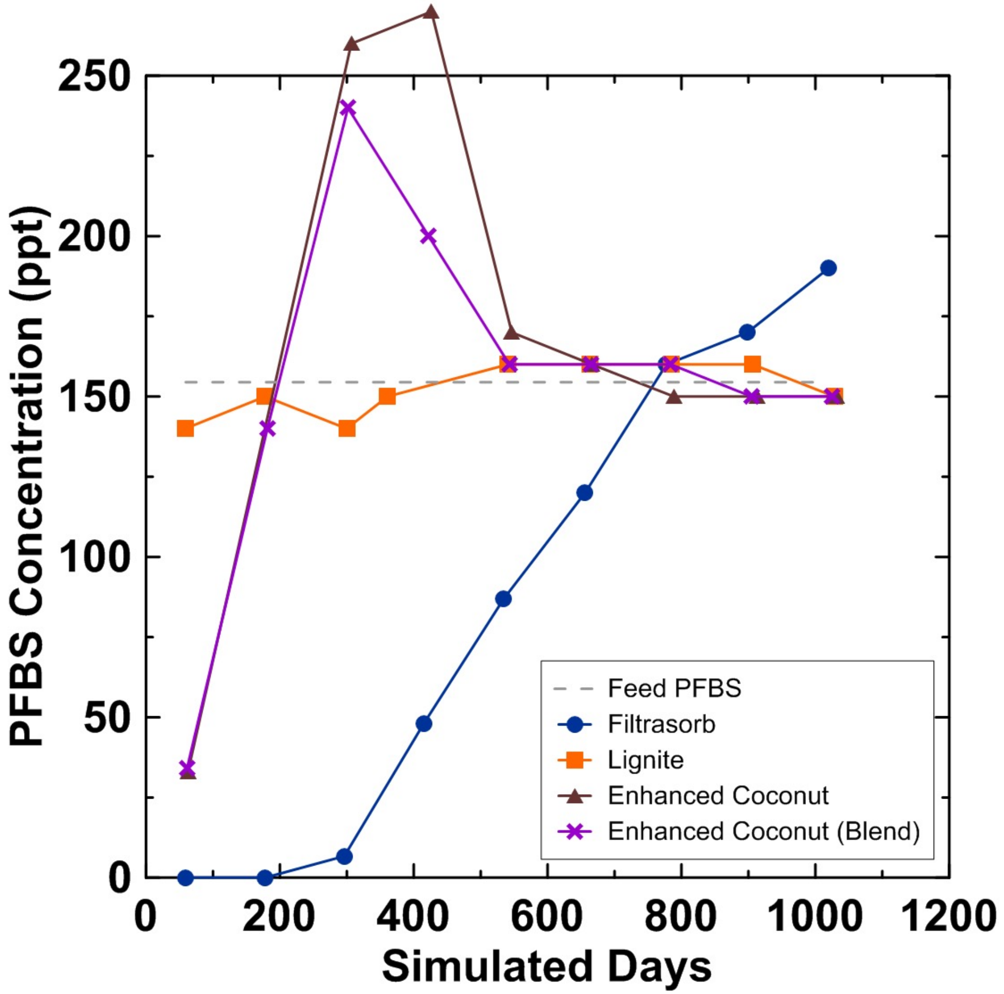




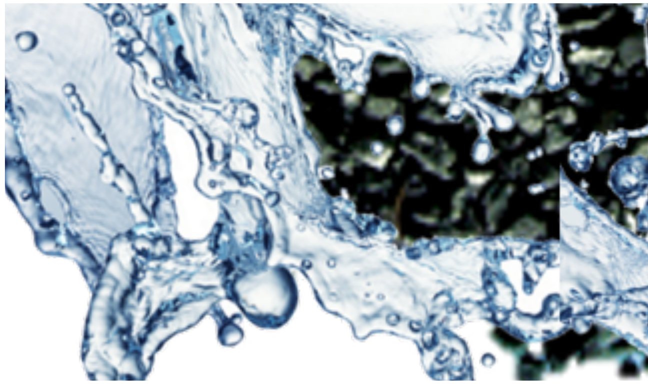


*Source: Eli Townsend, Calgon Carbon, Corp.*

# Worst removal was observed for PFBS, although re-agglomerated bituminous GAC worked reasonably well





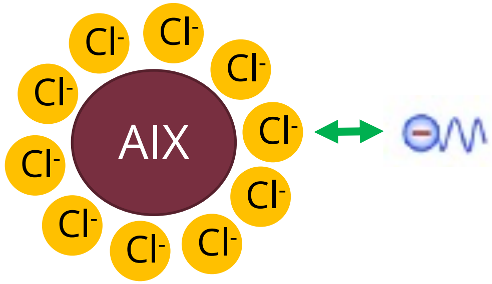


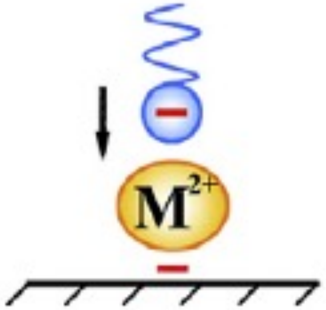
*Source: Eli Townsend, Calgon Carbon, Corp.*

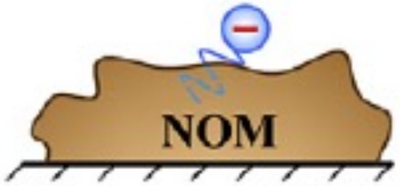
# How are PFAS removed by Anion Exchange?

PFOA





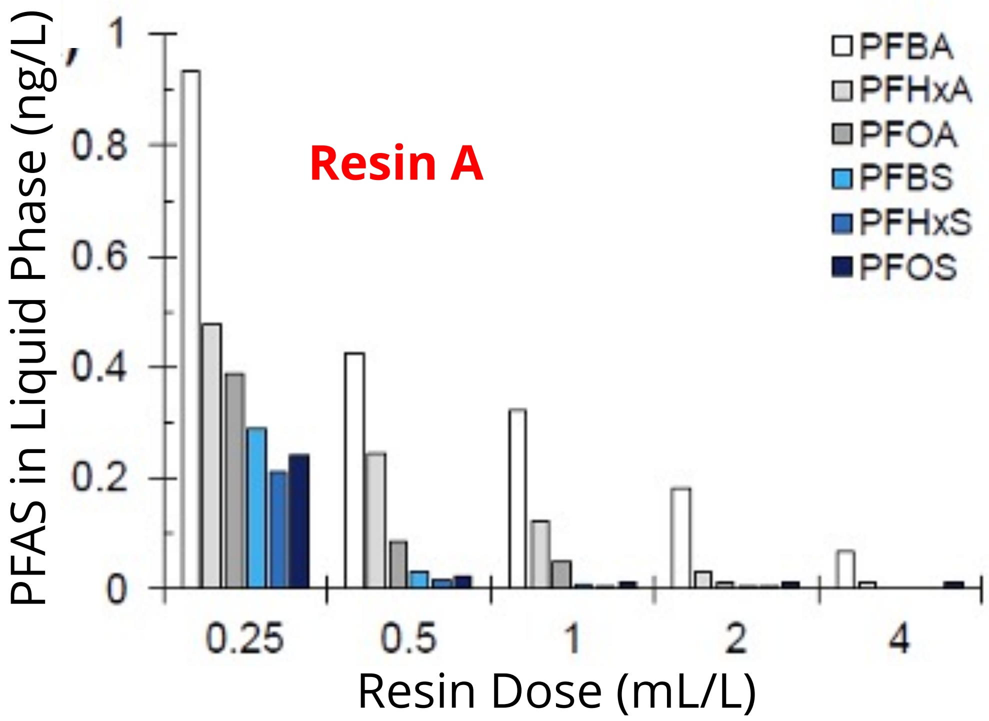



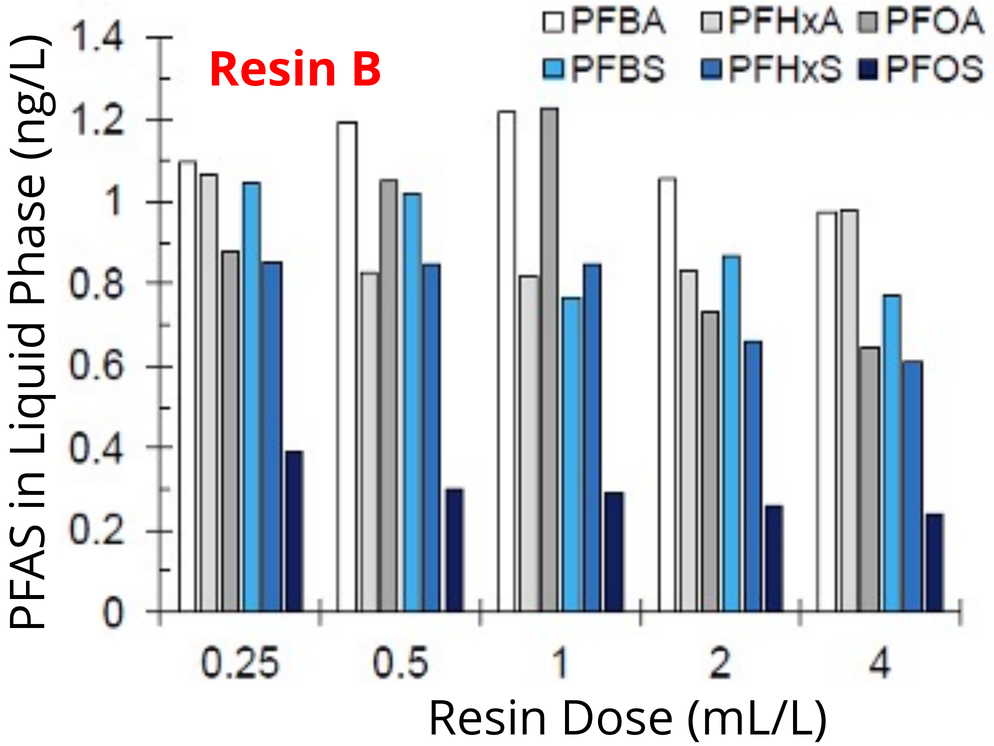




*Source: Treavor Boyer, ASU*

# Batch test in laboratory reveals varying removal efficiency of PFAS compounds

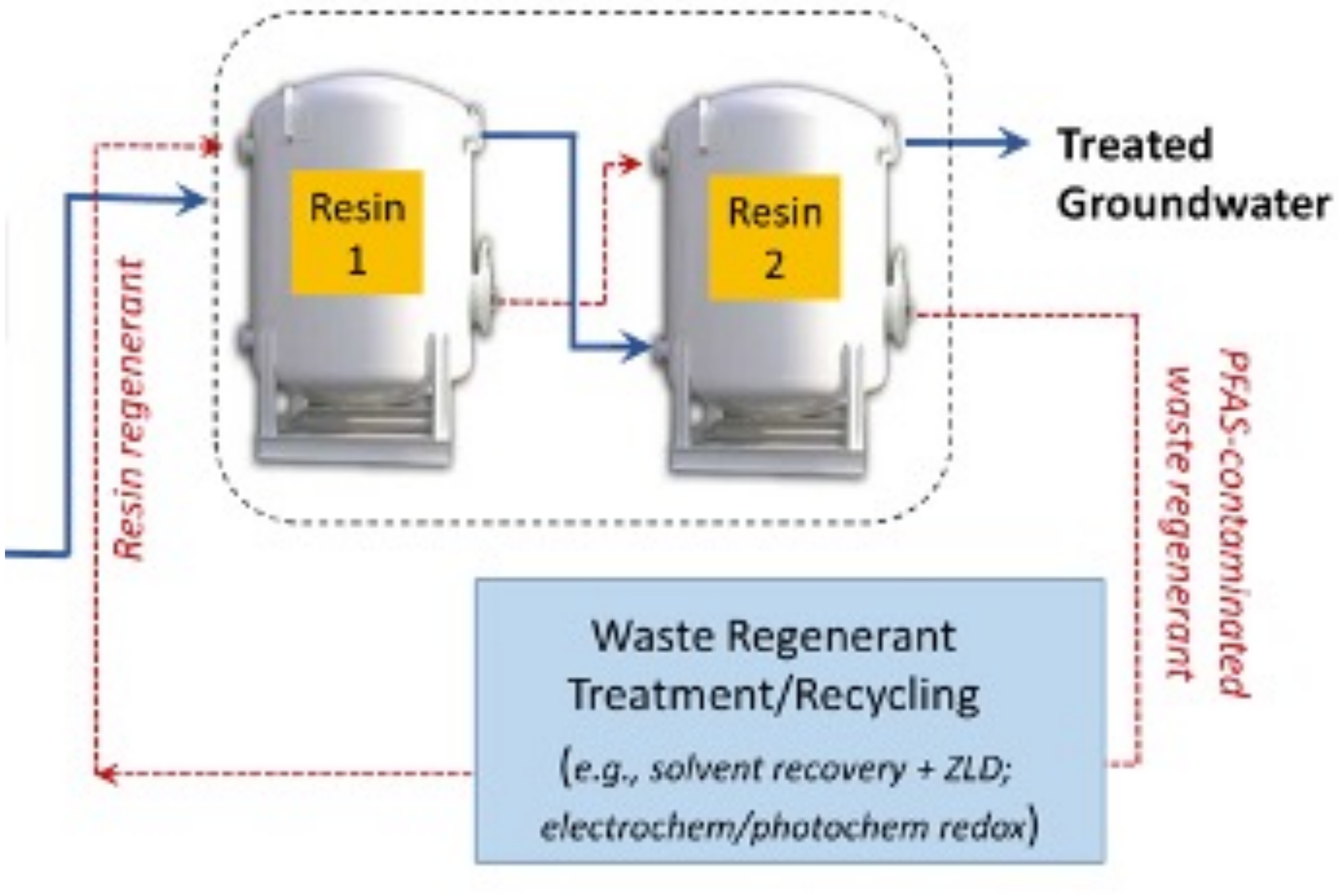
- Longer chain PFAS compounds (e.g. PFOA) are better removed
- Some resins perform better than the others



# Removal of PFAS from regenerant solution through destructive technologies increases sustainability of process

- AIX Resin is used to remove PFAS from water
- Sodium chloride is used to regenerate the resins
- Electrochemical or photochemical process is used on spent brine to destroy PFAS compounds
- Recovered regenerant is reused




*Source: Treavor Boyer, ASU*

# Summary of PFAS removal by various treatment processes (WRF 4322)

| Removal <10% | Removal 10-90% | Removal > 90% |
|---|---|---|

| Compound | | M.W. (g/mol) | AER | COAG/DAF | COAG/FLOC/SED/G- or M-FIL | AIX | GAC | NF | RO | $MnO_4$, $O_3$, $ClO_2$, $Cl_2$, CLM, UV, UV-AOP |
|---|---|---|---|---|---|---|---|---|---|---|
| Compound | PFBA | 214 | assumed | assumed | | | | | | |
| | PFPeA | 264 | | | | | | | | |
| | PFHxA | 314 | | | | | | | | |
| | PFHpA | 364 | | | | | | | | |
| | PFOA | 414 | | | | | | | | |
| | PFNA | 464 | | unknown | | assumed | assumed | | | |
| | PFDA | 514 | | unknown | | assumed | assumed | | | |
| | PFBS | 300 | | | | | | | | |
| | PFHxS | 400 | | | | | | | | |
| | PFOS | 500 | | | | | | | | |
| | FOSA | 499 | unknown | unknown | | unknown | assumed | unknown | assumed | unknown |
| | *N*-MeFOSAA | 571 | assumed | unknown | | assumed | assumed | assumed | | unknown |
| | *N*-EtFOSAA | 585 | | unknown | | assumed | assumed | assumed | | unknown[a] |

# Key Takeaways

**Proactive monitoring with low MRLs**

**Communication**

**Stay informed**

**Planning**

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# Questions?


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**February 24, 2022**