Woodard & Curran

September 13, 2023

NEWEA Joint Specialty Conference

Lessons Learned and Next Steps Forward

How we got here, and how PFAS can change our approach to emerging contaminants

Julia Wahl

Engineer

My Gut Says: the PFAS experience is our model for future emerging contaminants

- These opinions are my own
- There are patterns we can generalize from this experience
- Ideally, water professionals are in the drivers seat the next time around

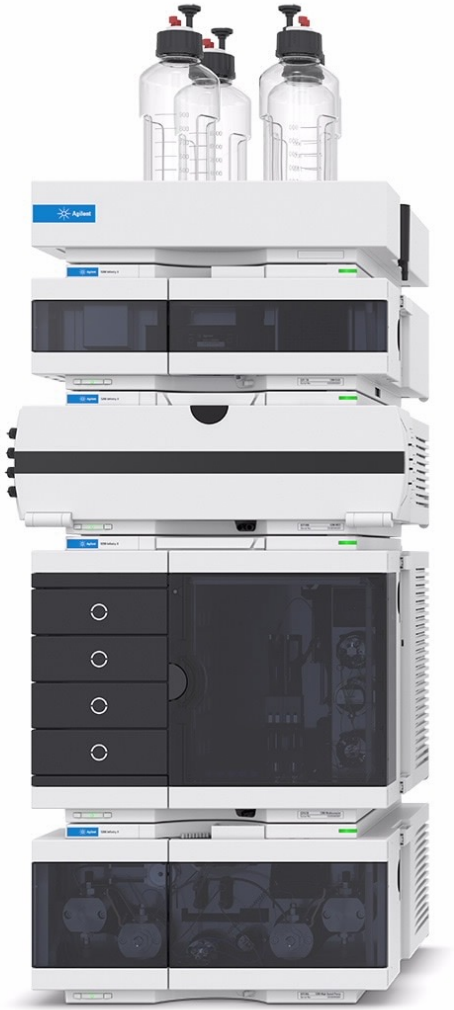
GOALS FOR THIS PRESENTATION

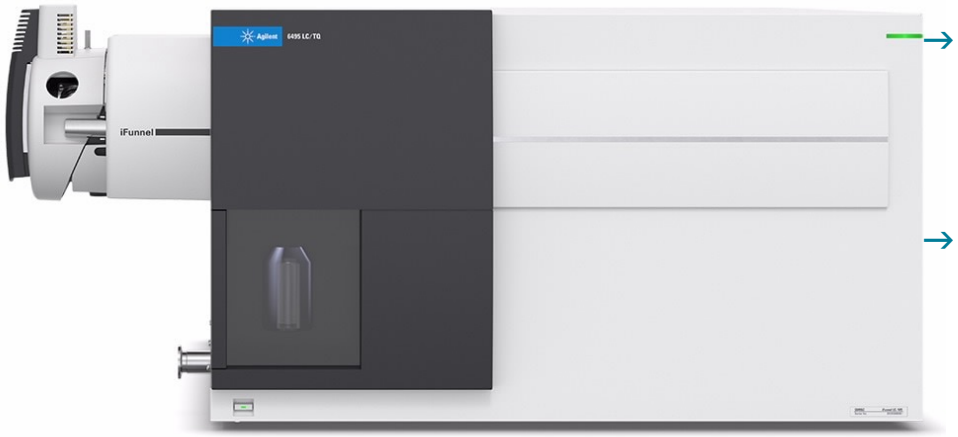
- How did we get here?
  - The impact of analytical chemistry
    - Matrix inhibitions and parallel timelines for critical media and regulatory protection
- What can we learn?
  - Compound production in the US and likely next CECs
  - Projected regulatory pathways
  - The legacy of PFAS chemistry and treatment for future contaminant removal in waters
    - C-F bonds
    - Mature treatments and their residuals
  - Advocacy

How did we get here: the impact of analytical chemistry

- Can't regulate what you can't measure
- Contaminants occur in the environment in relatively diffuse, widely dispersed concentrations
  - Ppb or ppt levels
- Environmental matrices are complex

How did we get here: the impact of analytical chemistry





- "Hyphenated mass spectrometry" (QTOF-TQMS, LC-MS/MS, UPLC-MS/MS…) represents the analytical method of choice for environmental sampling of pharmaceutical and PCP analytes
- PFAS compounds are being measured as a class/group
- Matrix inhibitions can complicate quantification
- Method development requires experimentation and time

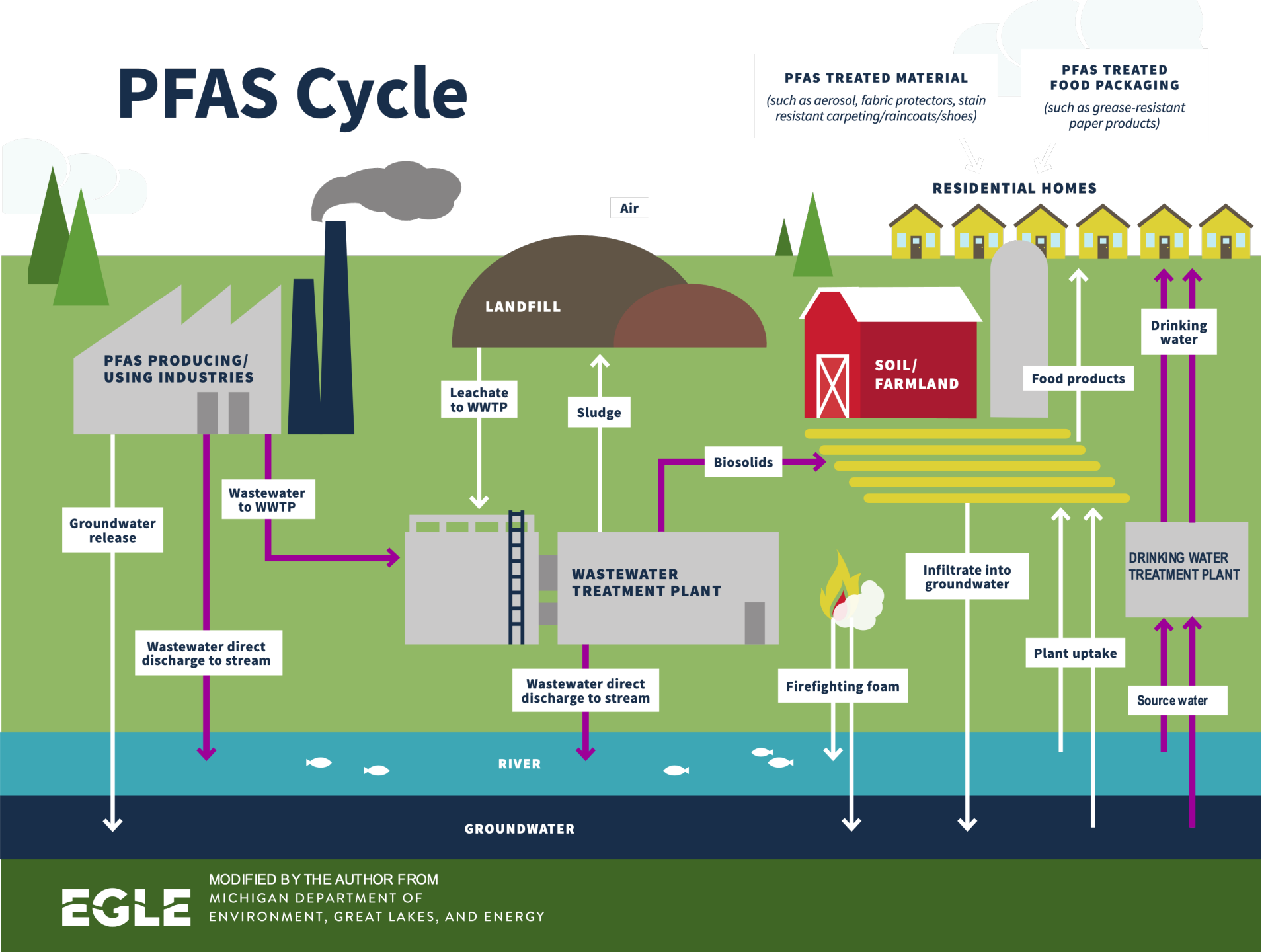
https://www.nebiolab.com/what-are-matrix-effect-in-liquid-chromatography-mass-spectrometry/#:~:text=In%20several%20liquid%20chromatography%2Dtandem,candidates%20to%20trigger%20matrix%20effects.

How did we get here: the impact of analytical chemistry

- Analytical method development bears out these challenges:
  - Method 537: finalized since 2009 (updated in 2018 to 537.1)
  - Method 537.1: final since 2018 (updated in 2020)
  - Draft Method 1633: final for surface water, groundwater, wastewater as of July 2023

- Still no finalized methods for "dirtier" media
  - Solids, biosolids, tissue samples finalized method out of Draft 1633
    - Still undergoing method development – on its 4th draft

https://www.epa.gov/water-research/epa-drinking-water-research-methods

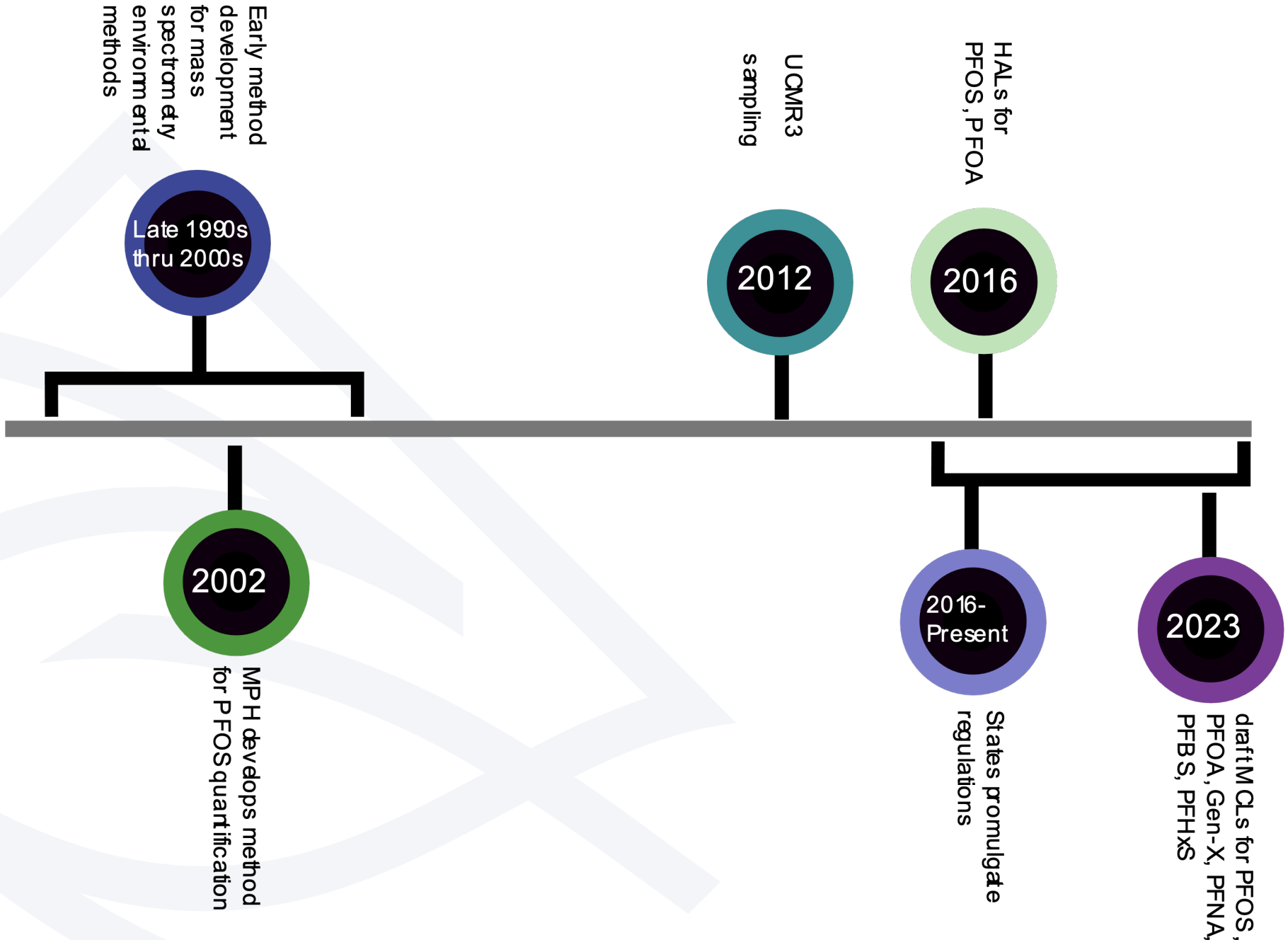


<u>Parallel timelines:</u>
immediacy of contaminant regulation in drinking water

and

facility of method development for contaminant quantification

All Together Now: A Timeline



What can we learn

And what should we be thinking about?

COMPOUNDS IN COMMERCIAL PRODUCTION

- Currently >80,000 chemicals in commerce in the US
- Roughly 2,500 are “high production volume” (HPV) chemicals,
  - manufactured > one million pounds annually
- Approximately 45% percent of HPV chemicals lack adequate toxicological studies to evaluate health effects on humans and on wildlife.
- ~2,000 new chemicals are introduced into commerce annually in the U.S.

https://dtsc.ca.gov/emerging-chemicals-of-concern/#:~:text=Further%2C%20about%202%2C000%20new%20chemicals,is%20allowed%20on%20the%20market.

What are our future emerging contaminants likely to be?

Diffuse concentrations, widely dispersed in the environment

High biological activity at low dosages

Likely dispersed by pass-through from wastewater treatment (industrial and municipal effluent)

What are our future emerging contaminants likely to be?

Pharmaceuticals and personal care products

Likely Future Emerging Contaminant Regulatory Timelines

Lagging regulations

Immediate human health impacts

Facility for quantitative methods

Mediated human health impacts

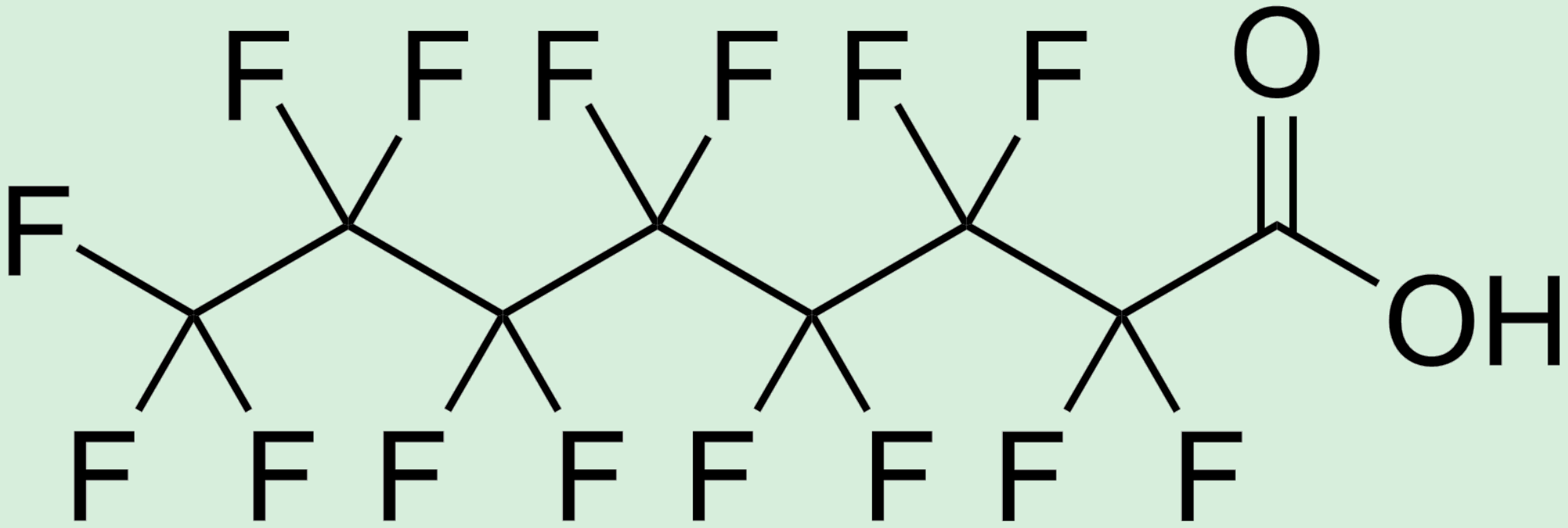
Challenges for developing quantitative methods

PFAS will leave a legacy on water treatment

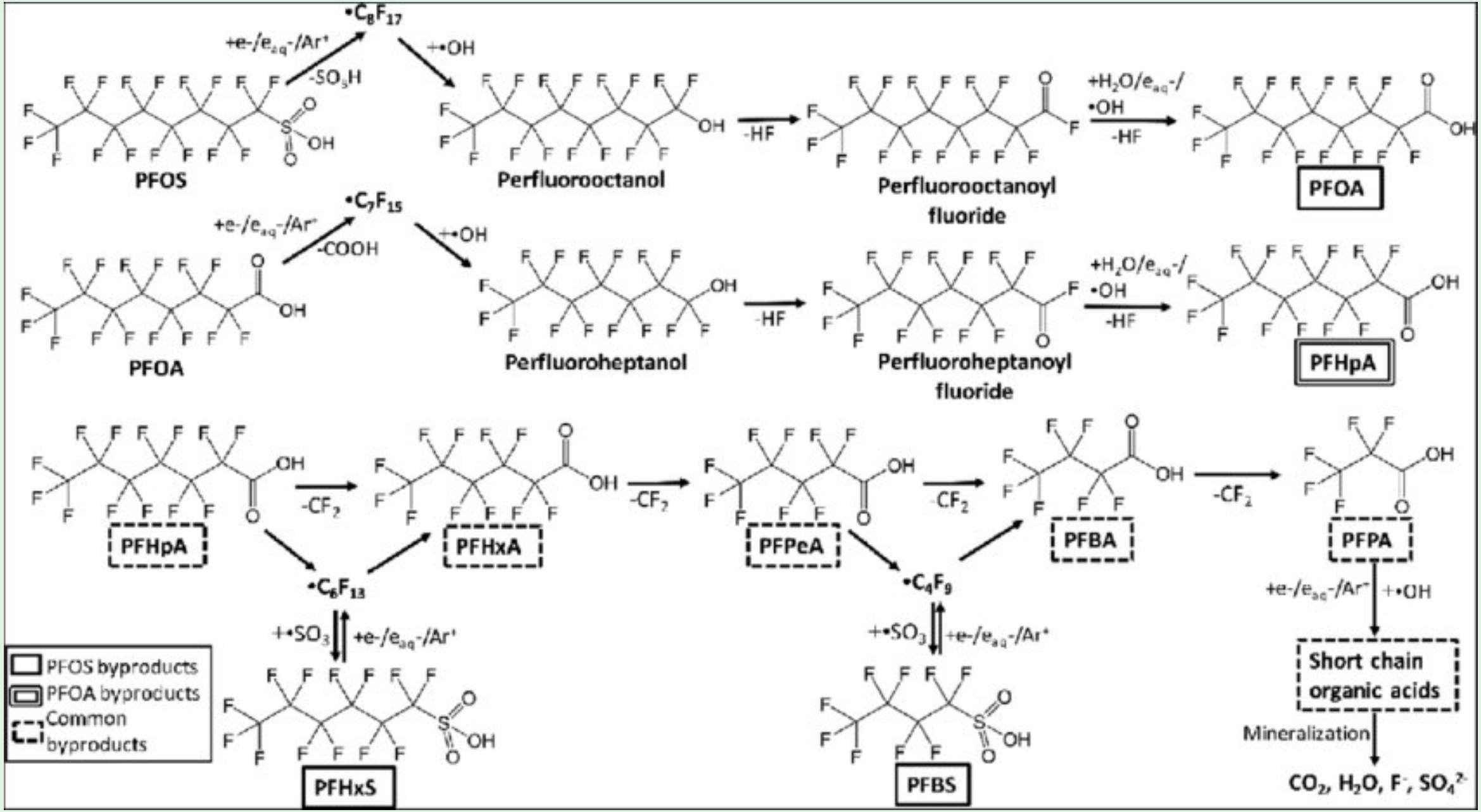
> *The carbon-fluorine bond is one of the strongest single bonds in chemistry (stronger than many double-bonds).*

- Chemistry Fact

PFOS Chemical Structure



Proposed Degradation Pathways of PFOS (plasma-generated free-radical degradation series)



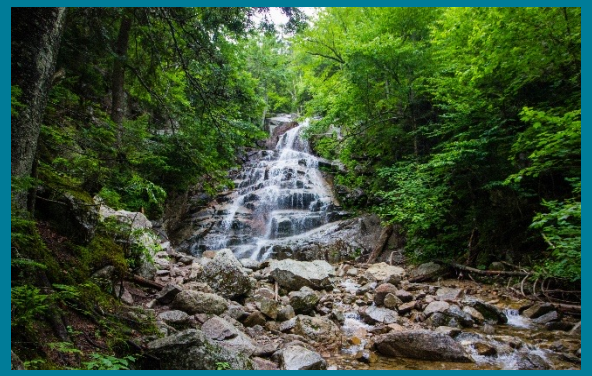
Singh, et al. EST 2019, 53, 5, 2731-2738

MATURE TREATMENT TECHNOLOGIES FOR PFAS, BY MEDIA

DRINKING WATER

- Filtration
- Adsorption

SURFACE/GROUNDWATER /WASTEWATER EFFLUENTS



- Filtration
- Adsorption
- Concentration
- Advanced Oxidation Processes (supercritical, electrochemical, etc)

SLUDGE/BIOSOLIDS

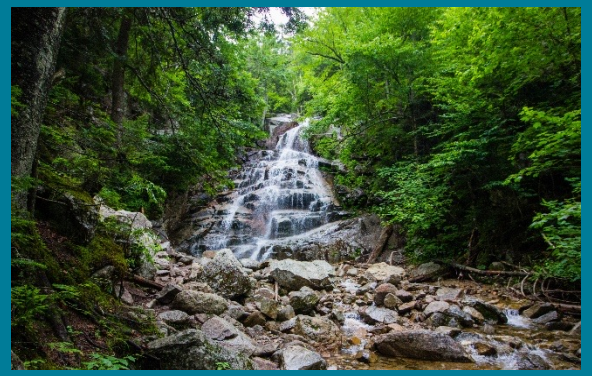
- Thermal treatment
- Advanced Oxidation Processes (supercritical, electrochemical)

RESIDUALS FROM PFAS TREATMENT TECHNOLOGIES

DRINKING WATER

- Spent media
- PFAS-impacted concentrate or filtrate

SURFACE/GROUNDWATER /WASTEWATER EFFLUENTS



- Spent media
- PFAS-impacted concentrate or filtrate
- Mineralized compounds

SLUDGE/BIOSOLIDS

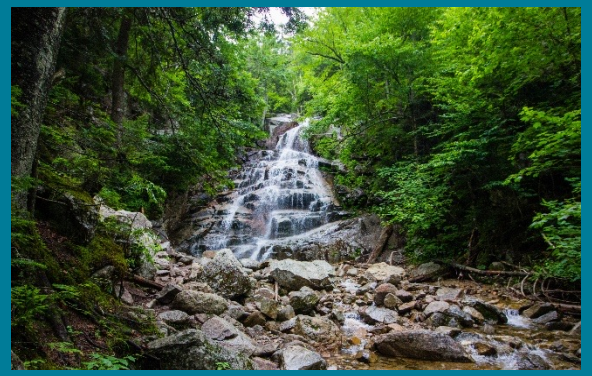
- Char, syngas
- Mineralized compounds

RESIDUALS FROM PFAS TREATMENT TECHNOLOGIES

DRINKING WATER

- Spent media
- PFAS-impacted concentrate or filtrate

SURFACE/GROUNDWATER /WASTEWATER EFFLUENTS



- Spent media
- PFAS-impacted

DESTRUCTION

SLUDGE/BIOSOLIDS

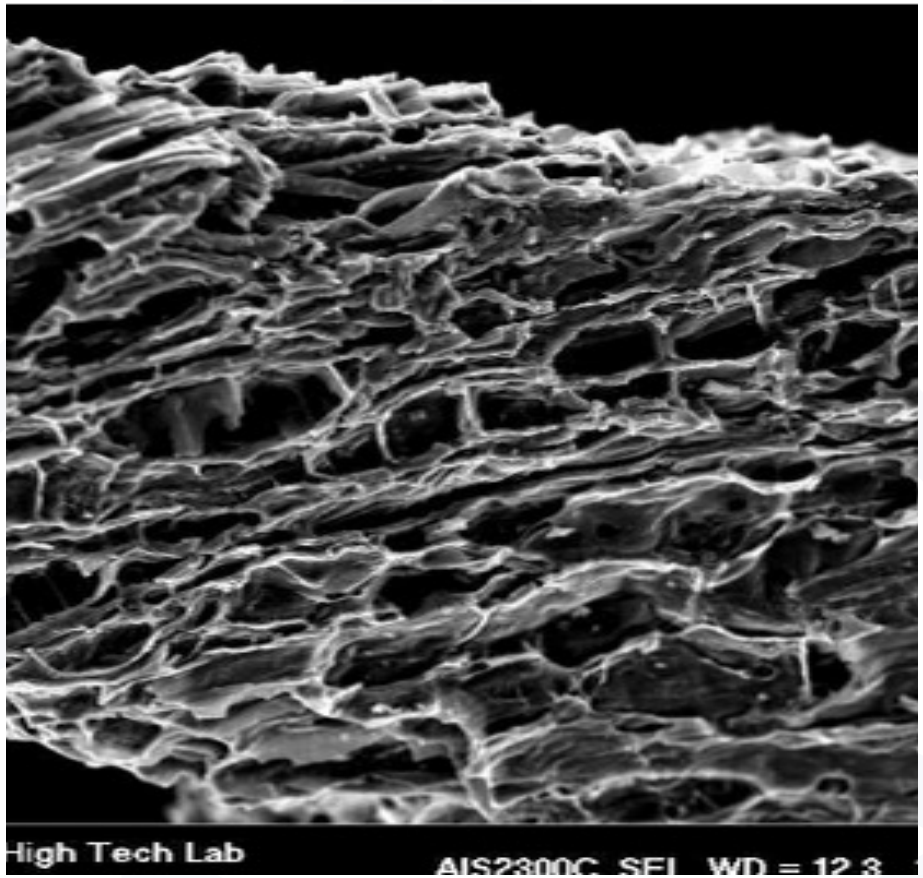
- Char, syngas
- Mineralized compounds

PFAS will leave a legacy on water treatment: so how can we manage that?

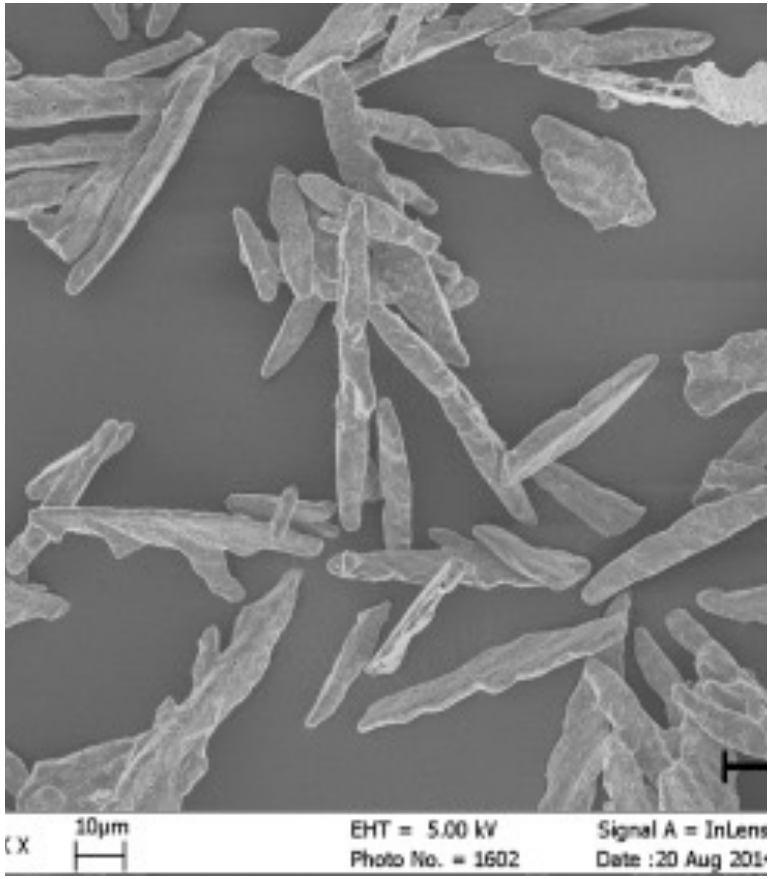
> *The carbon-fluorine bond is one of the strongest single bonds in chemistry (stronger than many double bonds).* ***So how can we retain nutrient values and reduce energy use and greenhouse gas production during destruction?***

- Things to think about as water professionals

Residuals recovery from PFAS destruction technologies



- Biochar as a sorbent/soil additive
- Phosphorus recovery (struvite generation) from mineralized waste streams



Advocacy to avoid emerging contaminant regulation moving from the regulatory process to the legislative process

PUBLIC SCIENCE LITERACY

EXPERT TO LAY-PERSON COMMUNICATIONS

My Gut Says: the PFAS experience is our model for future emerging contaminants

- → Pharmaceuticals and/or personal care products are next
- → Likely introduced as pass-throughs from wastewater treatment that is not designed to treat large organic chemicals at low concentrations
- → Regulation will proceed through critical media first, as supported by analytical method development
  - Watch the analytical chemistry journals as the canary in the coal mine
- → Treatment will likely be complex and costly
- → Public engagement will be critical

Woodard & Curran

Thank You!