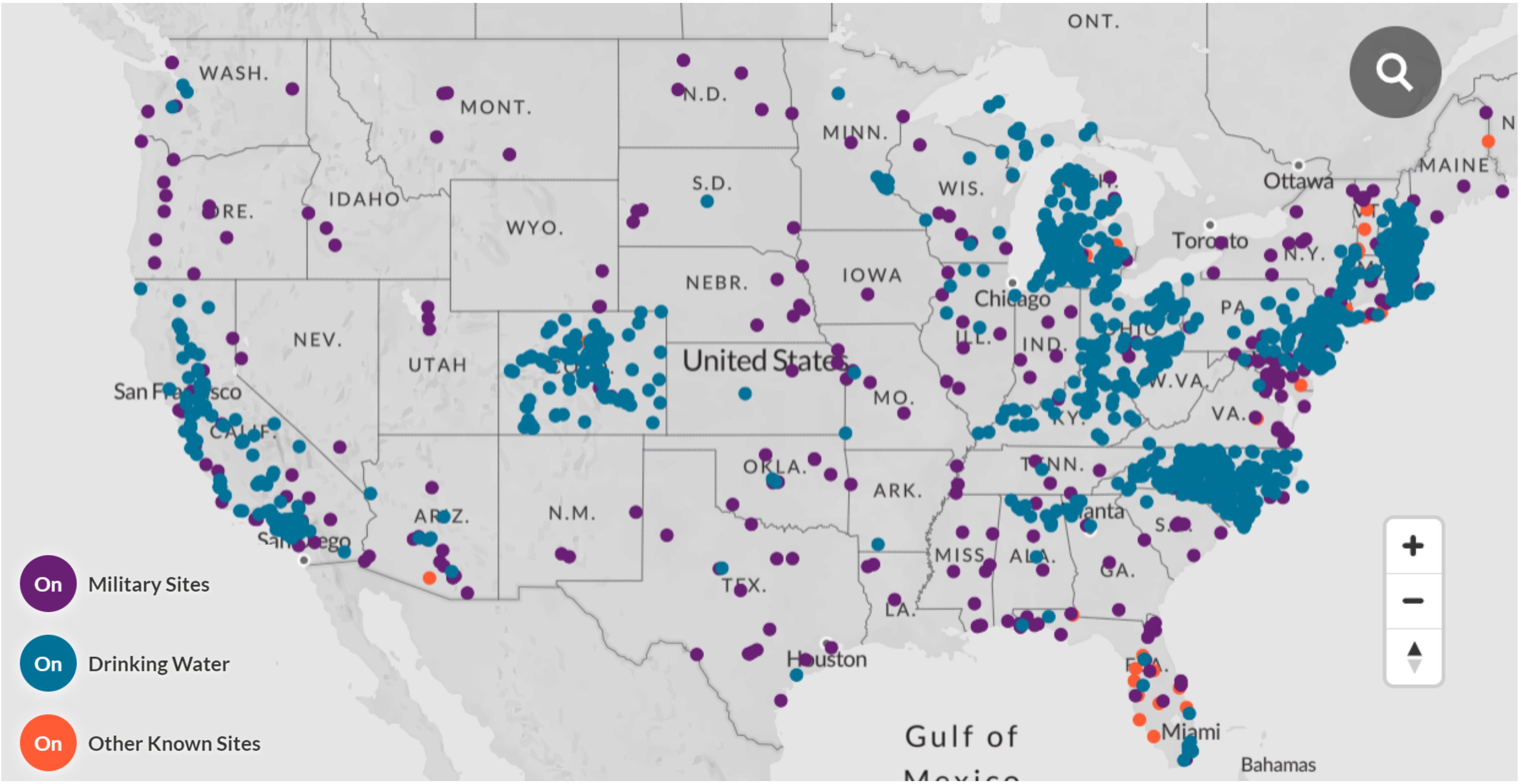
Aclarity

Electrochemical Destruction of PFAS in Water

Julie Bliss Mullen, CEO
julie.mullen@aclaritywater.com

Clean. Safe. Water.
aclaritywater.com

Per- and Polyfluoroalkyl Substances (PFAS) is everywhere!



Source: Adapted from EWG 2021

Aclarity

julie.mullen@aclaritywater.com

Common PFAS treatment requires disposal

GAC

Pros:
- Industry standard
- Lowest CapEx
- Spent GAC is reactivated
- Established supply chain
- Familiarity of disposal

Cons:
- Fast breakthrough
- Ineffective for smaller-chain PFAS
- High OpEx
- Incineration or landfill

IX

Pros:
- Regenerable options
- Smaller infrastructure footprint
- Effective for wider range of PFAS

Cons:
- Limited capacity
- PFAS specific are expensive
- Less common
- High OpEx
- Incineration or landfill

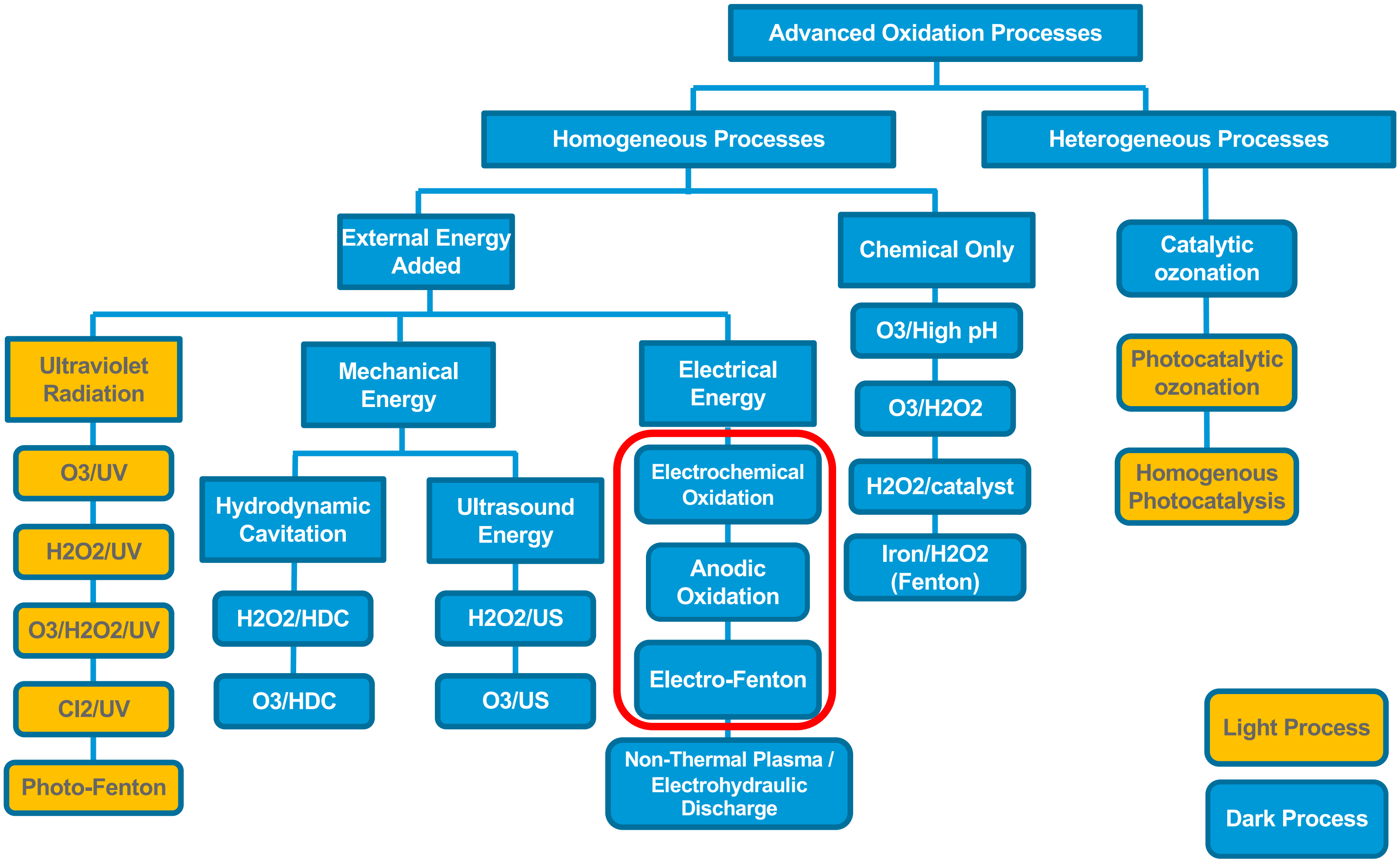
RO

Pros:
- Removal of all-chain compounds
- Comprehensive process

Cons:
- Energy intensive
- Mineral stripping
- Highest OpEx and CapEx
- Incineration or landfill

julie.mullen@aclaritywater.com

Electrochemical Advanced Oxidation Processes (eAOP) are a Subset of AOPs

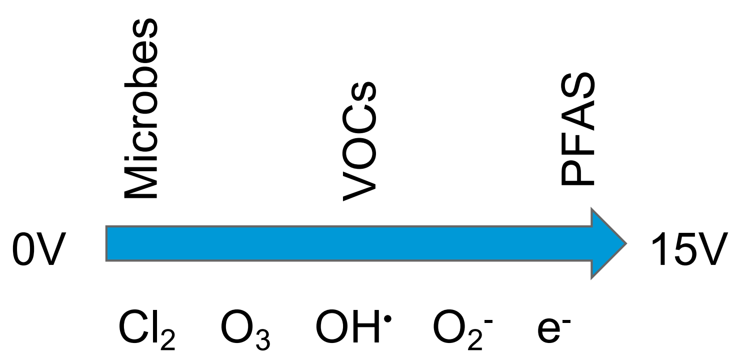


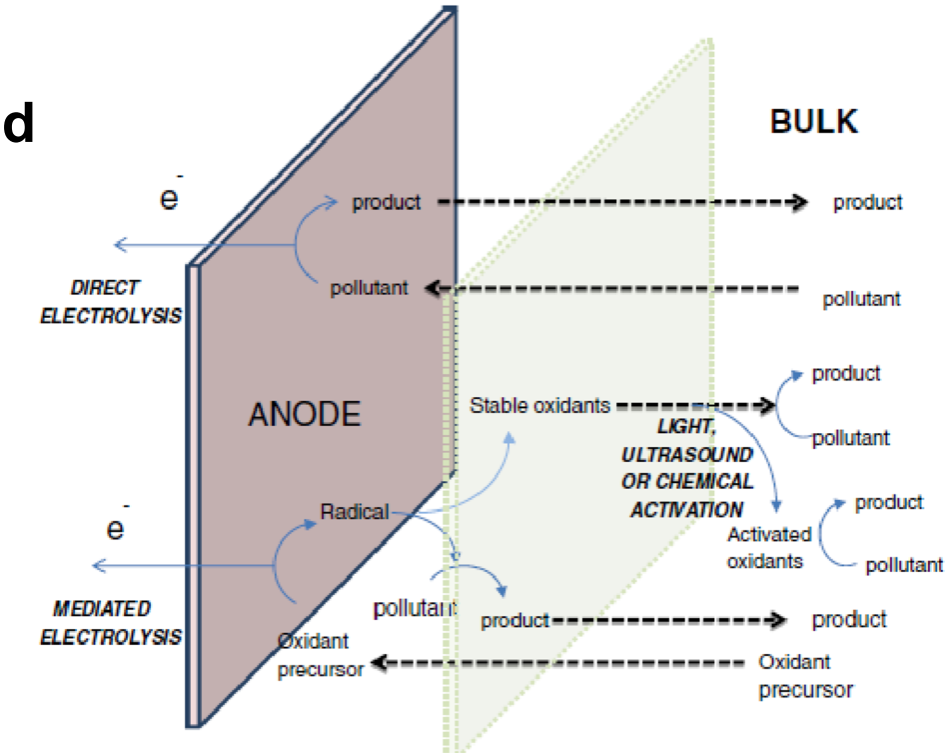
Source: Adapted from Sharma et al. 2011

julie.mullen@aclaritywater.com

eAOPs 101

- **Electrodes placed in water**
  - Heavy Metal Oxide Electrodes (SnO_2, Pt, TiO_2, IrO_2, etc.)
  - Boron Doped Diamond (BDD)
- **Electric potential above 1.23 V applied**
  - Surficial voltage at which water splits to O_2 and H_2
- **Mixed oxidant production with increasing voltage**





Aclarity

julie.mullen@aclaritywater.com

PFAS destruction is necessary but costly!

elementsix™
DE BEERS GROUP

Xogen® technologies inc.

ZYVANT RESEARCH & INNOVATIONS

ONVECTOR

OX BY EL

AECOM
DE-FLUORO™
PFAS DESTRUCTION TECHNOLOGY

MSU FRAUNHOFER USA CENTER FOR COATINGS AND DIAMOND TECHNOLOGIES
MICHIGAN STATE UNIVERSITY
Fraunhofer USA

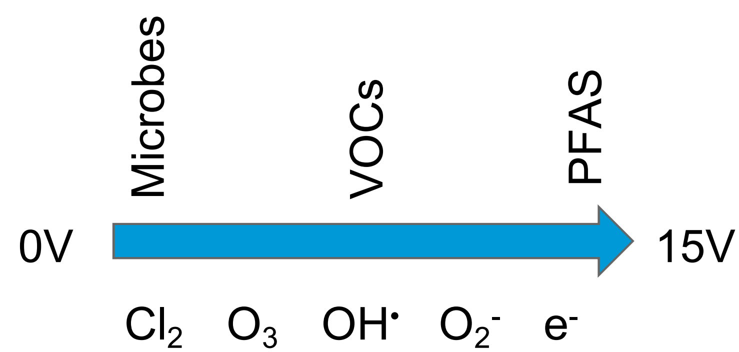
Aclarity

julie.mullen@aclaritywater.com

Aclarity: most powerful, least expensive destruction solution on the market

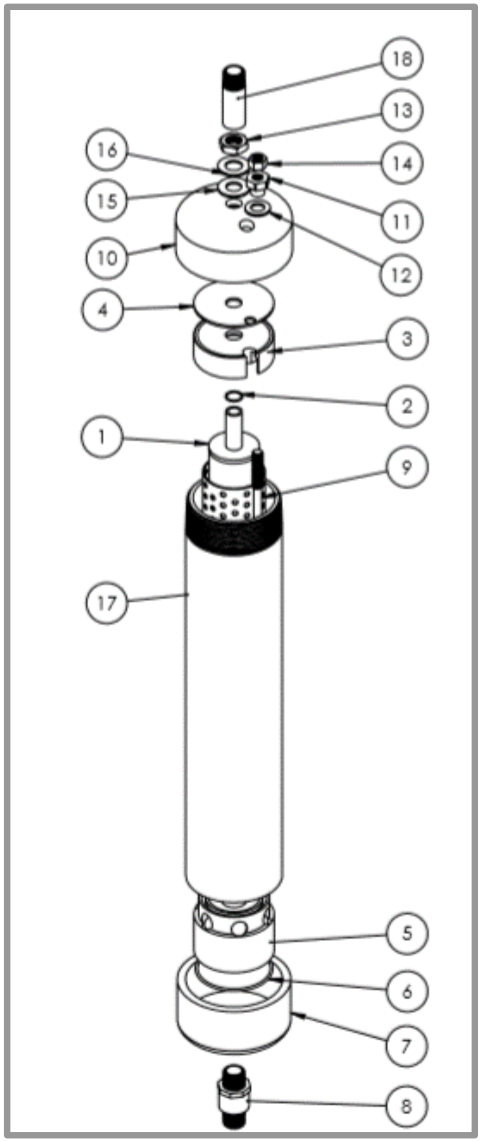
- High oxidation potential
- 1/10th cost BDD
- Low energy (<0.5 kWh/gal)
- Long-lasting electrodes (years)
- No moving parts
- Low maintenance
- No chemical storage
- Modular, stackable
- Suitable for low and high flows

Electrode Material	Overpotential (V)
Aclarity	2.5+
BDD	2.2-2.6+
Ti/SnO_2-Sb_2O_5	1.9-2.2
Ti/Pt	1.7-1.9
IrO_2/Ta_2O_5	1.5-1.8
RuO_2/TiO_2	1.4-1.7



julie.mullen@aclaritywater.com

Novel reactor design and electrodes



Electrode materials

Unique profile of inherent power, low cost anodes; pairing right cathodes increase this further

+

Geometry

Radial, porous shape with small band gap optimizes efficiency and speciation

+

Reactor flow

Flow-through path, mixing, and detention time ensure oxidants are used

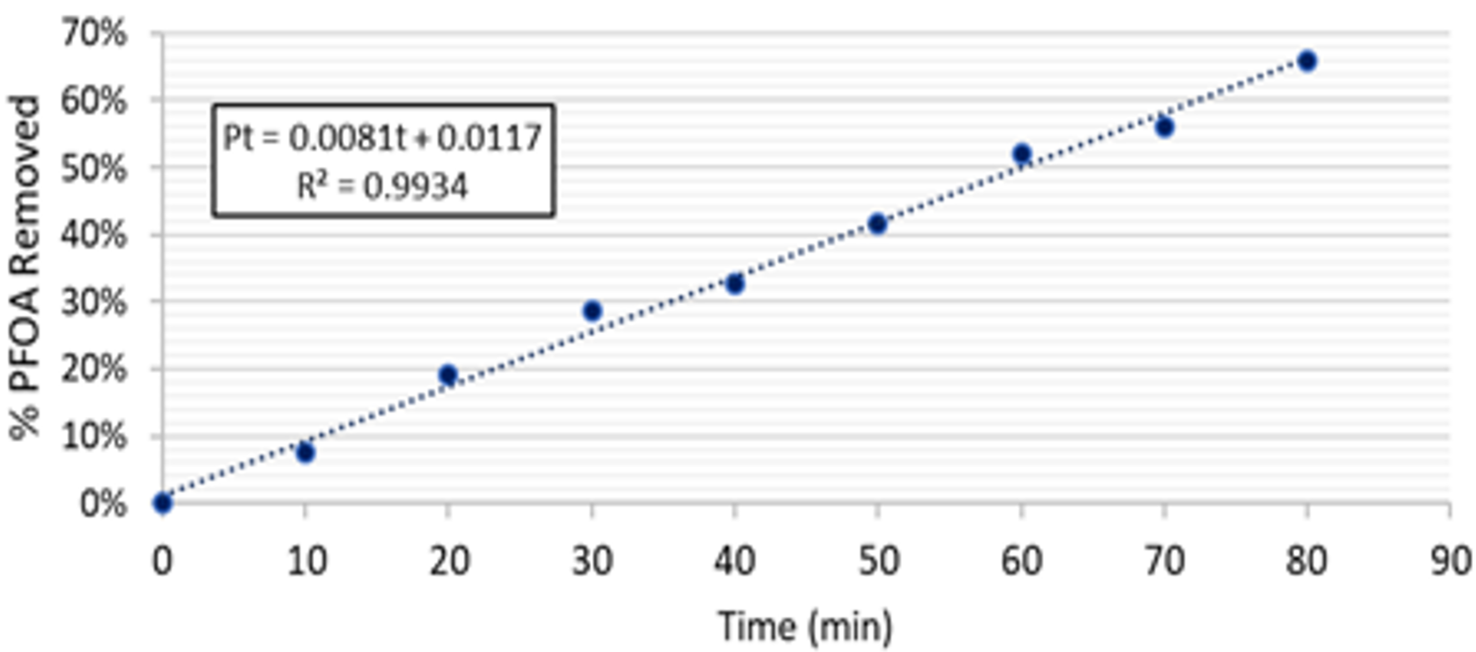
PATENT PENDING

julie.mullen@aclaritywater.com

PFAS at ppb range

PFOA brine pilot:

- Influent PFOA= 300 µg/L
- Treated via Aclarity Mobile Pilot System= 132 µg/L in closed loop for 80 minutes
- 0.36 log or 66% removal
- 890 A/m^2
- 0.078 kWh/gal

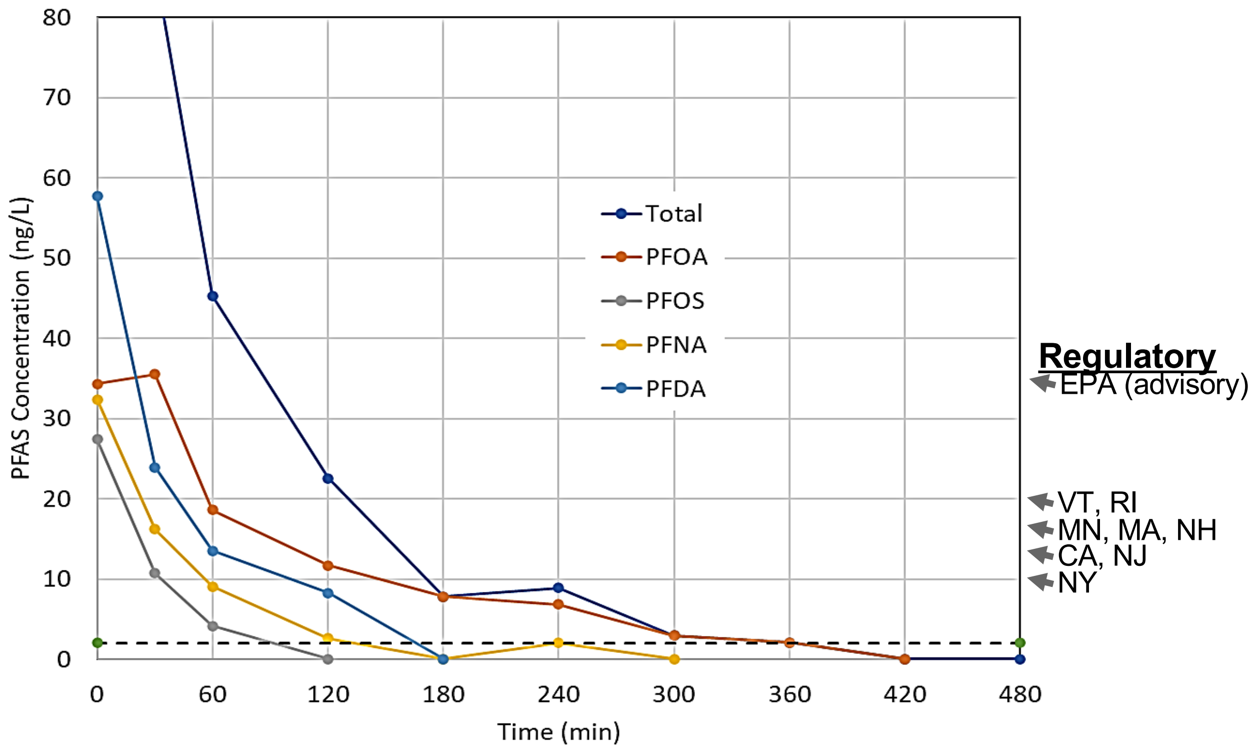


julie.mullen@aclaritywater.com

PFAS at ppt range

PFAS pilot:

- Influent PFAS= 150 ng/L, each starting between 27 and 58 ng/L
- Treated via Aclarity Mobile Pilot System= 8 ng/L in closed loop for 180 minutes
- 1.5 log removal
- 605 A/m^2
- 0.144 kWh/gal

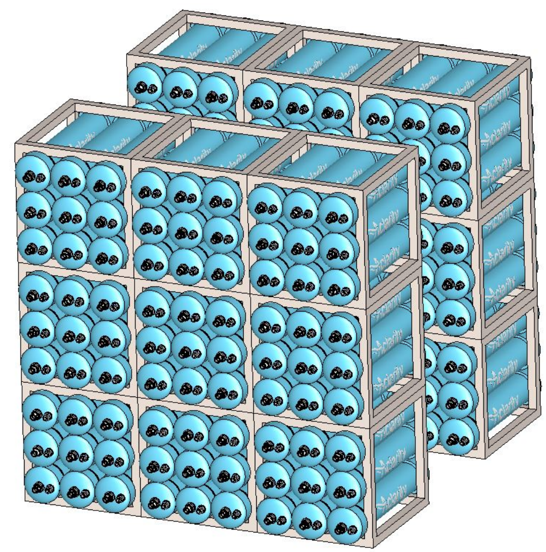


Source: Alpha Analytical (report 5/4/20 with Aclarity samples);
Bryan Cave Leighton Paisner, "State-by-State Regulation of Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water" (July 2019)
Note: EPA and MA levels are the sum of individual levels, shown here as the average allowed for each; median used if state has different limits for individual chemicals

Aclarity

julie.mullen@aclaritywater.com

Aclarity Mobile Pilot: 1-day pilot test for full-scale sizing

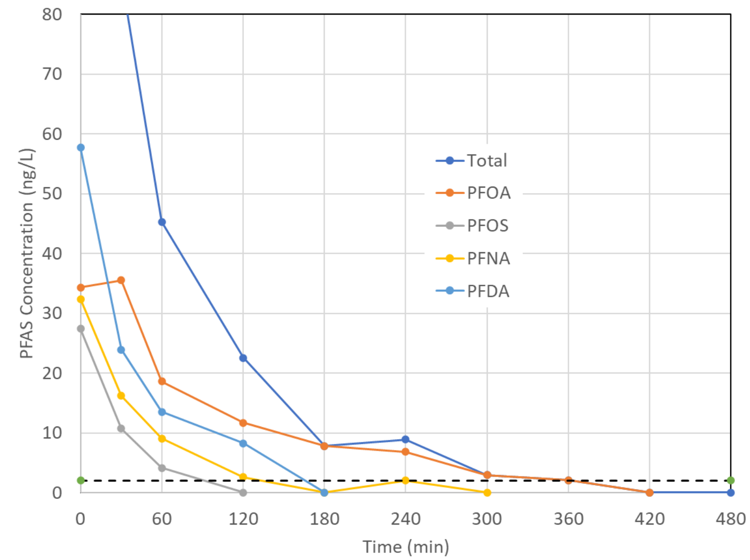


julie.mullen@aclaritywater.com

PFAS Destruction Economics

Example bench testing results with porous anode

- Initial concentration of PFAS: 50 ng/L
- Target concentration of PFAS: 5 ng/L
- Volume treated: 5 gallons
- Voltage: 15 V
- Amperage: 56 A
- Testing time required: 180 min



Conversion to full-scale using

Porous Anode:

- Design flow rate: 20,000 GPD
- Reactor CapEx + 10% redundancy: $325K
- Electrical cost per year: 0.093kWh/gal, $69K/yr
- Replacement cost per year: $32.5K

Solid Anode:

- Design flow rate: 20,000 GPD
- Reactor CapEx + 10% redundancy: $160K
- Electrical cost per year: 0.110kWh/gal, $82.6K/yr
- Replacement cost per year: $16K

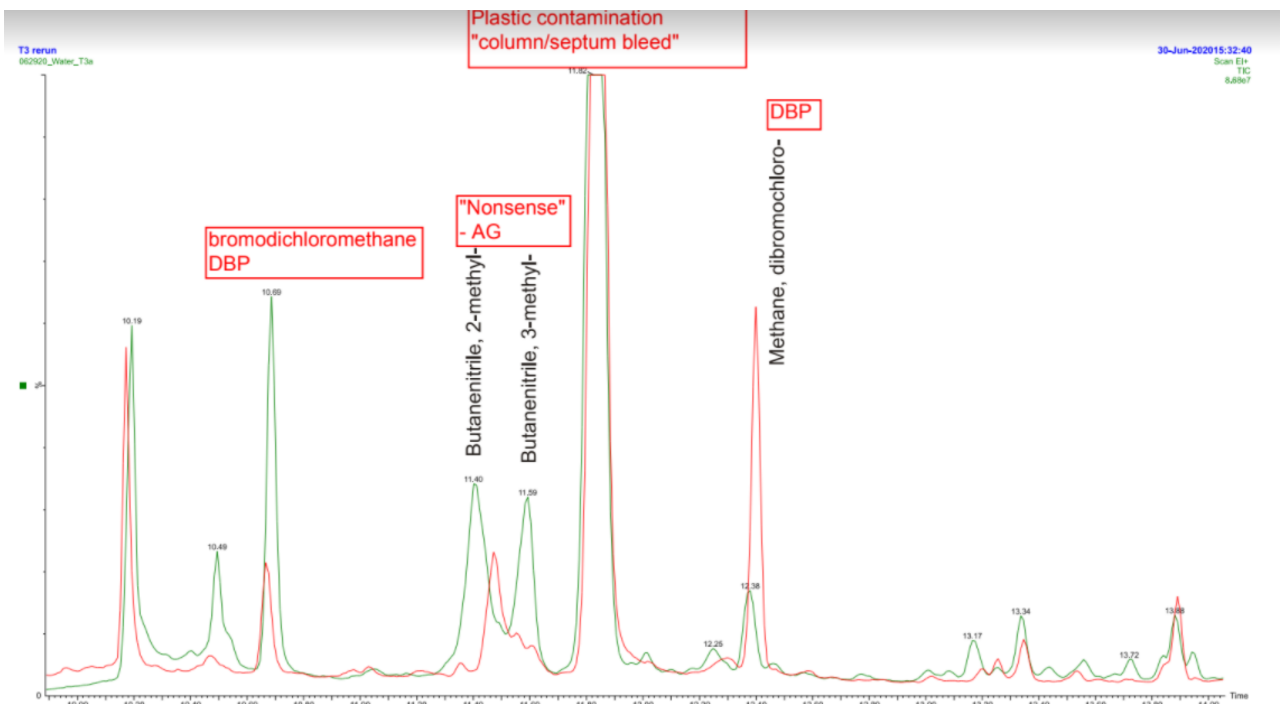
Aclarity

julie.mullen@aclaritywater.com

PFAS mineralization and byproducts study

Aclarity method for PFAS destruction:

- C-F bonds broken by free electrons
- Fragments mineralized by OH•
- CO_2, HF, F^-, and leftover products in very small quantities

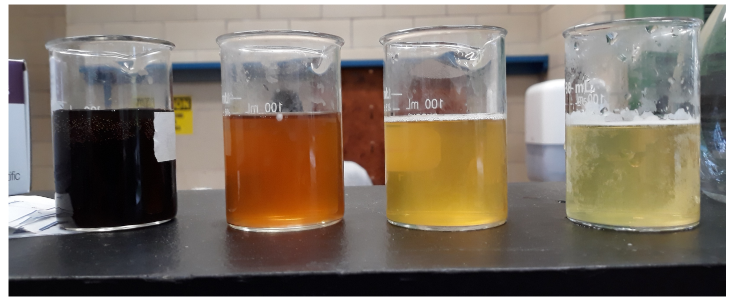


julie.mullen@aclaritywater.com

Ongoing PFAS pilots

Water Matrices:

- Landfill leachate
- Oil and Gas AFFF
- Military fire pit effluent
- Groundwater remediation
- Wastewater brines
- Municipal drinking water residuals



KEMCO SYSTEMS

xylem

Brown AND Caldwell

Aclarity

julie.mullen@aclaritywater.com

AES is proven in different use cases

Organics

Inorganics

	Examples		Status	Case Studies
Microbes	Bacteria, virus, algae, cysts	✓	Live in field	WATTS Water Technologies: NSF/ANSI P231 >6.3 log removal for bacteria and viruses UNTAPPED (Unlock the Potential of the Next Billion): Active municipal water system in Bamako, Mali
Chemicals	PFAS, VOCs, 1,4-dioxane, pesticides, pharmaceuticals, alcohols	✓	Field tested	PowerTech Water: Sizing 2 full-scale systems for automotive wastewater reuse Massachusetts: Groundwater VOC pilot for town wells Brown and Caldwell: 15 pilots for PFAS contaminated wastewater
Non-metals	Ammonia, nitrates, cyanide	✓	Field tested	Heartland Water Technology: Treatment of ammonia in landfill leachate PowerTech Water: Destruction of cyanide and chelating agents in electroplating
Metals	Arsenic, hardness, iron	✓	In development	TBD
Salinity	Sea water	--	Future device	TBD

Aclarity

julie.mullen@aclaritywater.com

Looking Forward

Applications
- Pharmaceuticals, reuse, pesticides
- Reduction processes– perchlorate, nitrate, hexavalent chromium, etc.

Engineering
- Testing 7-cell reactors to be ready for sale Q4 2021
- Manufacturing solid electrode reactor for high turbidity applications
- Find where economy of scale ends

Sales Channel Partners
- 1 day pilots for sizing full-scale systems
- Expanding partnerships with engineering firms, OEMs, and technology providers

Fundraising
- Awarded $1M NSF SBIR Phase II, raised $700K Seed VC
- New hires: Director of Industrial Sales, VP Finance, R&D Engineer II

Aclarity

julie.mullen@aclaritywater.com

Aclarity

Thank you!

Julie Bliss Mullen
julie.mullen@aclaritywater.com

Clean. Safe. Water.
aclaritywater.com