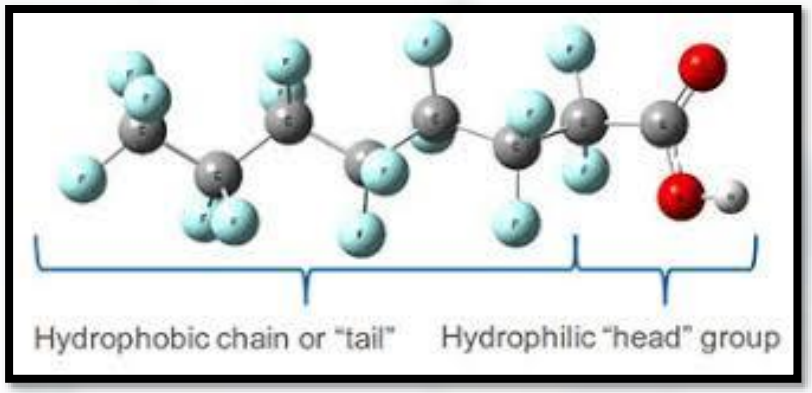
Webinar

Addressing PFAS

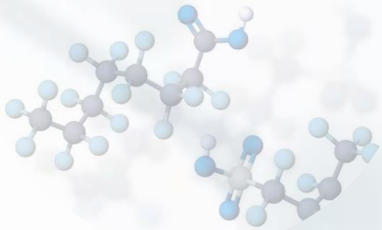
What Engineers Need to Know

56th Annual WWOA Conference

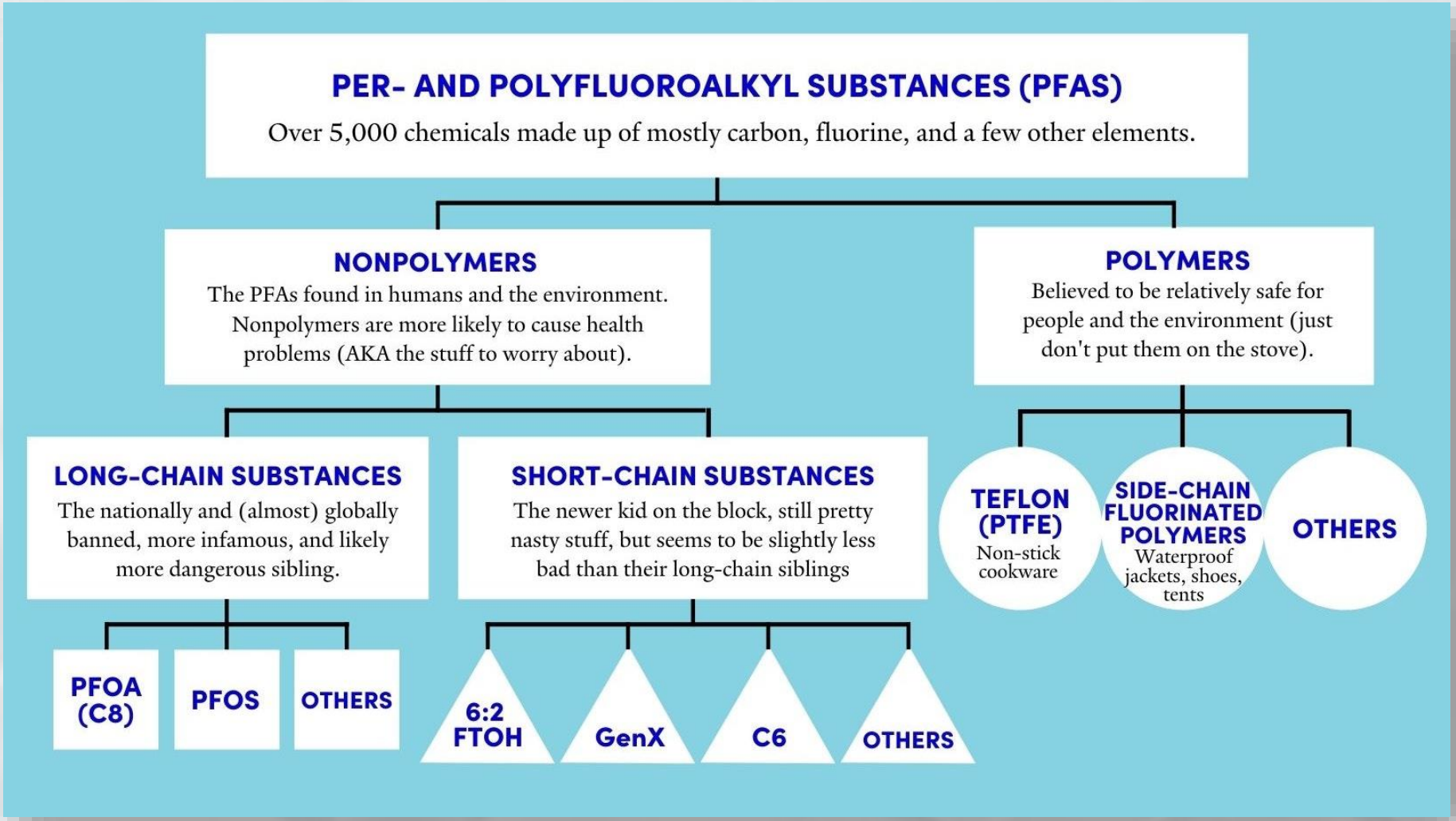
What is PFAS



- Poly- or per-fluorinated alkyl substances
  - a general term for over 4,700 specific compounds (and growing)
  - PFOA - perfluorooctanoic acid
  - PFOS - perfluoro sulfonate
  - PFBS- Perfluorobutanesulfonic acid
  - GenX - ammonium salt of hexafluoropropylene oxide dimer acid (HFPO-DA) fluoride
- Fluorinated linear carbon compounds that ***may*** have a functional group at one end.
- Tend to bioaccumulate (build up)
- Recalcitrant – very slow to breakdown in nature and difficult to treat with conventional means
- Some PFAS shown to have toxic effects at high doses and potential for carcinogenicity.

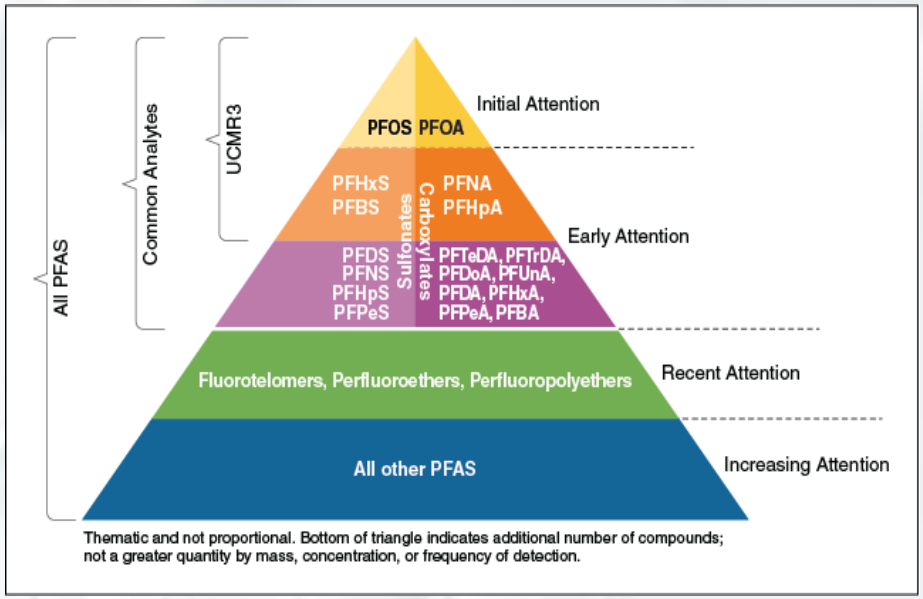


"Contaminant of the Decade"



https://choosefinch.com/blog/what-to-know-about-pfas-a-story-of-polyfluorinated-chemicals

PFAS Bad Actors



The most common are:

- PFOA – Perfluorooctanoic acid
- PFOS – Perfluorooctane sulfonate
- PFBS – Perfluorobutanesulfonic acid
- GenX- **ammonium salt of hexafluoropropylene oxide dimer acid (HFPO-DA) fluoride**
- PFNA – Perfluorononanoic acid (PFOA with an extra carbon)
- PFHxS – Perfluorohexanesulfonic acid –was an additive to dental floss

History of PFAS

April 1938 Roy J. Plunkett (1910 – 1994), accidentally invented polytetrafluorethylene (PTFE), a saturated fluorocarbon polymer—the "first compound in the family of Perfluorinated compounds (PFCs), "to be marketed commercially

1947 3M (then the Minnesota Mining and Manufacturing Company) began producing PFOA by electrochemical fluorination.
1951, DuPont purchased PFOA from 3M for use in the manufacturing of specific fluoropolymers—commercially branded as Teflon, but DuPont internally referred to the material as C8.

1945, DuPont commercialized PTFE as Teflon. They found that PTFE was resistant to corrosion, had low surface friction, and high heat resistance.[19] Tetrafluorethylene (TFE) can cyclize with a wide variety of compounds which led to the creation of a range of organofluorine compounds.

1951 Dupont began using C8 in the manufacturing of Teflon at their plant in West Virginia

1952 The original formula for Scotchgard was discovered accidentallyby 3M chemists Patsy Sherman and Samuel Smith.

History information
https://www.epa.gov/pfas/pfas-laws-and-regulations
https://en.wikipedia.org/wiki/Timeline_of_events_related_to_per-_and_polyfluoroalkyl_substances
https://www.linkedin.com/pulse/breaking-down-pfas-action-act-timeline-jeffrey-hale/?articleId=6629132672750940160

1998 The United States Environmental Protection Agency (EPA) "was first alerted to the risks" of PFAS—man-made "forever chemicals" that "never break down once released and they build up in our bodies" The EPA's Stephen Johnson, said in Barboza's 18

May 2000 *Times* article that The EPA first talked to 3M in 1998 after they were first alerted to 3M's 1998 laboratory rat study in which "male and female rats were given doses of the chemical and then mated. When a pregnant rat continued to get regular doses of about 3.2 milligrams per kilogram of body weight, most of the offspring died within four days." According to Johnson, "With all that information, [the EPA] finally talked to 3M and said that raises a number of concerns. What are you going to do?"[34]

https://en.wikipedia.org/wiki/Timeline_of_events_related_to_per-_and_polyfluoroalkyl_substances

Recent regulatory action driving PFAS treatment market

https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan.pdf

Sept 2021 Preliminary Effluent Guidelines Program Plan 15- announced that the development of effluent guidelines and standards for PFAS manufacturers is warranted. EPA therefore plans to revise the existing OCPSF ELGs (40 CFR Part 414) to address PFAS discharges from facilities manufacturing PFAS- FOCUS: metal finishing, pulp, paper and paperboard, textile and carpet and commercial airports.

October 26, 2021,- the U.S. Environmental Protection Agency (EPA) announced it would initiate two rulemakings to address per- and polyfluoroalkyl substances (PFAS) under the Resource Conservation and Recovery Act (RCRA). The rules would propose listing four PFAS chemicals as "hazardous constituents" in 40 CFR Part 261, Appendix VIII: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorobutane sulfonic acid (PFBS), and GenX.

Listing these PFAS chemicals in Appendix VIII would have two consequences:

- First, the listed chemicals would be subject to RCRA corrective action requirements at hazardous waste treatment, storage, and disposal facilities (TSDFs).

- Second, this listing would be the first step necessary toward a future formal rulemaking process under 40 CFR § 261.11(a)(3) to regulate these chemicals as listed hazardous wastes.

https://www.newpig.com/rcra-101-part-10-land-disposal-restrictions/c/8024?show=All

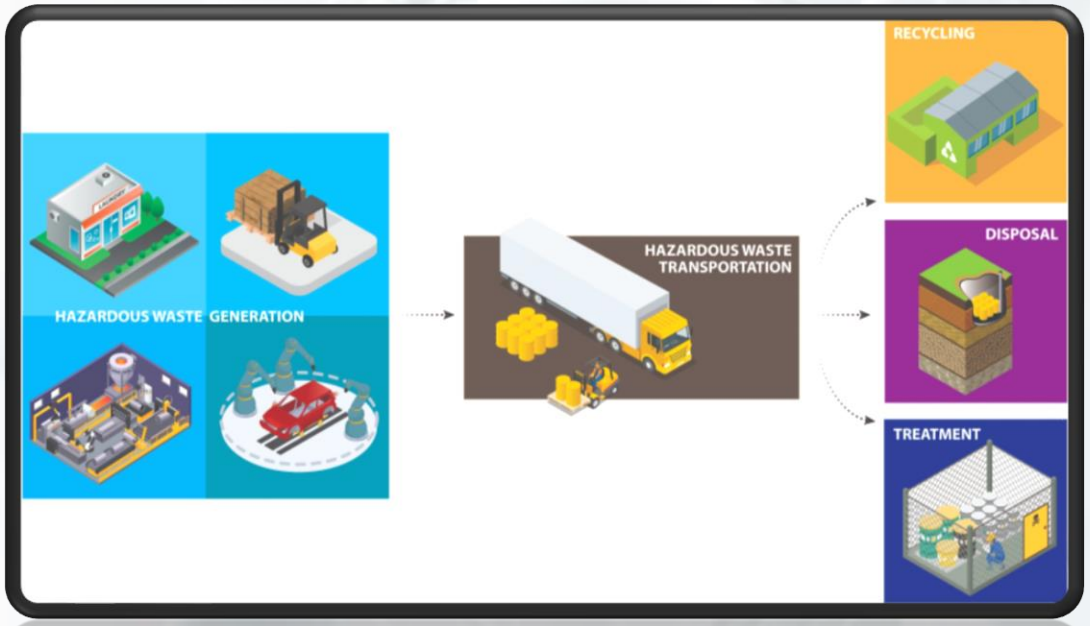
https://www.crowell.com/NewsEvents/AlertsNewsletters/all/EPA-to-Initiate-Regulation-of-PFAS-Under-RCRA

https://en.wikipedia.org/wiki/Timeline_of_events_related_to_per-_and_polyfluoroalkyl_substances

What Does this Mean?

RCRA - The Resource Conservation and Recovery Act passed in 1976- Established the framework for proper management of Hazardous waste

- Cradle to Grave
- Special Handling
- Special Storage
- Special treatment and disposal



Current Generators

https://www.epa.gov

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is commonly known as Superfund. Superfund allows for federal assistance in clean up and mitigation efforts . CERCLA is not a regulatory act, it's a clean up and liability law….BUT it creates a dependence on utilizing RCRA practices to avoid becoming a CERCLA site.

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- If polluters cannot be Identified, Superfund can pay

Strict- intentional negligence is not a factor

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Its Focus….

Generators, Transporters and Disposal

" Cradle to Grave"

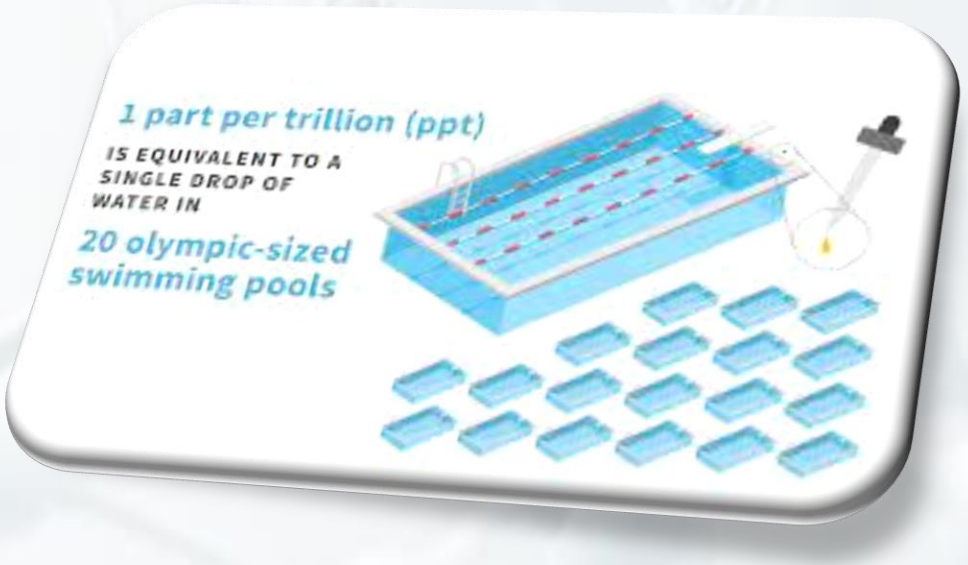
13 April 2022 14 State Attorneys General signed a letter to the EPA urging the agency to use its current-year funding to "meet commitments and deadlines outlined in its PFAS Strategic Roadmap".[114]

15 June 2022 The EPA issued interim updated drinking water health advisories for PFOS and PFOA, drastically lowering previous levels from 70 ppt for both to:

- 0.02 ppt for PFOS
- 0.004 ppt for PFOA.

The agency also issued final health advisories for:

- 10 ppt GenX - HFPO-DA and its ammonium
- 2000 ppt PFBS [115]



https://fanaticcook.com/2021/12/16/pfas-1-parts-per-trillion-ppt-is-equivalent-to-one-drop-of-water-in-20-olympic-sized-swimming-pools/
https://en.wikipedia.org/wiki/Timeline_of_events_related_to_per-_and_polyfluoroalkyl_substances

April 28,2022 The EPA Announced it was seeking to proactively use existing NPDES authorities to reduce discharges of PFAS at the source and obtain more comprehensive information through monitoring on sources of PFAS.

EPA issued a memo titled, *Addressing PFAS Discharges in EPA-Issued NPDES Permits and Expectations Where EPA is the Pretreatment Control Authority.* This memo provides instructions for monitoring provisions, analytical methods, the use of pollution prevention, and best management practices to address discharges of PFAS.

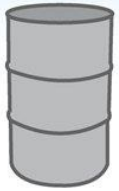
EPA is proposing the first Clean Water Act aquatic life criteria for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS)—two of the most well-studied chemicals in this group.

EPA's Draft Method 1621 -EPA's new *Screening Method for the Determination of Adsorbable Organic Fluorine (AOF) in Aqueous Matrices by Combustion Ion Chromatography (CIC)* provides an aggregate measurement of chemical substances that contain carbon-fluorine bonds. Based on organofluorines in wastewater.

https://www.epa.gov/newsreleases/epa-delivers-three-water-commitments-agencys-pfas-strategic-roadmap#:~:text=PFAS%20are%20a%20common%20source,successfully%20completed%20single%20laboratory%20validation.

How much is one part per ...

million (ppm)
milligrams/liter (mg/L)

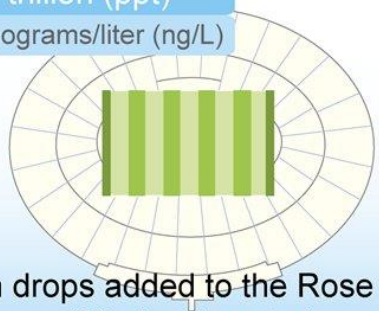


= three drops added to a 42-gallon barrel

billion (ppb)
micrograms/liter (µg/L)

= one drop added to a large tanker truck

trillion (ppt)
nanograms/liter (ng/L)



= ten drops added to the Rose Bowl (filled with water)

quadrillion (ppq)
picograms/liter (pg/L)

= two teaspoons added to the Great Salt Lake of Utah

https://twitter.com/mwdh2o/status/902549920317677568/photo/1

January of 2021 – EPA Publishes –Advanced Notice of Proposed Rulemaking
Addressing PFOA and PFOS in the Environment: Potential Future Regulation Pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act

Broad Categories identified in the ANOPR

- Manufacturers and processors of PFOS/PFOA
- Manufacturers of products containing PFOS/PFOA
- Downstream product manufacturers and users of PFOS/PFOA products
- Waste management facilities
- Effluent treatment facilities

Within the above categories, specific industries may include:

- Aviation
- Carpet manufacturers
- Car washes
- Electroplaters
- Paint and coatings manufacturers
- Fire-fighting foam manufacturers
- Landfills
- Fire departments/training centers
- Paper mills
- Petroleum refineries and terminals
- Photographic film manufacturers
- Wax and cleaning product manufacturers
- Polymer manufacturers
- Textile mills
- Wastewater treatment plants

Sept 6, 2022 – Notice of Rulemaking

Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA" or "Superfund"), the Environmental Protection Agency (EPA or the Agency) is proposing to designate perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), including their salts and structural isomers, as hazardous substances. CERCLA authorizes the Administrator to promulgate regulations designating as hazardous substances such elements, compounds, mixtures, solutions, and substances which, when released into the environment, may present substantial danger to the public health or welfare or the environment. Such a designation would ultimately facilitate cleanup of contaminated sites and reduce human exposure to these "forever" chemicals.

https://www.federalregister.gov/documents/2022/09/06/2022-18657/designation-of-perfluorooctanoic-acid-pfoa-and-perfluorooctanesulfonic-acid-pfos-as-cercla-hazardous

EPA identifies the immediate, direct effects of the rulemaking as:

1) new reporting requirements to the National Response Center (NRC) and other authorities within 24 hours of known releases of at least one pound of PFOA or PFOS by a vessel or facility

2) entities selling or transferring federally-owned property must provide notice about on-site PFOA/PFOS storage, release, or disposal and warrant that remedial action has been or will be taken on any hazardous substances on the property, either before or after the transaction

3) a requirement that the US Department of Transportation (DOT) list PFOA and PFOS as hazardous materials under the Hazardous Materials Transportation Act.

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Other PFAS Regulations

April 26,2022 The DoD initiated a ban on the incineration of all PFAS laden materials focused on Biosolids and AFFF foam

Illinois, Michigan and New York have banned incineration as well.

State	PFOA	PFOS	APFO
Michigan	0.07 µg/m^3 (24-hr)	0.07 µg/m^3 (24-hr)	N/A
New Hampshire	N/A	N/A	0.05 µg/m^3 (24-hr) 0.024 µg/m^3 (annual)
New York	0.0053 µg/m^3 (annual)	N/A	N/A
Minnesota	0.063 µg/m^3 (24-hr, > 30 day, and > 8 yr)	0.011 µg/m^3 (24-hr, > 30 day, and > 8 yr)	N/A
Texas	0.05 µg/m^3 (1-hr) 0.005 µg/m^3 (annual)	0.1 µg/m^3 (1-hr) 0.01 µg/m^3 (annual)	0.1 µg/m^3 (1-hr) 0.01 µg/m^3 (annual)

https://www.trccompanies.com/insights/pfas-air-emissions-standards-and-trends-for-summer-2021/

Regulations by State

Currently

- 18 States have No PFAS regulations or advisories on the books
- 11 States have advisory levels but no formal regulations
- 21 states have passed formal regulations

As of August 1, 2004 New PFAS Administrative Rules Now In Effect in WI

- The rules set regulatory standards for: PFAS in drinking water.
- PFAS in surface water.
- Sets requirements for using PFAS-containing firefighting foam.

WI Regulations

The standards set a limit of 70 parts per trillion in drinking water for PFOA and PFOS combined

The rules also create a standard of 8 parts per trillion in most surface waters. *Reading an 8 ppt limit for PFOS, and a 20 ppt for PFOA in surface waters used as a public drinking source and a 95 ppt limit for other surface waters.*

The DNR will require PFAS testing of discharges from wastewater and industrial facilities to determine whether they're meeting surface water standards for the chemicals. If facilities exceed standards, the agency will work with permitted facilities to reduce PFAS to avoid costly treatment. Those facilities will have up to seven years to implement plans to minimize PFAS levels.

Fire foam regulation state that it can be used in emergency but not in training

** Gov. Evers has announced he is pushing for Groundwater Rules*

WI DHS Recommended limits- Required notices

Summary of DHS' Recommended Groundwater Standards for PFAS

PFOA = 20*	PFNA = 30	PFUnA = 3,000
PFOS = 20*	PFHxS = 40	PFBA = 10,000
FOSA = 20*	GenX = 300	PFTeA = 10,000
NEtFOSA = 20*	PFDA = 300	PFHxA = 150,000
NEtFOSAA = 20*	PFDoA = 500	PFODA = 400,000
NEtFOSE = 20*	DONA = 3,000	PFBS = 450,000

* DHS recommends a combined standard of 20 ng/L for PFOA, PFOS, FOSA, NEtFOSA, NEtFOSAA, and NEtFOSE. All recommendations are shown as nanograms of PFAS per liter of water (ng/L), which is equivalent to parts per trillion (ppt).

More information on these recommendations can be found on our Cycle 10 and Cycle 11 pages.

PFAS Testing

Potential Sources of PFAS Contamination

- water used during decontamination
- materials used within the sampling environment
- sampling equipment
- field clothing
- personal protective equipment (PPE)
- sun and biological protection products
- personal hygiene and personal care products (PCPs)
- food packaging
- environment

Do NOT USE materials containing the following …

- Polytetrafluoroethylene (PTFE) that includes the trademark Teflon® and Hostaflon®, sometimes found in the lining of hoses and tubing
- Polyvinylidene fluoride (PVDF) that includes the trademark Kynar®, found in tubing, films/coatings on aluminum, galvanized or aluminized steel, wire insulators, and lithium-ion batteries
- Polychlorotrifluoroethylene (PCTFE) that includes the trademark Neoflon®, common in valves, seals, gaskets, and food packaging
- Ethylene-tetrafluoroethylene (ETFE)
- Fluorinated ethylene propylene (FEP) that includes the trademarks Teflon® FEP and Hostaflon® FEP, and may also include Neoflon®, found wire and cable insulation and covers, pipe linings, and some labware.
- Low-density polyethylene (LDPE) especially for any items that will come into direct contact with the sample media. LDPE can be found in many items, including but not limited to containers and bottles, plastic bags, and tubing.
    - LDPE bags (e.g., Ziploc®) that do not come into direct contact with the sample media and do not introduce cross-contamination with samples may be used. *LPDE has PFAS in the manufacturing process*

https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/General.pdf?rev=5fb24f7dabf0468b9415679b60681503

What to Use….

- Use materials that are either made of high-density polyethylene (HDPE), polypropylene, silicone, or acetate.

- Glass bottles or containers may be used if they are known to be PFAS-free
    - *NOTE: PFAS have been found to adsorb to glass, especially when the sample is in contact with the glass for a long period of time (e.g. being stored in a glass container). If the sample comes into direct contact with the glass for a short period of time (e.g. using a glass container to collect the sample, then transferring the sample to a non-glass sample bottle), the adsorption is minimal.*

- Powderless nitrile gloves
- Polyvinyl chloride (PVC) or wax-coated fabrics.
- Neoprene
- Well-laundered synthetic or 100% cotton clothing, with most recent launderings not using fabric softeners

Things to consider when Sampling…..

- PFAS Migrate to the air/water interfaces
  - Churning water with foam will have high concentrations in the foam and at the surface
- PFAS bind to substances and sink
  - Do not sample at the very bottom of a Lake
- *Concentrations may fluctuate, especially early in a pumping cycle. Therefore, samples should be collected from each water system entry point during the final third of a pumping cycle (i.e., pumping of the source well(s) at least 67% of the way through the current cycle) to aid in result comparability across samples*

Check for PFAS Waterproof Notebooks, Sticky Notes, Lotions, Some Sunscreens, Fabric Softeners, etc.

Helpful links

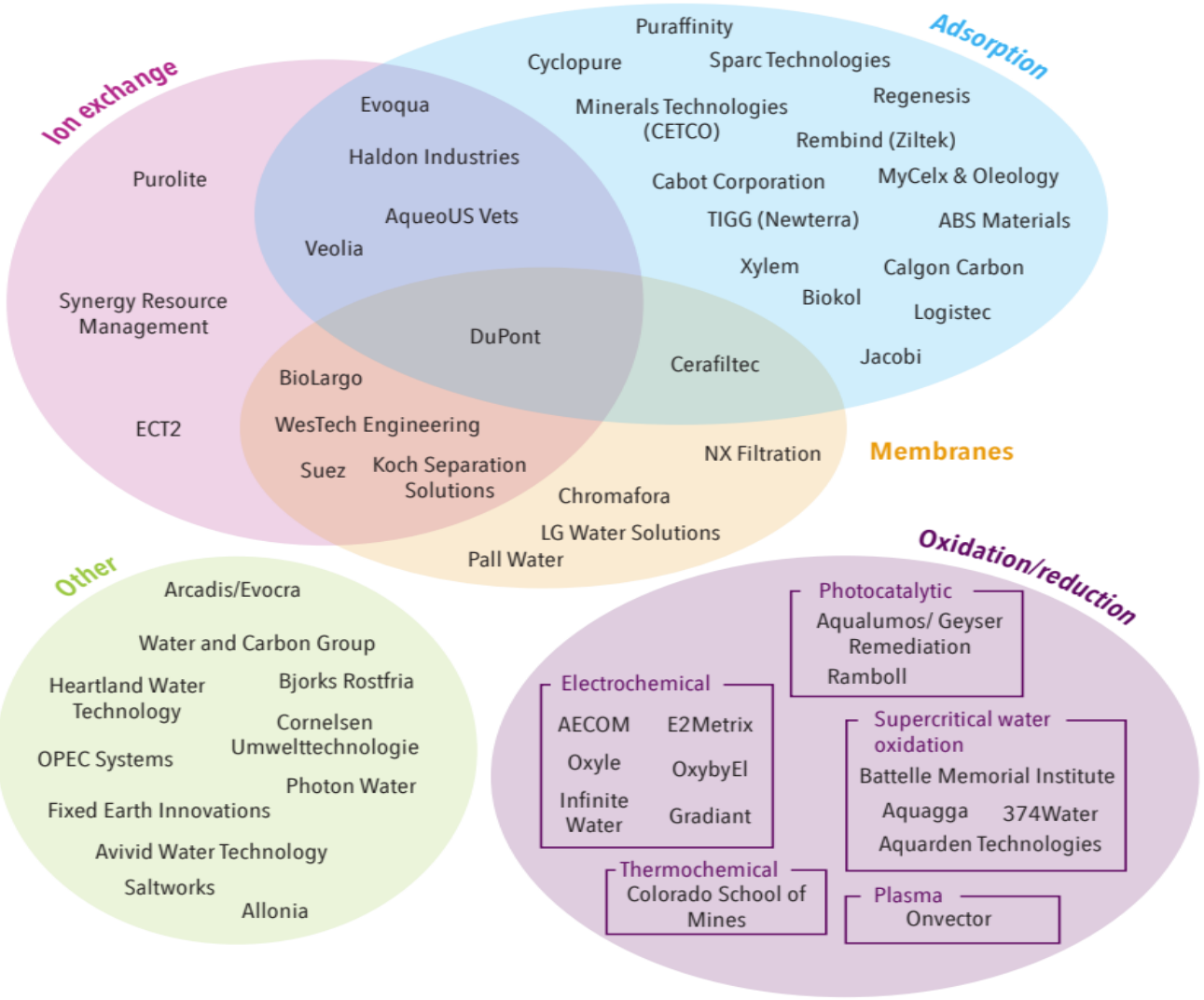
https://dnr.wisconsin.gov/sites/default/files/topic/PFAS/DG_PFASSamplingProtocol.pdf

https://www.michigan.gov/pfasresponse/-/media/Project/Websites/PFAS-Response/Sampling-Guidance/General.pdf?rev=5fb24f7dabf0468b9415679b60681503

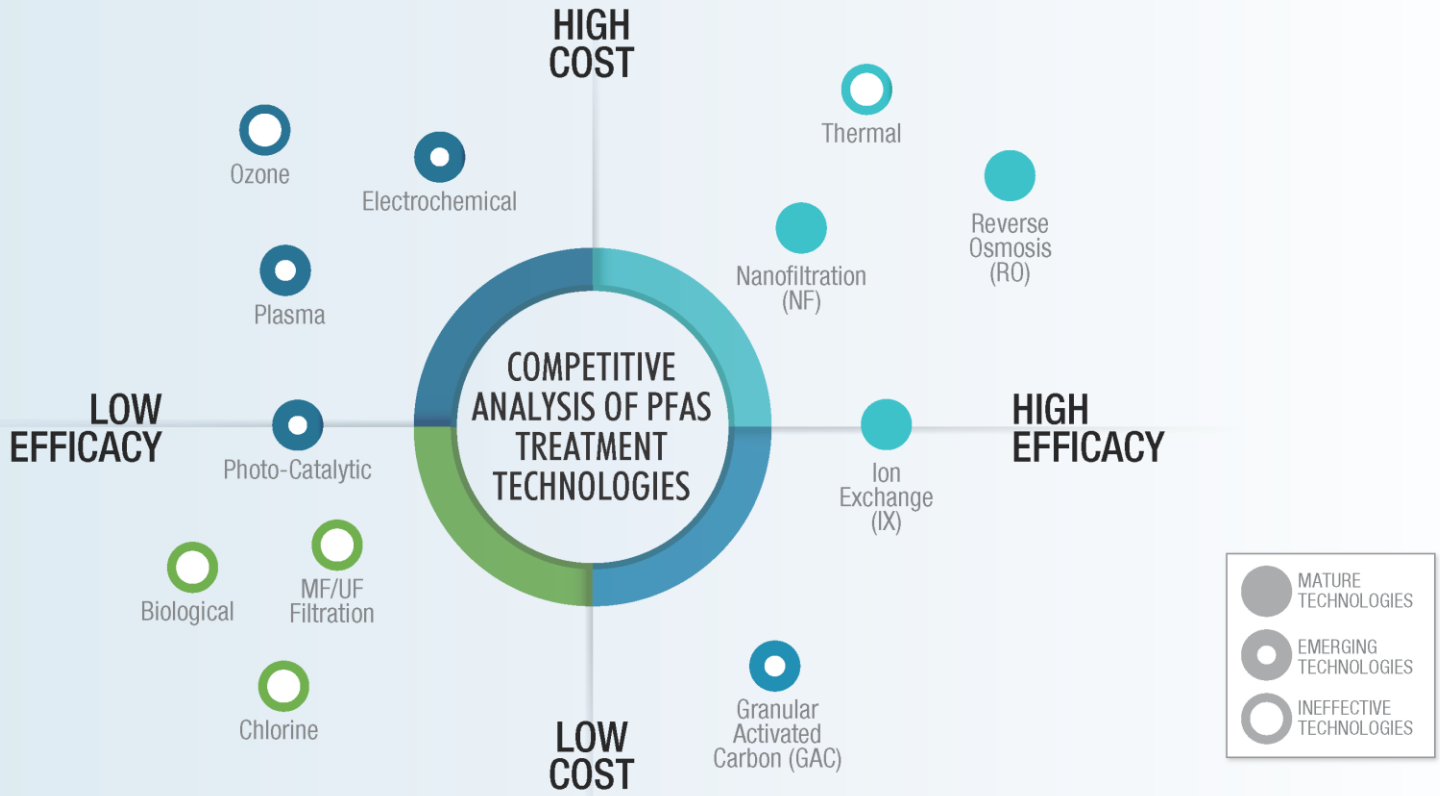
Treatment Technologies

PFAS MARKET PLAYERS: A GUIDE

The market players shown here are arranged according to the separation principles with which their technologies most closely align. There is a flurry of activity in exploring methods of oxidation and reduction, while the 'other' category encompasses a number of companies offering physical/chemical solutions including foam fractionation, flotation and evaporation. Several engineering companies are also staking a claim in this technology market, often in partnership with research organisations.



Source: GWI



https://carollo.com/expertise/pfas/

A Few Questions to ask.....

- What is the source water?
- What other constituents are in the water?
- What utilities are available?
- What PFAS do you have?
- What resources do you have (manpower, etc.)?
- Is there grant money available?

What are the biproducts of the treatment?

What are the consumables?

O&M vs Capital cost

Disposal

Most Common PFAS Treatment Technology

- Membrane Filtration
- Adsorption Treatment and GAC
- Ion Exchange-Regenerable

Granular Activated Carbon(GAC) Filtration

Pros

- Low operational cost
- Low Capital cost
- Moderately effective on Long Chain PFAS
- Well known and understood technology

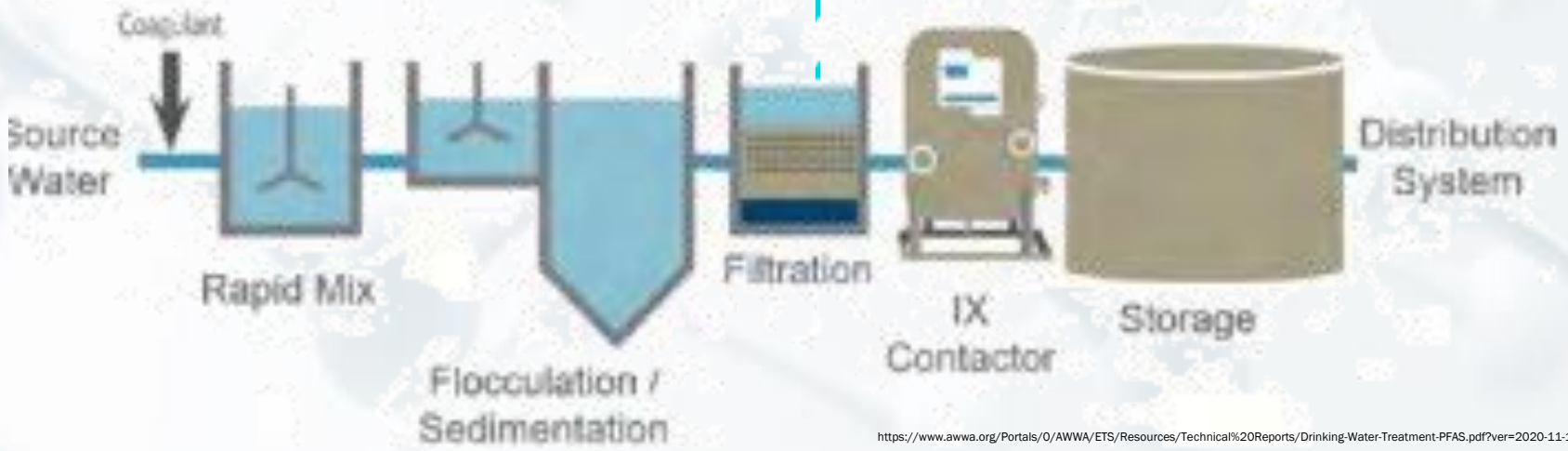
Cons

- Media cannot be regenerated
- Long contact time (10 min+)
- Large amounts of spent media will require disposal
- Does not absorb short chains well
- Media can grow bacteria if not at a constant flow
- Media can channel quickly
- Media life dependent on organics in water

Ion Exchange for PFAS Removal

- Well Known and understood technology
- Contact time 3-5 minutes
- Low operational cost
- Moderately low capital cost
- Good with long chain PFAS and some small chain PFAS

- Cannot remove PFBA
- Not as effective on small chains-PFAS
- Competing Ions can reduce useful life
- Recommended as once through – no regeneration
- Fluffing of PFAS can occur on resin
- Large amounts of waste to dispose of
- Concentrated waste stream if regeneration allowed



https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Technical%20Reports/Drinking-Water-Treatment-PFAS.pdf?ver=2020-11-10-100726-250

GAC	AIX
~10-minute EBCT	~3-minute EBCT
Larger & taller infrastructure footprint	Smaller & shorter infrastructure footprint
Typical bed life: 50-120,000 bed volumes	Typical bed life: 250-300,000 bed volumes (last longer)
GAC media unit cost is lower	AIX media unit cost is higher
Less effective for short chain PFAS	Effective for a wider range of PFAS
Well established technology	Not as extensively practiced as GAC
Initial backwash is required	Backwash recommended with some resins
Spent GAC is reactivated	Spent AIX is incinerated
Remove other organic pollutants	Remove other anionic compounds
Little to no corrosion control impact	Likely impact on chloride-to-sulfate ratio for corrosion control
Coconut shell based and coal based GAC can both effective	Not all AIX products achieve effective PFAS removal

Note: Pretreatment may be needed for both technologies to increase media life span

https://www.cdmsmith.com/en/Client-Solutions/Insights/Comparing-Common-PFAS-Treatment-Options

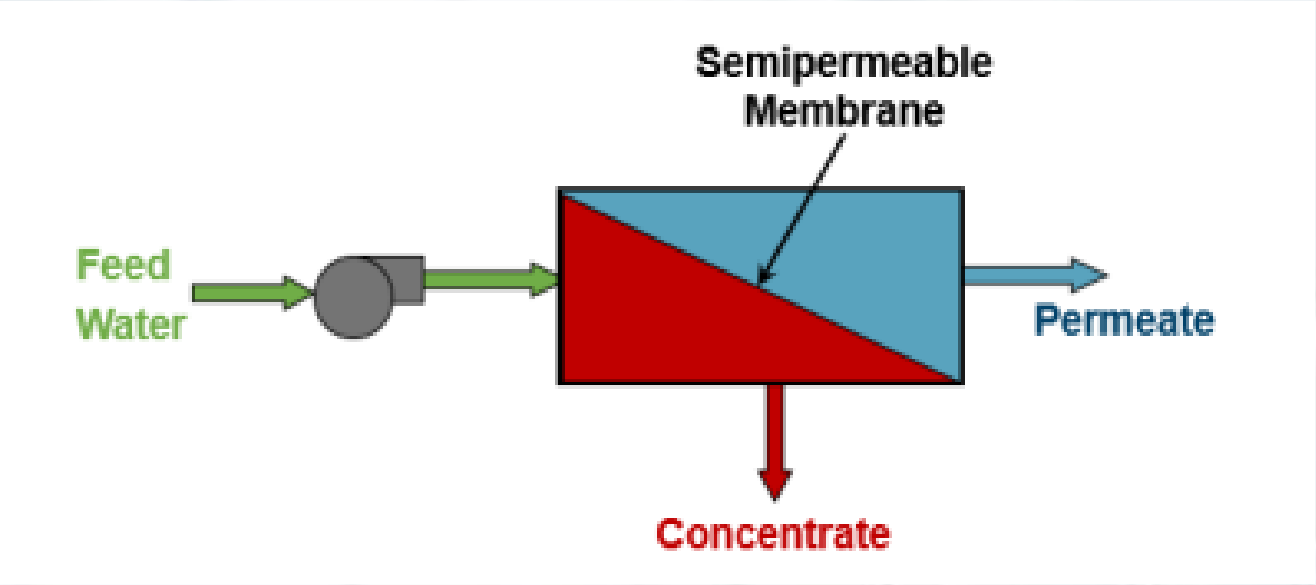
Membrane Filtration for PFAS
Reverse Osmosis or Nanofiltration

Pros

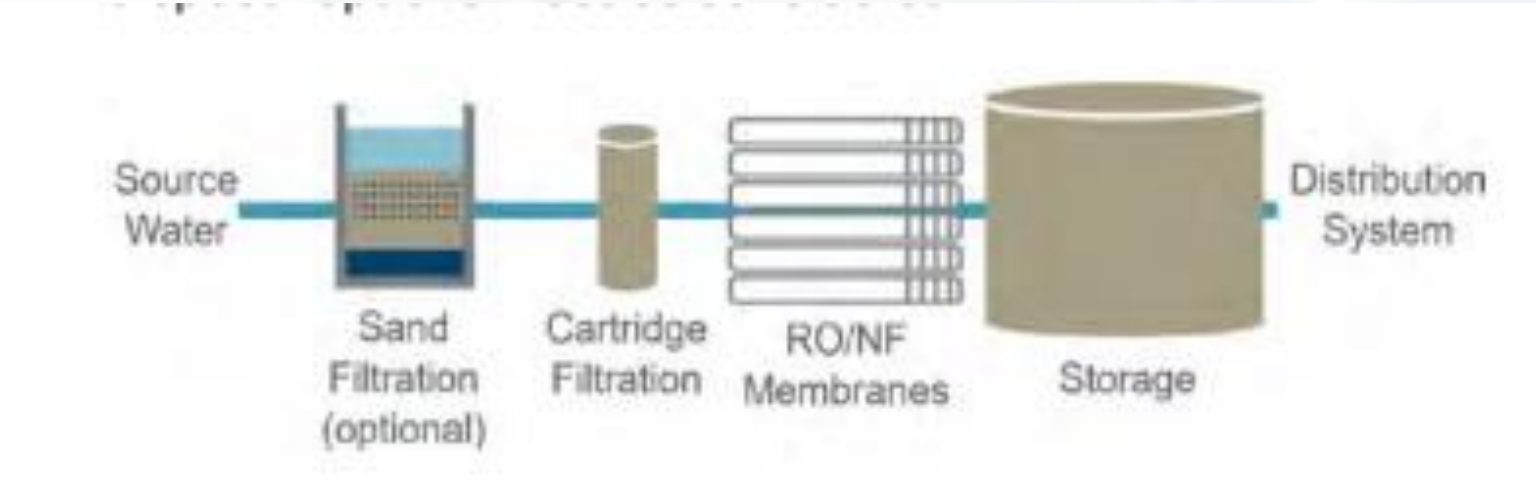
- Good for multiple contaminants
- Well understood technology
- Low contact time
- Low Maintenance

Cons

- Concentrated Waste Stream
- Spent membrane disposal
- 80-90% removal efficiency
- Not as effective on short chain PFAS
- Creates corrosive water – must buffer
- High Energy consumption
- Higher capital cost.
- Higher O&M costs



Water Treatment Process Train Using NF or RO Membranes

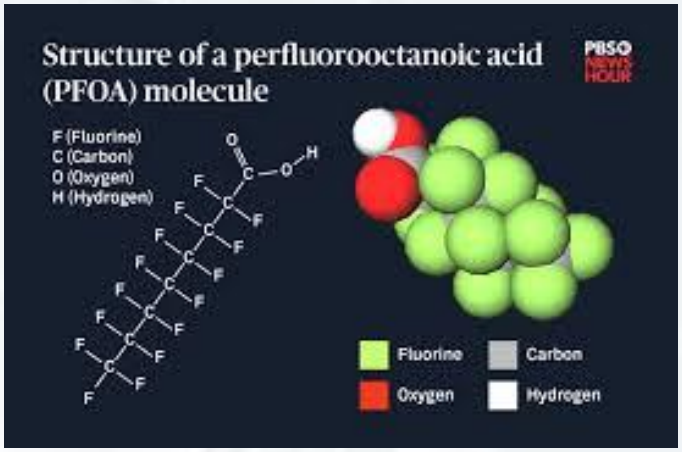


PFAS INNOVATION

"Our need will be the real creator" Plato's Republic
"Necessity is the mother of invention" English Proverb

WHAT MAKES PFAS INNOVATION SO DIFFICULT

"Fluorine-Carbon bond is one of the strongest in organic chemistry. And PFAS unfortunately, is a short chain of fluorine-carbon bonds," says Nigel Sharp, University of Alaska – Fairbanks entrepreneur in residence and Aquagga co-founder and CEO.



This bond makes for a recalcitrant molecule that bioaccumulates making removal difficult

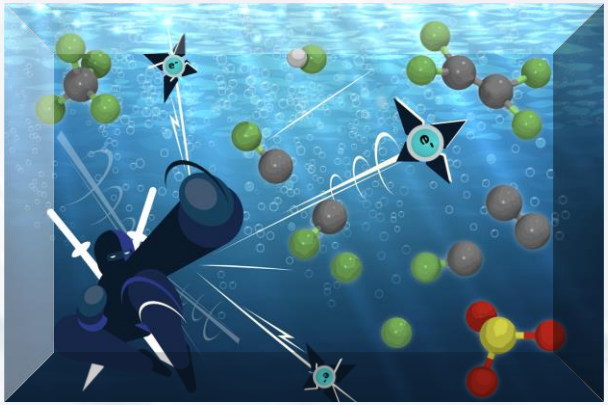
Breaking the bond is not often enough, as the compounds created from the break can be more harmful than the PFAS itself.

"mass is neither created nor destroyed in chemical reactions"
The Law of Conservation of Mass

PFAS INNOVATION

FOCUS OF INNOVATION

- Electro Chemical
  - Electrochemical oxidation
  - Plasma technologies
- Advanced Oxidation
  - Supercritical water oxidation
- Bioremediation



AEC
AQUEOUS ELECTROSTATIC CONCENTRATOR

The BioLargo
Family of Companies

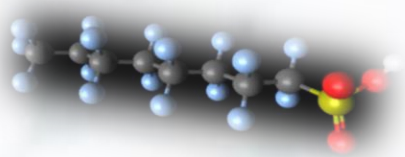
BioLargo, Inc. is a sustainable science, technology & full-service enviromental engineering company that **makes life better** by delivering world-class products and services across a broad range of industries, with a drive to deliver clean water, clean air, and advanced antimicrobials for healthcare.

BioLargo
Engineering, Science & Technologies

- Trusted industry veterans
- Innovators
- Solutions providers
- System integrators
- Project managers
- Science collaborators

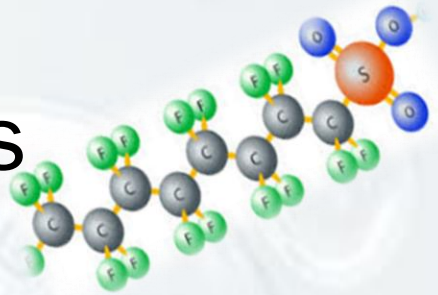
Experience Serving Big Clients

The Hypothesis



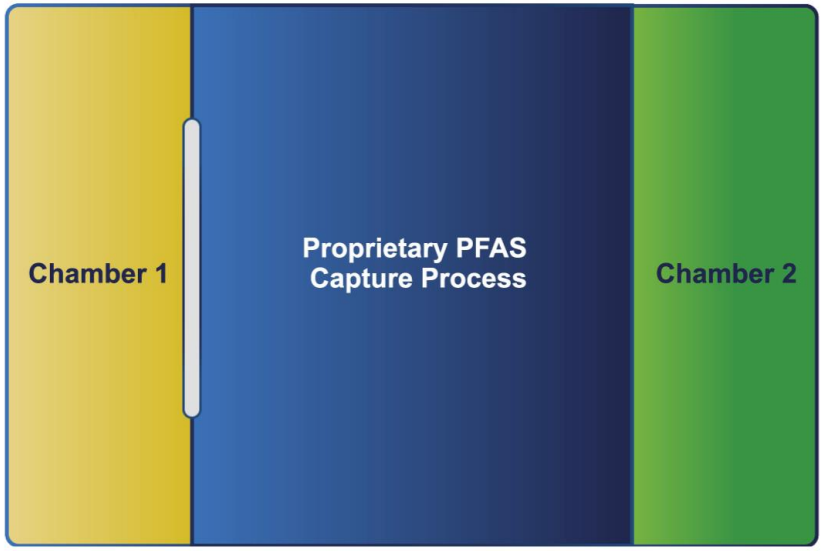
- The AEC Device will produce a concentrated stream and a PFAS depleted stream.
- Goal is to produce a depleted stream that meets all existing and proposed standards.
- Multiple stages would have the potential to produce DI quality water
- Removal would remain a low energy process
- The cost of removal would remain affordable

The Results

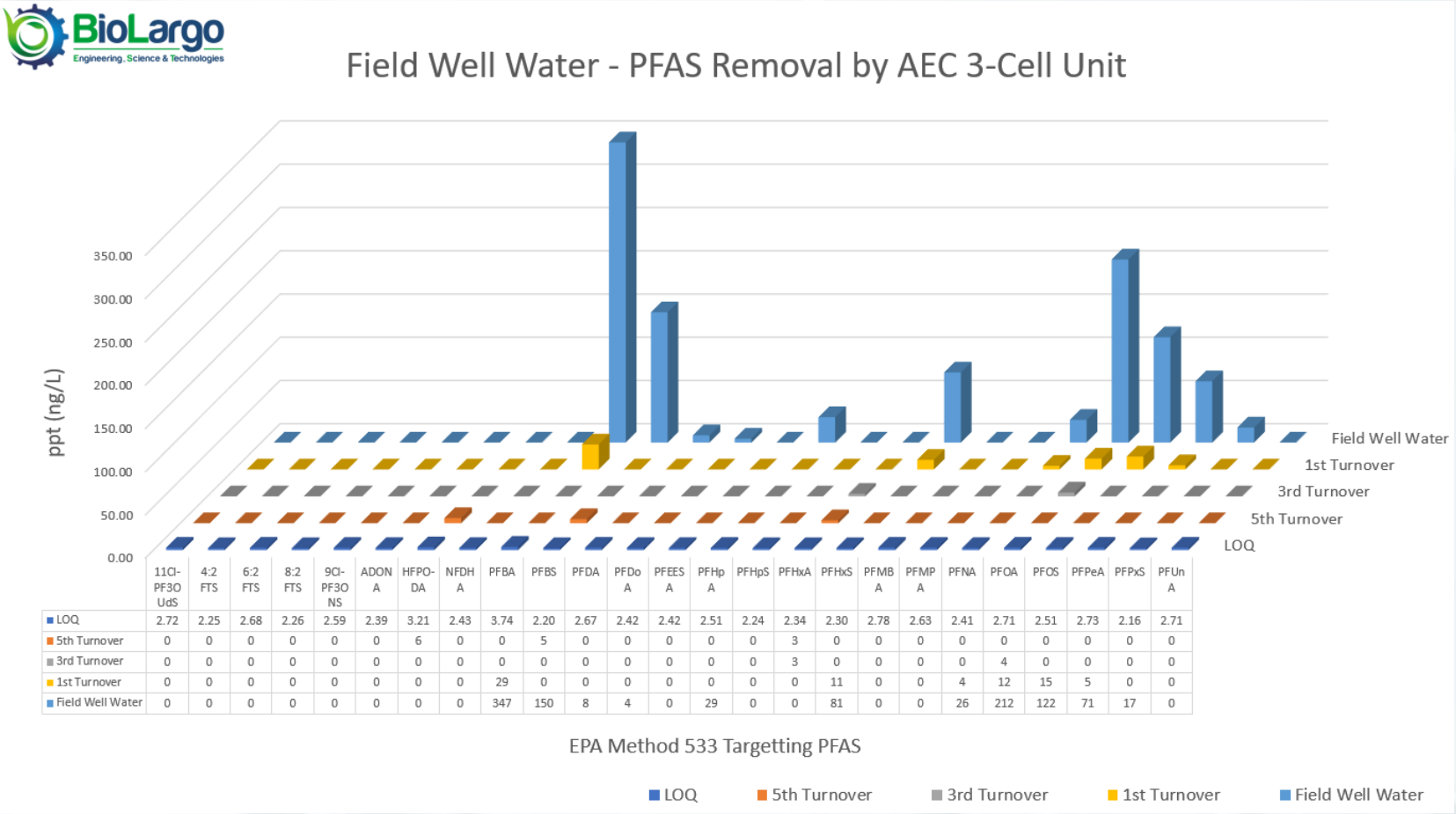


- ✓ No Concentrated Stream – PFAS stays on Membrane
- ✓ System has shown ability to effectively concentrate PFOA and PFOS over 99% in a single stage
- ✓ Side benefit of low energy desalination observed.
- ✓ Destruction of PFOA and PFOS observed in anode chamber.
- ✓ Energy costs as low as 30 cents per 1,000 gallons.

How it works


Chamber 1
Proprietary PFAS
Capture Process
Chamber 2
Incoming water stream with PFAS

RESULTS



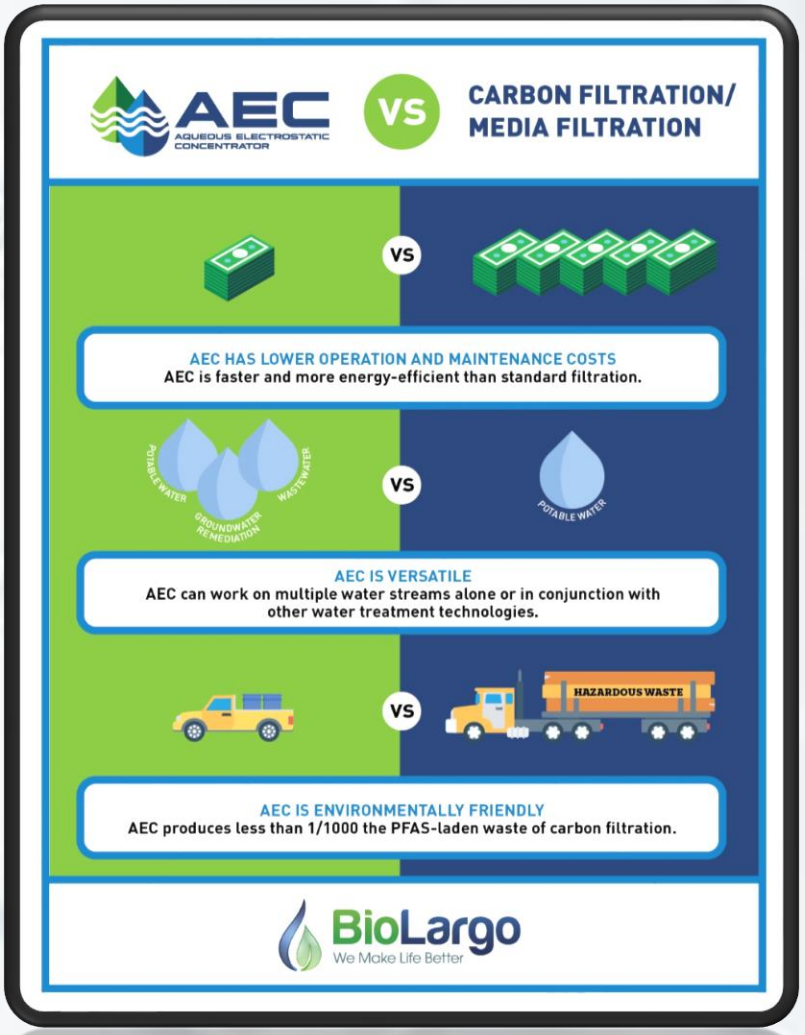
	11Cl-PF3OUdS	4:2 FTS	6:2 FTS	8:2 FTS	9Cl-PF3ONS	ADONA	HFPO-DA	NFDHA	PFBA	PFBS	PFDA	PFDoA	PFEESA	PFHpA	PFHpS	PFHxA	PFHxS	PFMBA	PFMPA	PFNA	PFOA	PFOS	PFPeA	PFPxS	PFUnA
LOQ	2.72	2.25	2.68	2.26	2.59	2.39	3.21	2.43	3.74	2.20	2.67	2.42	2.42	2.51	2.24	2.34	2.30	2.78	2.63	2.41	2.71	2.51	2.73	2.16	2.71
5th Turnover	0	0	0	0	0	0	6	0	0	5	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
3rd Turnover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	4	0	0	0	0
1st Turnover	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	11	0	0	4	12	15	5	0	0
Field Well Water	0	0	0	0	0	0	0	0	347	150	8	4	0	29	0	0	81	0	0	26	212	122	71	17	0

AEC Advantages

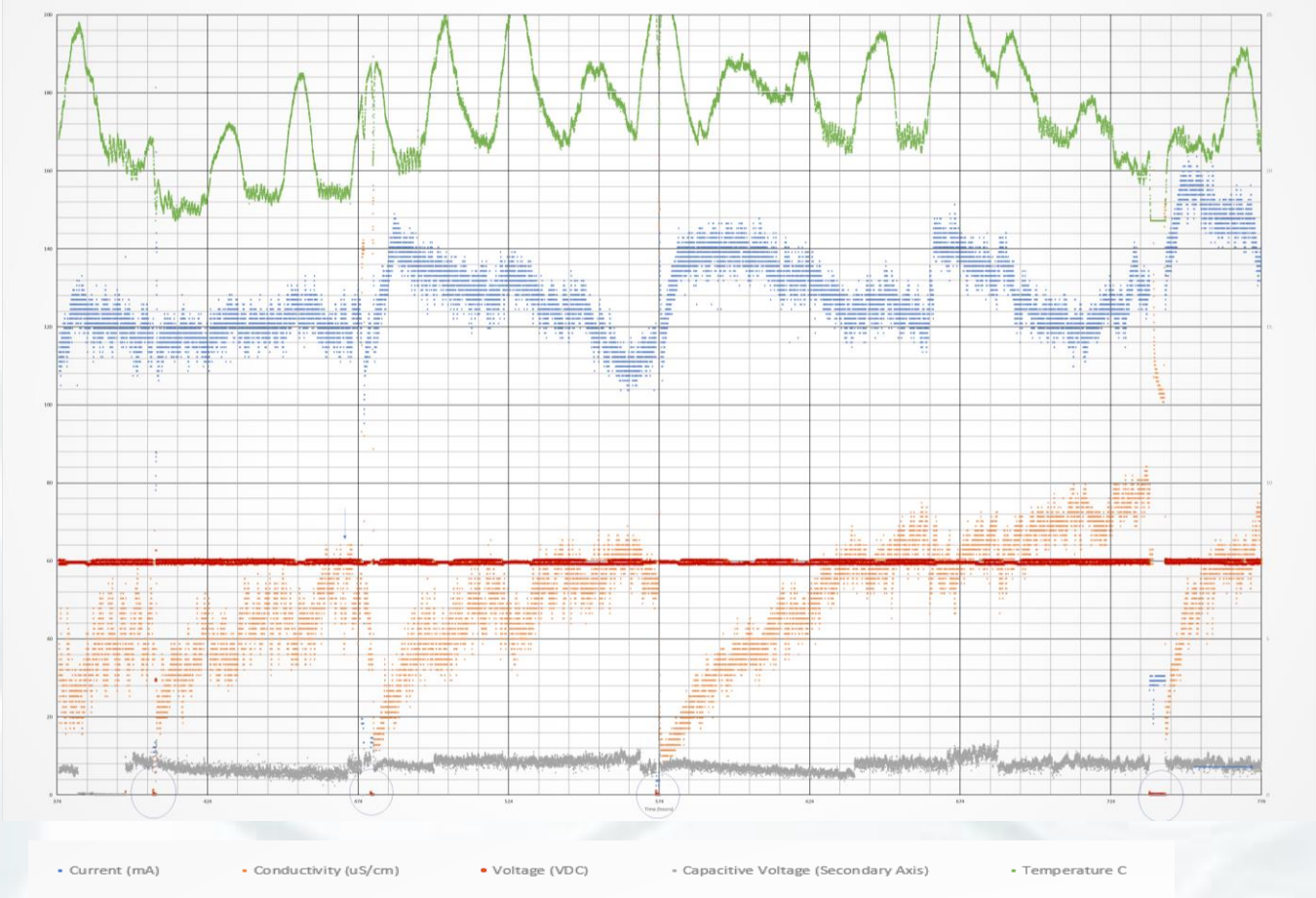
- Lower energy requirements to remove PFAS due to separation and collection instead of destruction
- No moving parts
- Extended operating life – anions and cations pass to side chambers. Only PFAS compounds are captured
- Extremely high capacity
  - At 70 ppt inlet PFOA, a 10,000 GPM unit would operate 3.8 Million hours to capacity
  - Filtering 2,304,000,000,000 gallons.
- Easy disposal of PFAS containing membranes- maintenance contract

AEC Disadvantages

- New technology – no long-term data
- Still has consumable parts, removal not destruction
- Operational costs based influenced by other constituents in the water
- Requires maintenance contract
- Requires electricity



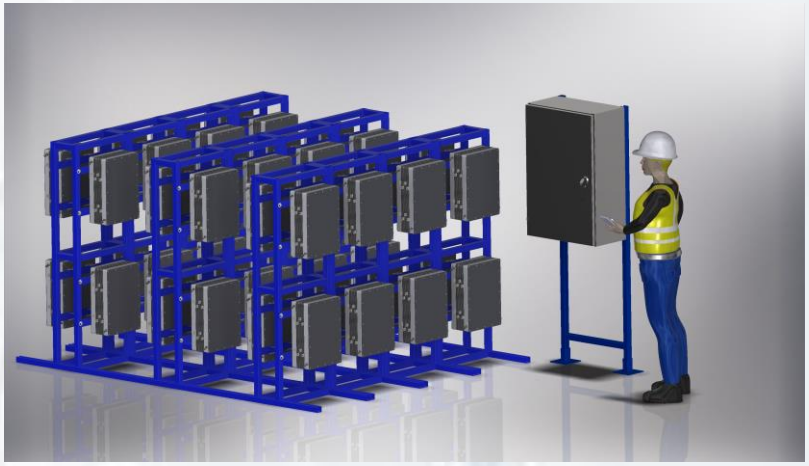
System Measures Important Performance Variables



Additional Measurements include

- Continuous PFAS removal measurement
- Excess Charge Drain
- Tunable

Technology Comparison



GAC Technology - single pass			AEC Technology single pass		
GPM	Estimated Foot print	Estimated Disposal Weight (lbs) when spent	GPM	Estimated Foot print (Ft)	Estimated Disposal Weight (lbs) when spent
50	6x6x9	1,000	50	10x12x10	85
100	8x8x10	2,000	100	12x12x10	170
300	11x11x12	10,000	300	15x15x10	510
1,000	16x16x120	80,000	1,000	20x20x10	1,700
10,000	150x70x20	200,000	10,000	60x70x12	17,000

What is the PFAS Testing Program (PTP)

Multi-phased approach to ensure
"proof of concept" and "piece of mind"

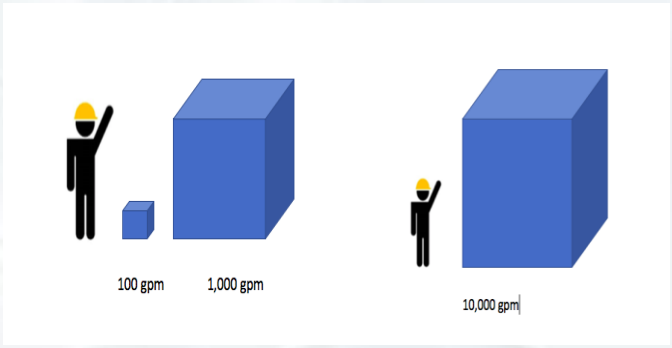
- ✓Bench Scale Pilot testing in "Water Lab"
- ✓On-site Pilot Testing
- ✓Full Scale Installation
- ✓Service Exchange Maintenance Program

Current Commercialization

- PFAS Testing Programs and trials
  - Canadian Province
  - Governmental Agencies
  - Multiple State samples including WI, CA NJ, and others

AEC
AQUEOUS ELECTROSTATIC CONCENTRATOR

- AEC installations = large capital expenditure projects/ Low Operational costs
  - Design
  - Equipment
  - Construction
  - Maintenance



Want to Learn More

October 4-7, 2022, Green Bay, WI

WISCONSIN WASTEWATER OPERATORS ASSOCIATION

ICS GROUP

Booth#
802, 804, 806

WWOA TECHNICAL PROGRAM SCHEDULE Tuesday, October 4, 2022 Pre-Conference Workshops			
		Workshop #1	**Workshop #2**
		Moderator: Rick Mealy Grand ABC/FGH	Moderator: Josh Voigt Grand ABC/FGH
1:00 -4:00 pm		*Rick Mealy / Tom Trainor* *WWOA / WI DNR*	*Tonya Chandler* *BioLargo Engineering, Science & Technologies, LLC*
		The Fine Art of BOD Analysis	**PFAS: History, Treatment, and Regulatory Direction**

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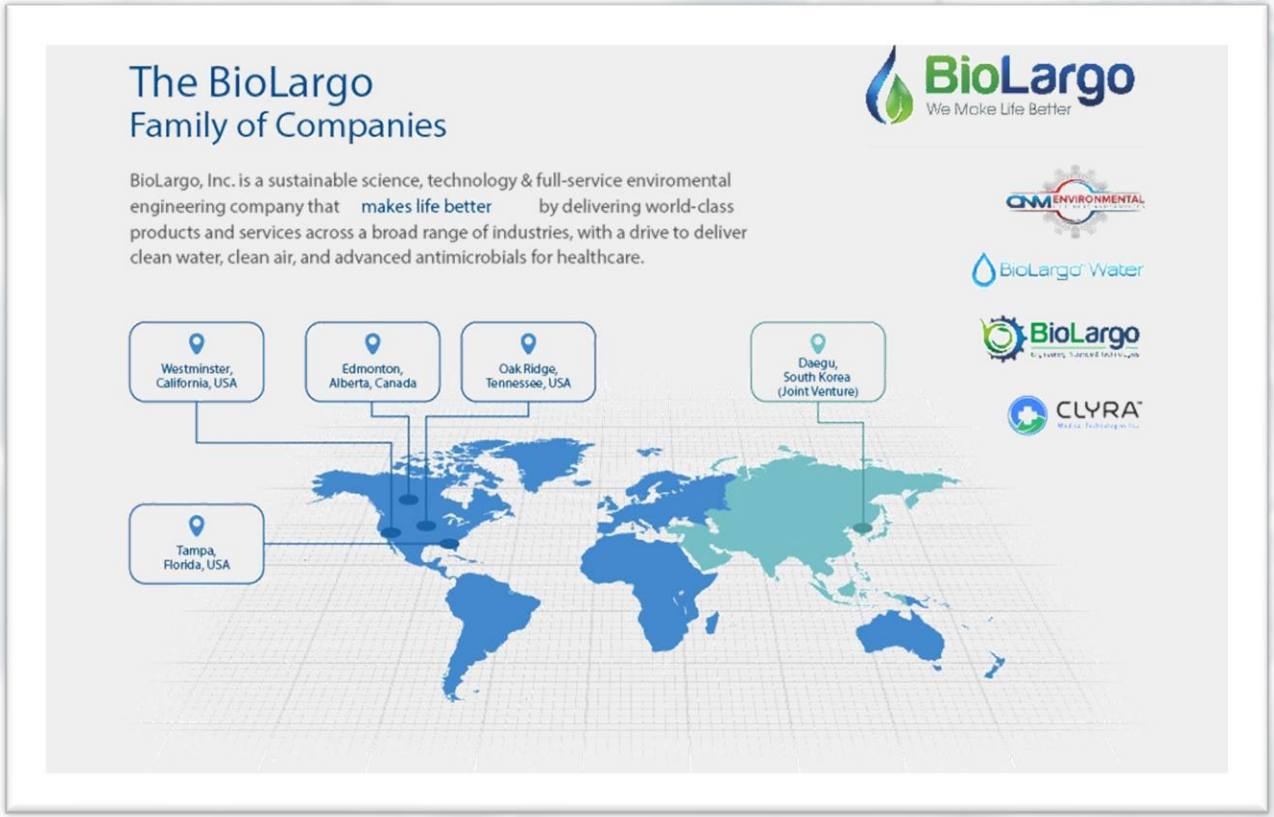

Contact Information