UNDERSTANDING PFAS
A Comprehensive Exploration
AND
PFAS Destine For Destruction

Exploring Health Risks, Research, and Remediation Efforts

OVERVIEW

- Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are manmade chemicals with strong resistance properties.
- PFAS have leached into the environment through various industries and products, posing potential health risks.
- Exposure to PFAS can occur through contaminated water, food, products, and air.
- PFAS molecules have a persistent nature in the environment due to the strong carbon-fluorine bond, leading to concerns about bioaccumulation.
- PFAS are a group of nearly 15,000 synthetic chemicals, according to a chemicals database maintained by the U.S. Environmental Protection Agency.
- Different forms of disposing PFAS using technology and their PROS and CONS.
- PHAS Destine for Destruction with BME Environmental remediation process technology.

PFAS CONTAMINATION EXPOSURE

- PFAS chemicals have leached into the environment from Landfills, Manufacturers, Municipal WasteWater Treatment Plants and Airports. See page 4 to see how industries leach PFAS into the ecosystem.

- Military and Air Force bases, Fire Fighting (Foam) operation sites and many other locations. See page 5 to see how airport firefighting foam leaches into the ecosystem.

- Exposure to PFAS can occur through contaminated ground water, food, household products, fires extinguishers, plastics, paper products and packaging, air and many other objects.

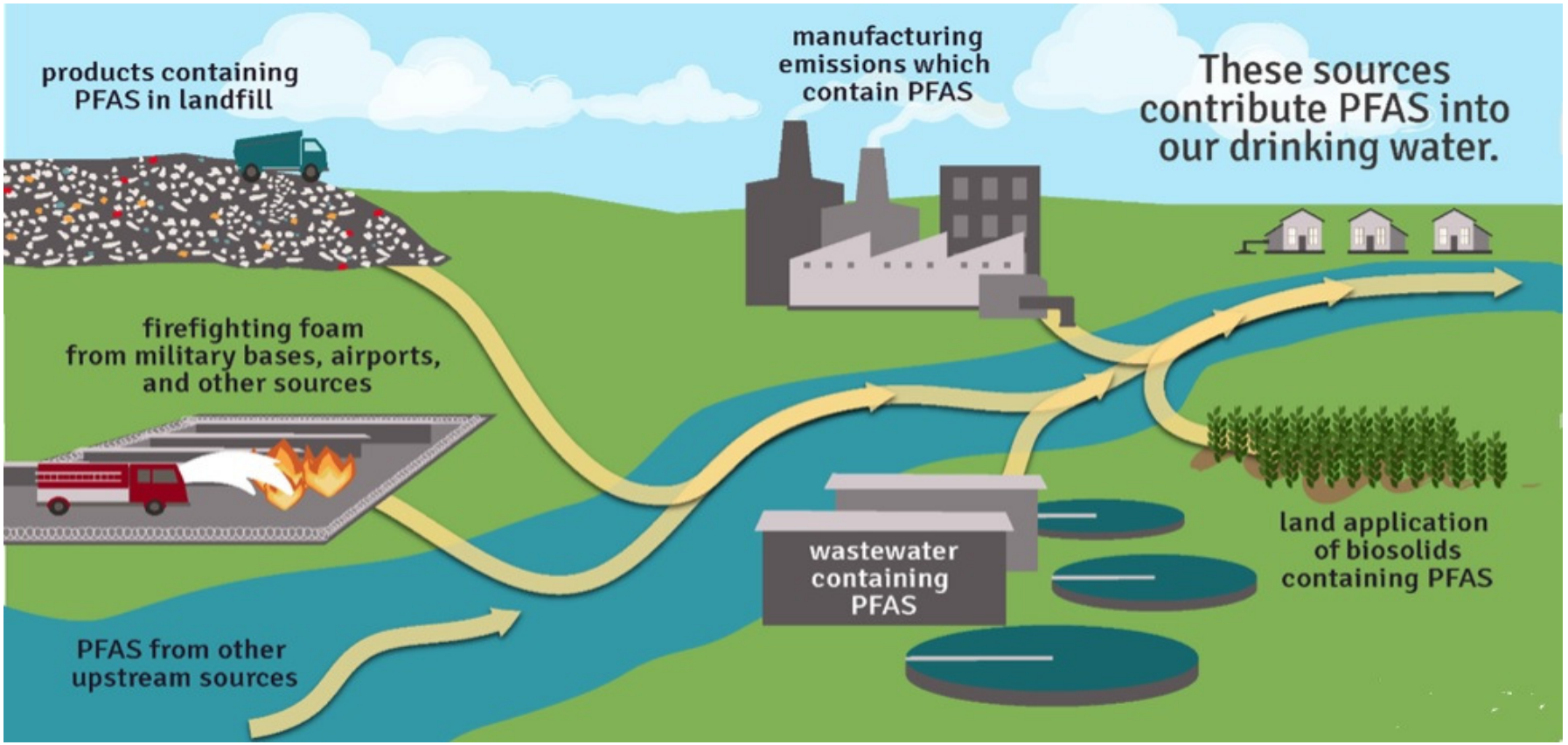
- Over 57,400 sites throughout the United States are contaminated with PFAS, see map page 6.

- PFAS molecules have a strong carbon-fluorine bond, making them persistent in the environment.

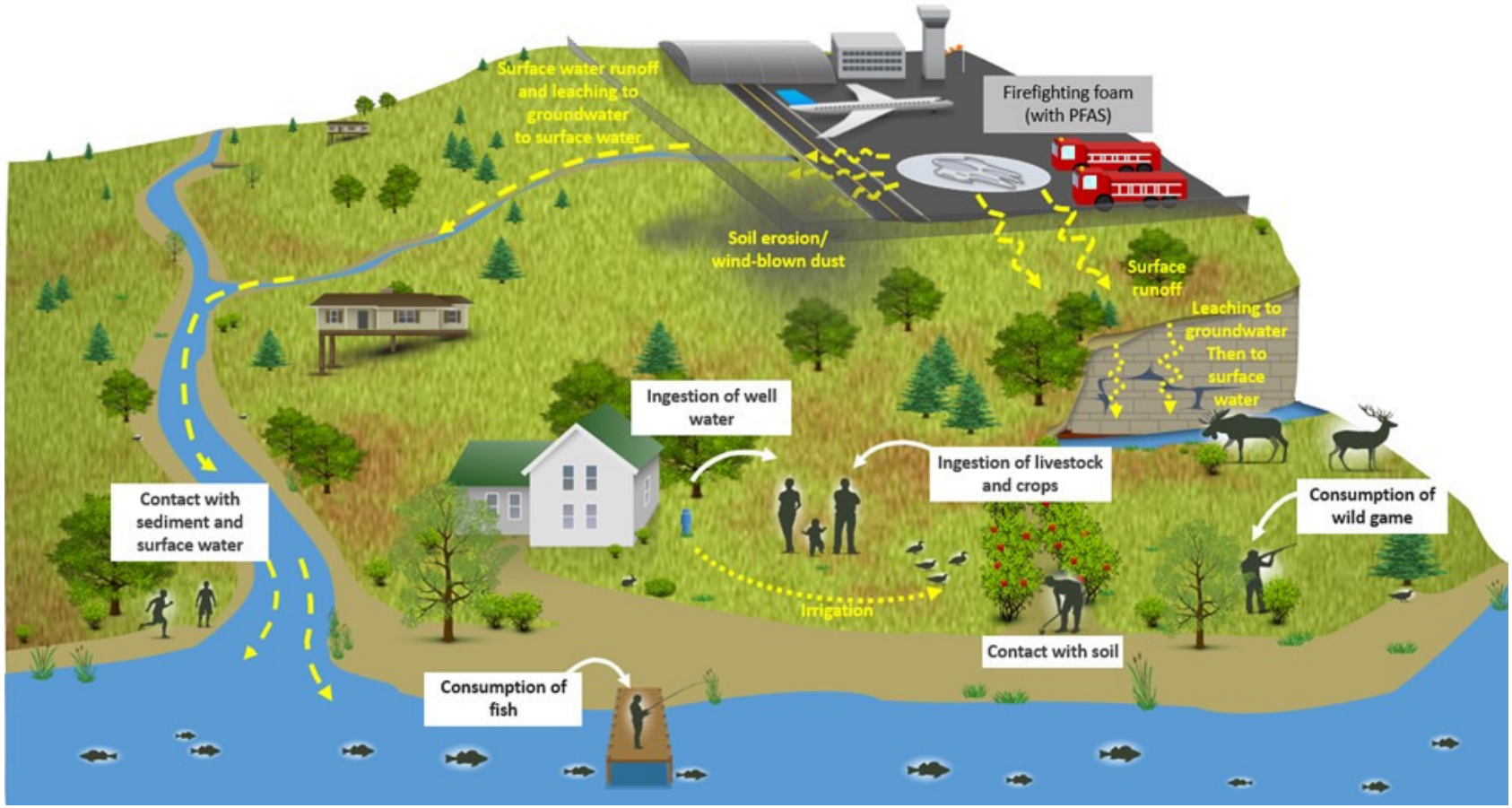
- Studies found PFAS in the blood of 97% of many humans and in animals.

- PFAS exposure may lead to adverse health outcomes such as effects on metabolism, pregnancy, children's cognition, neurobehavioral development, and the immune system.

HOW INDUSTRIES' PFAS LEACH INTO THE ECOSYSTEM



HOW AFFF FOAM WITH PFAS LEACHES INTO THE ECOSYSTEM



At least 57,400 contaminated facilities across the USA could be discharging toxic PFAS Compounds into the air, soil and water, according to an National Post article, see map below.

RESEARCH on PFAS HEALTH EFFECTS

Research is ongoing to understand the mechanisms of PFAS toxicity. The epidemiological evidence suggests associations between increases in exposure to (specific) PFAS and certain health effects on:

Heart
Increases in cholesterol levels (PFOA, PFOS, PFNA, PFDA)

Vaccine
Lower antibody response to some vaccines (PFOA, PFOS, PFHxS, PFDA)

Liver
Changes in liver enzymes (PFOA, PFOS, PFHxS)

Infant Birth Weights
Pregnancy-induced hypertension and preeclampsia (PFOA, PFOS)

Infant Birth Weights May Also Cause
Small decreases in birth weight (PFOA, PFOS)

Cancer Ribbon
Kidney and Testicular cancer (PFOA)

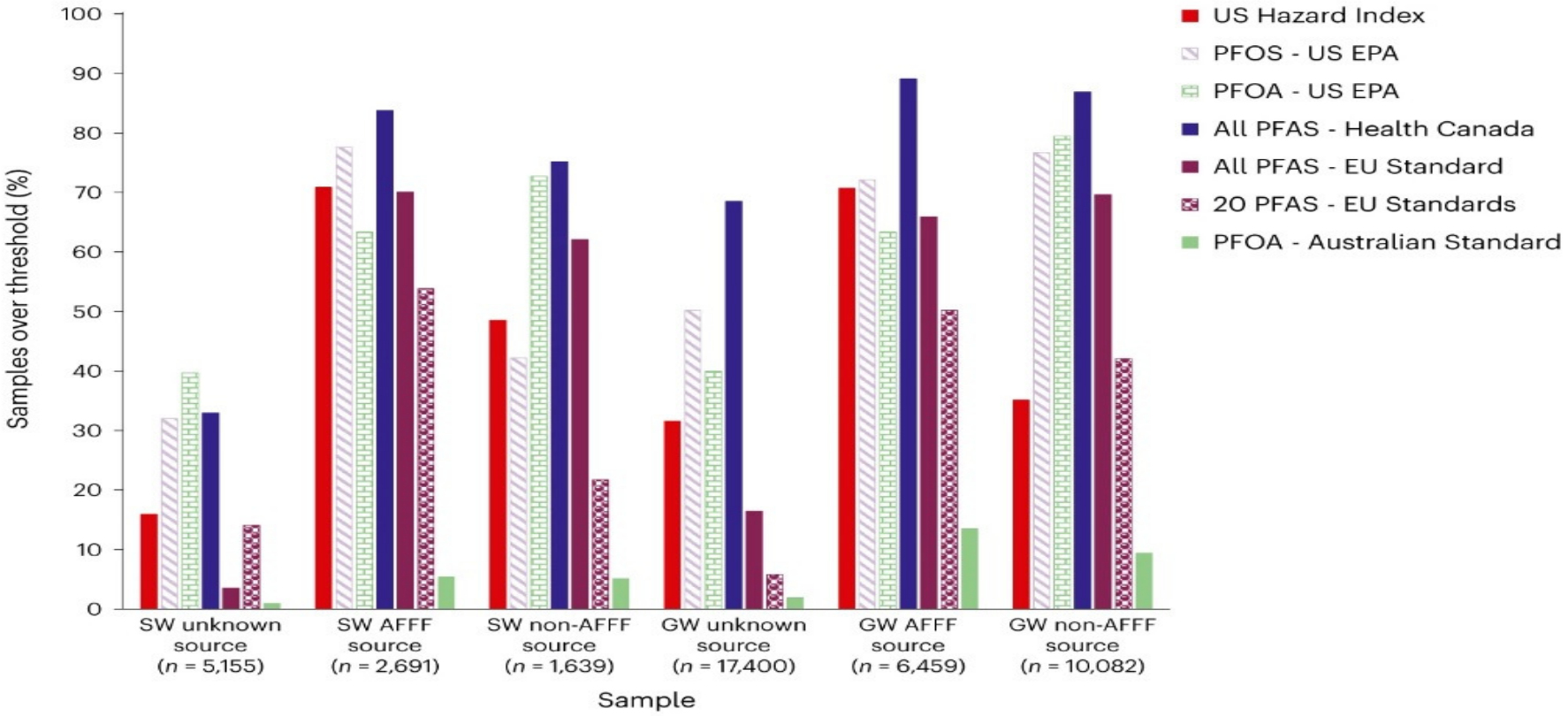
PFAS Health Effects may lead to adverse health outcomes such as effects on metabolism, pregnancy, children's cognition, neurobehavioral development, and the immune system

WORLDWIDE PHAS ISSUES

- PHAS is not only in North America, it is a Worldwide contamination issue.
- The WHO declared PFOA a category one human carcinogen.
- A publication in Nature Geoscience by a UNSW led international study, assessed the levels of PFAS at 45,000 sites around the world have been underestimated the burden of how wide spread PFAS has impacted the ecosystem.
- North America, Australia, Europe and China are PHAS hotspots.
- All hotspot countries, except United States, have incidence of exceeding PFAS Regulatory Standards or Advisories, see chart page 9.
- United States in 2024 lower their regulation standards for PHAS to 4 to 10 parts per trillion for drinking water.
- **Global cost to remove PFAS** from the environment is estimated to be more than the global GDP; if met the PFAS discharge rate, cost for remediating would be at **$20 to $7,000 trillion USD per year**, see chart page 10.

COUNTRIES EXCEEDING REGULATIONS

Incidence of exceedance of PFAS regulatory standards or advisories.



For samples where PFAS concentrations were below detection limits, a PFAS concentration was randomly assigned between zero and the detection limit.

Estimated scale of costs to remove PFAS from the environment at current emission rates

Thought exercise: if we scale-up PFAS remediation and destruction rates to match current emission rates, maintaining a steady-state global PFAS mass balance, how much would it cost and how could that inform decision making and policy?

Global Emission Rate (mass/year)		**Active Remediation and Destruction Costs ($ USD/mass)**		**Theoretical Steady-State Costs (mass/year)**
from all sources and product phases		to destroy PFAS from environmental media using existing technologies		to achieve global steady-state PFAS mass
20 to 10,000 tonnes PFAAs/year	X	$0.9 to $65 million USD/kg PFAA destroyed	=	$20 to $7,000 trillion USD/year for PFAAs only
10 to 10,000 times higher for total PFAS		Remediation cost poorly characterized for non-PFAA PFAS		Likely orders of magnitude higher for total PFAS

Conclusion: Removing PFAS from the environment at the rate we are adding it right now would cost more than the global GDP. Thus, remediation alone cannot manage global PFAS stocks.

REMEDIATORIAL PROCESSES OF PFAS

Electrocoagulation (EC) versus Filter Membrane and Incineration Pros & Cons

BME's EC Processing (Remediation)

- Unit remediates contaminants to an **inert state**
- No chemicals during processing
- Kills viruses, cysts, E.coli bacteria and other pathogens
- Generates less residue to remove from water
- Process time through unit is 60 seconds
- Can remediate large and fine particles
- Processes cleaner water and generates 80% less solids than Chemical systems
- Can remediate large majority of contaminants (see website for minimum list)
- No temperature effects the unit's operation
- No moving parts except a pump and a small footprint

Membrane and Incineration and Treated

- **Membrane** methods do not convert any contaminants to an inert state
- Membranes creates a secondary hazard when disposed in landfills
- Chemicals are required in some cases for processing
- Can't kill most pathogens
- Cannot treat many contaminants
- Generates more residue to remove from water if flocculants are used
- **Incineration** will cause air pollution
- Incineration still produces large volumes of waste solids & sludge
- Large footprint

ANALYSIS RESULTS USING EC TO REMEDIATE PFAS

- There has been several studies indicating absolute positive results remediating PHAS using an EC.

- Lipscomb University in Tennessee has concluded that the EC exceeded commercial activated carbon filtration by 40%. (Hindawi Journal of Chemistry Volume 2020, Article ID 1836264 October 28, 2021)

- Garver – Dole PFAS study using EC remediation resulted in PFOS (raw) from 140 ng/L to 3.1 ng/L. That is **97.7% destruction** of the toxic compound. USEPA new standard is 4 – 10 ng/L. (Eric Dole, PE, Water and Energy Practice Lead Study July 16, 2021)

- Inkster, Michigan - PHAS analysis study used various methods to remediate PHOS and PFOA using Aluminum and iron blades along with different processing times. **Best results was using Aluminum blades at a one minute processing rate and undetectable PHAS.** (Powell & Valicor Inkster Landfill – Enthalpy Analytical testing study, (Job No. 1120-722-1 PFAS Screen Nov. 15, 2022)

- SERDP Final Report – Degrade of PFAS Substances and Other Organic Contaminants in Groundwater – test results by EC showed using low current density removed 99% of PFOS and above 90% of PFOA. Having a lower pH level had great results. (SERDP Project ER18-1278 by AECOM, WOOD and University of Georgia. August 2021)

- BME Environmental owns a certified copyright on the engineered remediation process that encompasses the Electrocoagulation System.

- The advanced, energy efficient EC technology can process large flows from 50 GPM (189 LPM) up to 2,500 GPM (9,460 LPM) and more. BME's remediation process is cost effective compared to other methods. See Electrical Usage Table page14.

- The EC unit is CSA approved.

- Other than for pH adjustments and blade cleaning, NO CHEMICALS are used in the remediation process, resulting in significant reduction of sludge generation.

- Contaminant's molecular structure is converted into an oxidized non-hazardous state. Therein, the inert contaminant residue can be buried without harm to the ecosystem.

- A list of contaminants is posted on our website at www.bmeenvironmental.com

Energy Consumption Cost

Cost Effective Energy Savings of The EC

EC Size-gpm	Blade Cost/year	CIP Cost/year	Electrical Cost/year	Total Cost/year	Total Cost/5 years	Cost / 1,000 gallons
		Based on $0.05/KWH				
1.5	$ 103	$ 3	$ 82	$ 187	$ 936	$ 0.34
3	$ 205	$ 5	$ 164	$ 374	$ 1,872	$ 0.34
6	$ 410	$ 10	$ 329	$ 749	$ 3,745	$ 0.34
10	$ 684	$ 20	$ 657	$ 1,361	$ 6,806	$ 0.34
15	$ 1,026	$ 40	$ 1,314	$ 2,380	$ 11,901	$ 0.34
30	$ 2,052	$ 80	$ 2,628	$ 4,760	$ 23,802	$ 0.34
50	$ 3,421	$ 133	$ 4,380	$ 7,934	$ 39,671	$ 0.34
90	$ 6,157	$ 240	$ 7,884	$ 14,281	$ 71,407	$ 0.34
135	$ 9,236	$ 360	$ 11,826	$ 21,422	$ 107,111	$ 0.34
250	$ 17,104	$ 667	$ 21,900	$ 39,671	$ 198,353	$ 0.34
360	$ 24,630	$ 960	$ 31,536	$ 57,126	$ 285,628	$ 0.34
500	$ 34,208	$ 1,333	$ 43,800	$ 79,341	$ 396,706	$ 0.34
600	$ 41,049	$ 1,600	$ 52,560	$ 95,209	$ 476,047	$ 0.34
2,400	$ 164,197	$ 6,400	$ 210,240	$ 380,837	$ 1,904,187	$ 0.34

Example

EC Size-gpm	Blade Cost/year	CIP Cost/year	Electrical Cost/year	Total Cost/year	Total Cost/5 years	Cost / 1,000 gallons
600	$ 41,049	$ 1,600	$ 52,560	$ 95,209	$ 476,047	$ 0.34
		Based on $0.05/KWH				
	43%	2%	55%			

1,000 Gallons = 3,785 Litres = $0.34
1 Litre = $0.00009

Based on 22 hour/day operaton
These cost will vary depending on the water constituents

BME Environmental

Typical Plant Setup

50 Gallon Per Minute Plant
EC Unit at top of Platform

BME Environmental

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