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Eliminating PFAS: Advances in Destructive Technology

ICPRB Potomac River Conference

September 22, 2022

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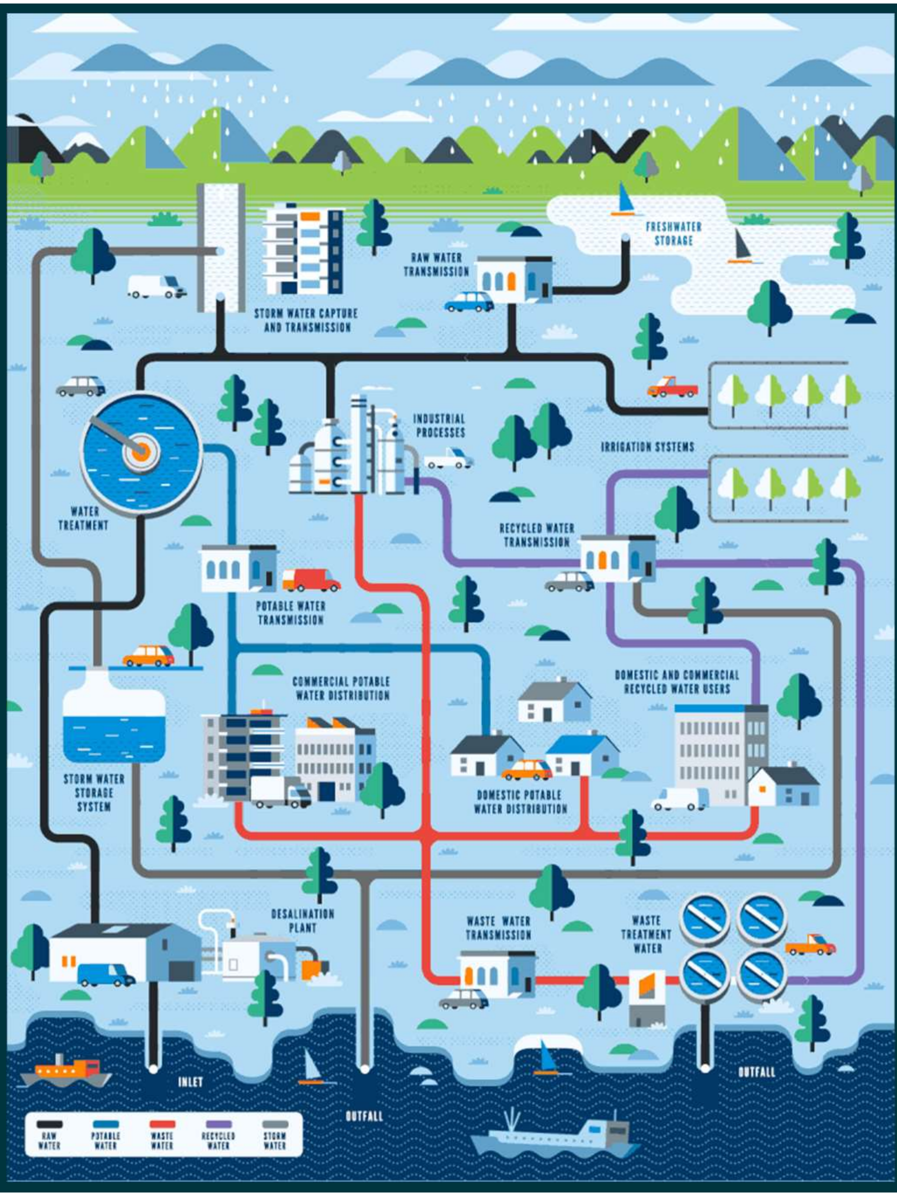
Agenda

- PFAS in the One Water Cycle
- PFAS Treatment Approaches
  – PFAS Separation Technologies
  – PFAS Destruction Technologies

In this presentation, the identification of commercial treatment options is not an endorsement of any technology or approach.

Technology selection ALWAYS requires a project-specific evaluation.

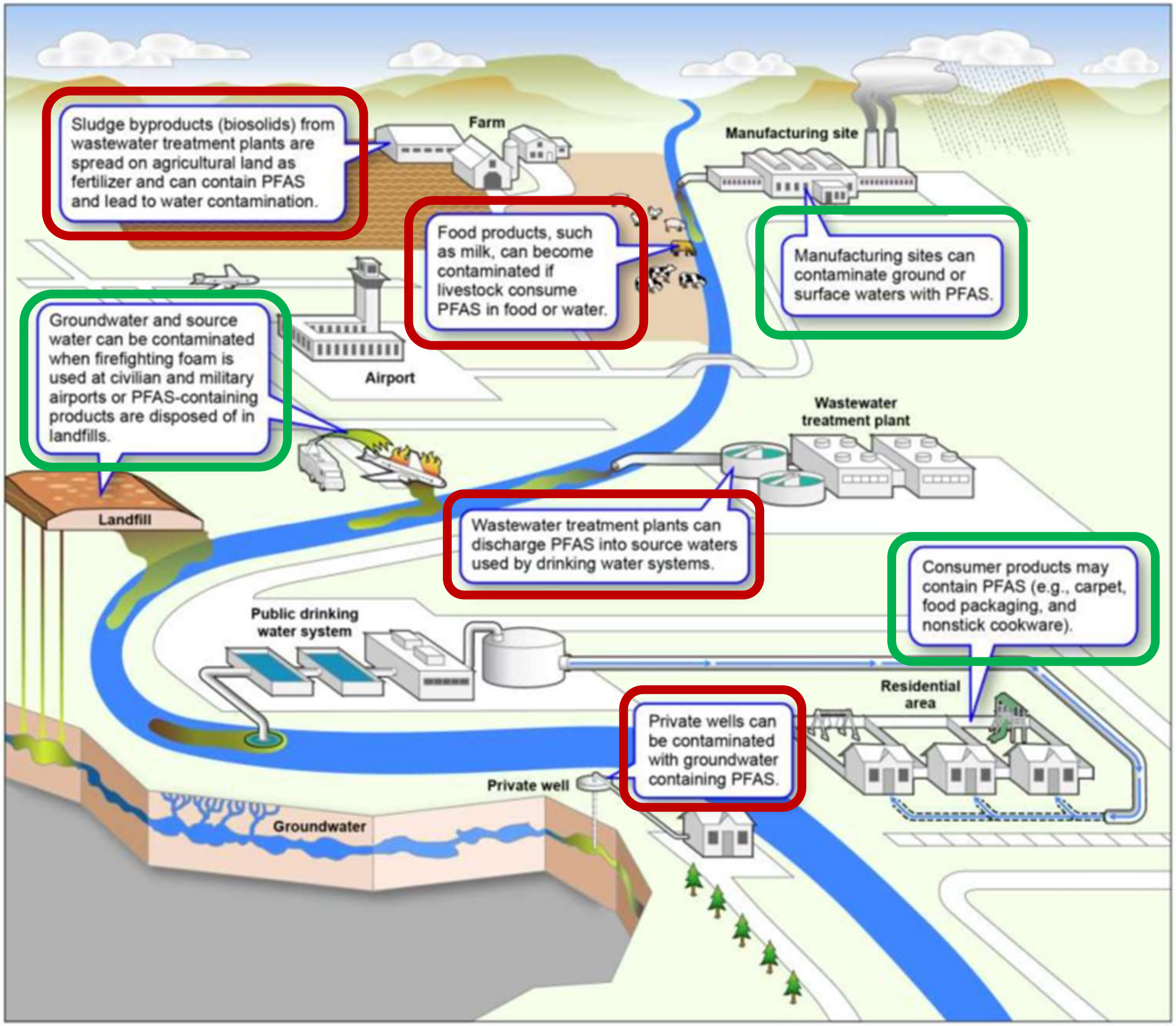


PFAS in the One Water Cycle

PFAS: One Water Perspective

PFAS Sources

PFAS Impacts



Source: GAO. | GAO-21-37

PFAS Treatment Approaches

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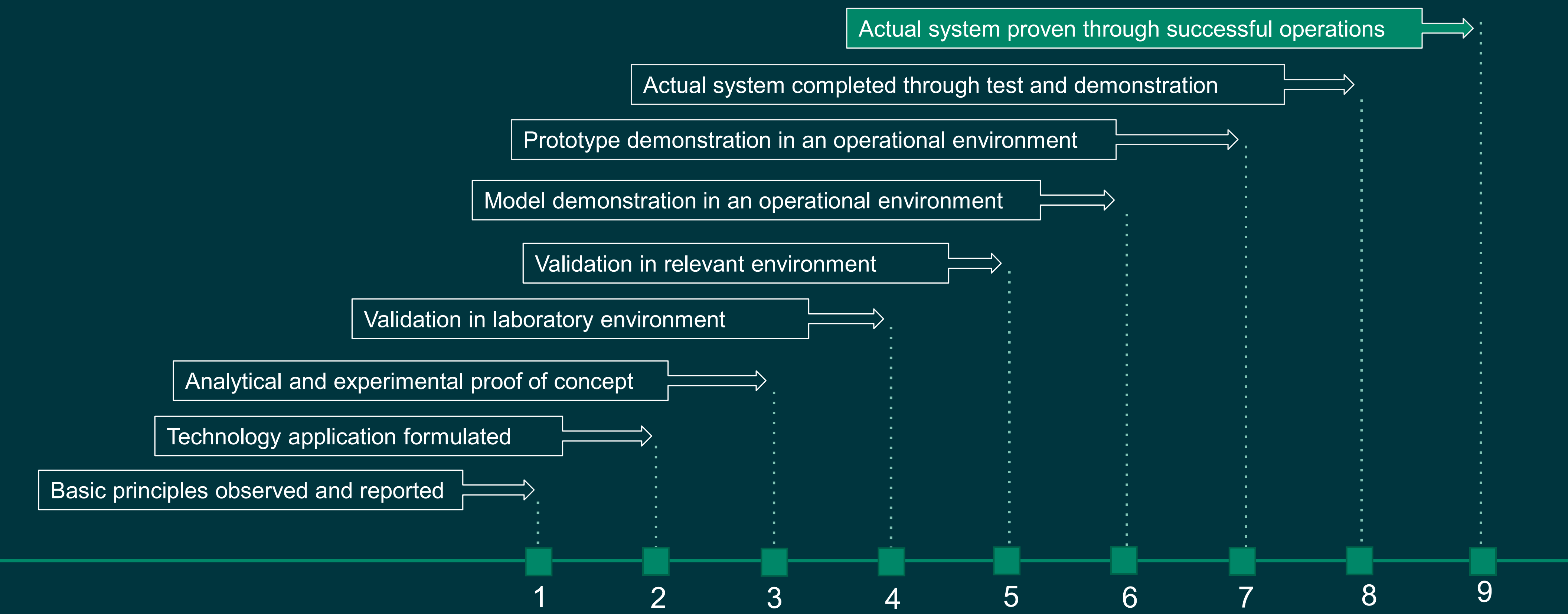
Technology Readiness Level Advancement

Reference: https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf

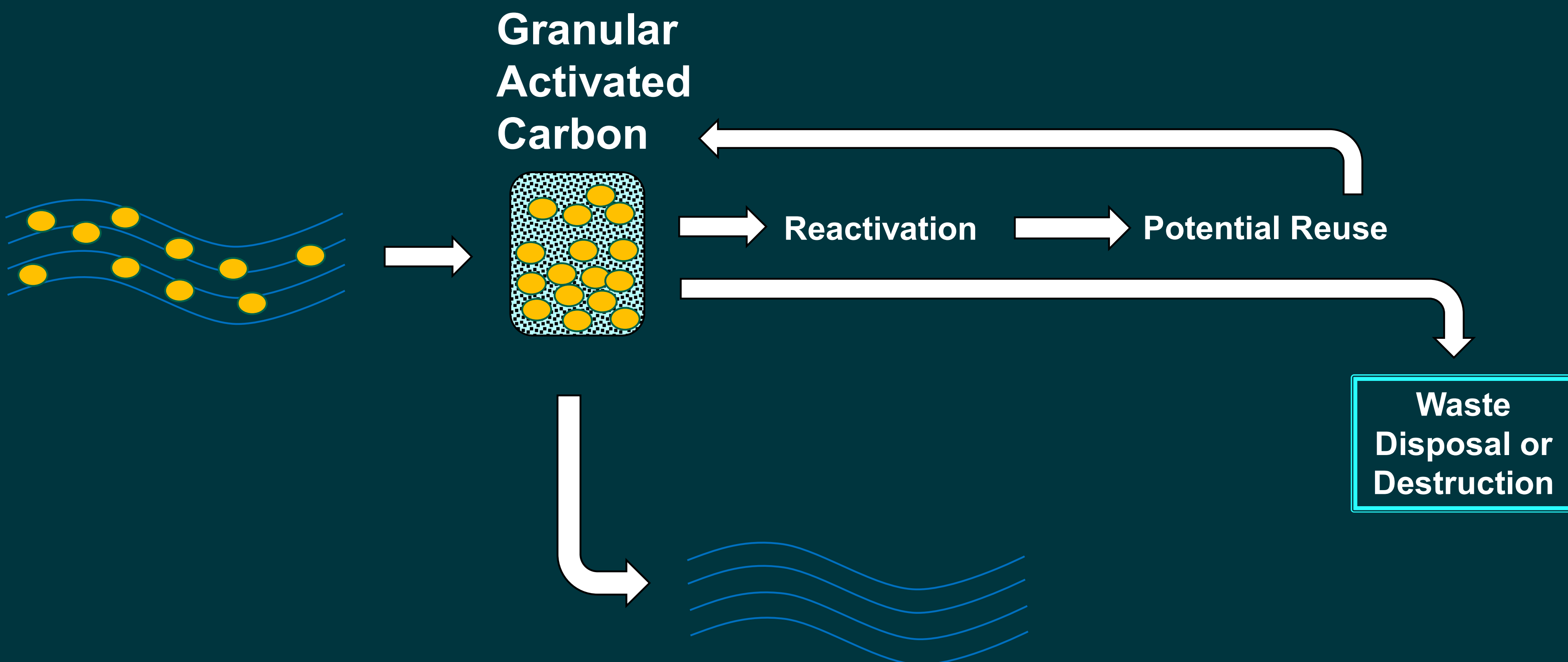


PFAS Treatment Technologies

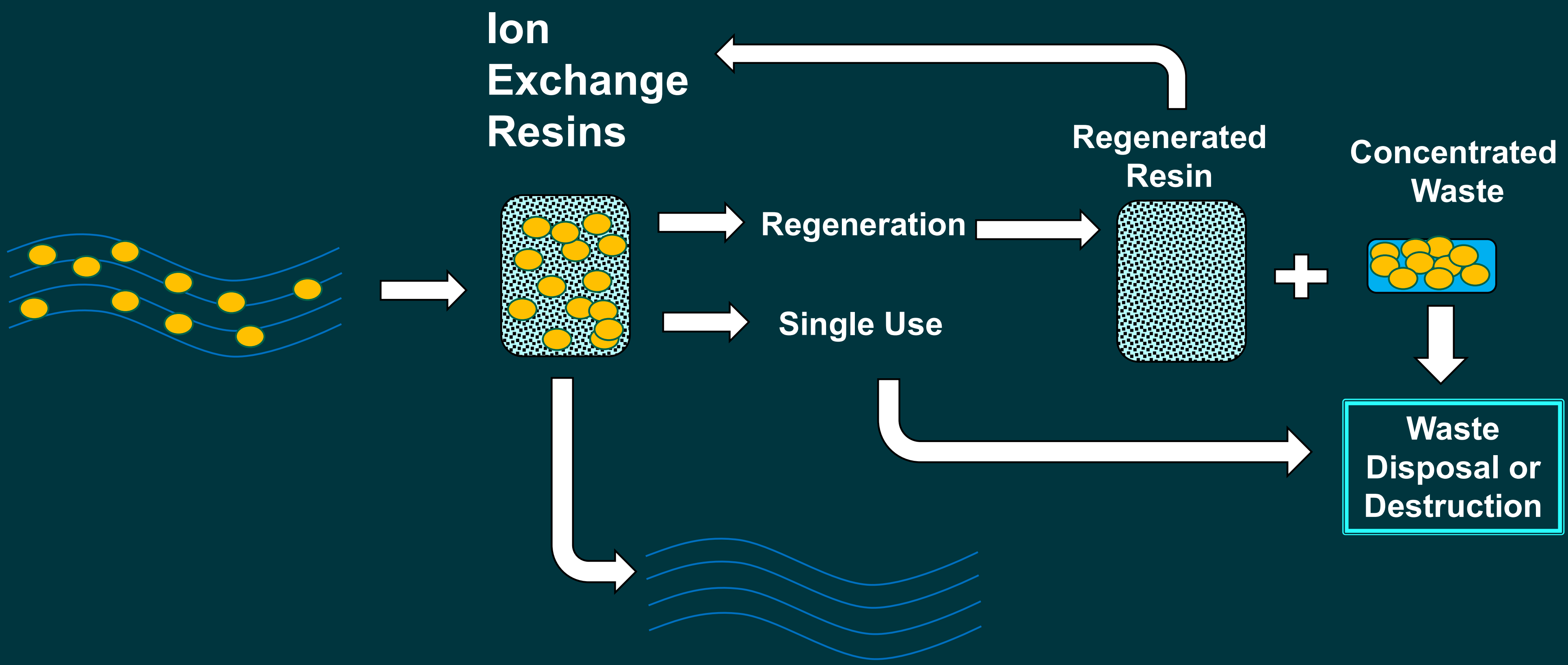
	Ex-Situ	In-Situ
Separation	• **Granular activated carbon** • **Ion exchange resin** • **Reverse osmosis, Nanofiltration** • **Foam fractionation** • *Novel sorbents* • *Chemical precipitation and flocculation* • *Electrocoagulation*	• **Colloidal activated carbon** • **Powdered sorbent** • **Foam fractionation** • *Phytoremediation* • *Thermal desorption*
Destruction	• **Thermal (incineration/ cement kiln)** • *Advanced oxidation (SCWO)* • *Electrochemical oxidation* • *Plasma* • *Sonolysis* • *Mechanochemical degradation*	• *Chemical oxidation* • *Chemical reduction* • *Enzyme catalyzed oxidation* • *Microbial degradation*

Commercially available technologies *Developing technologies*

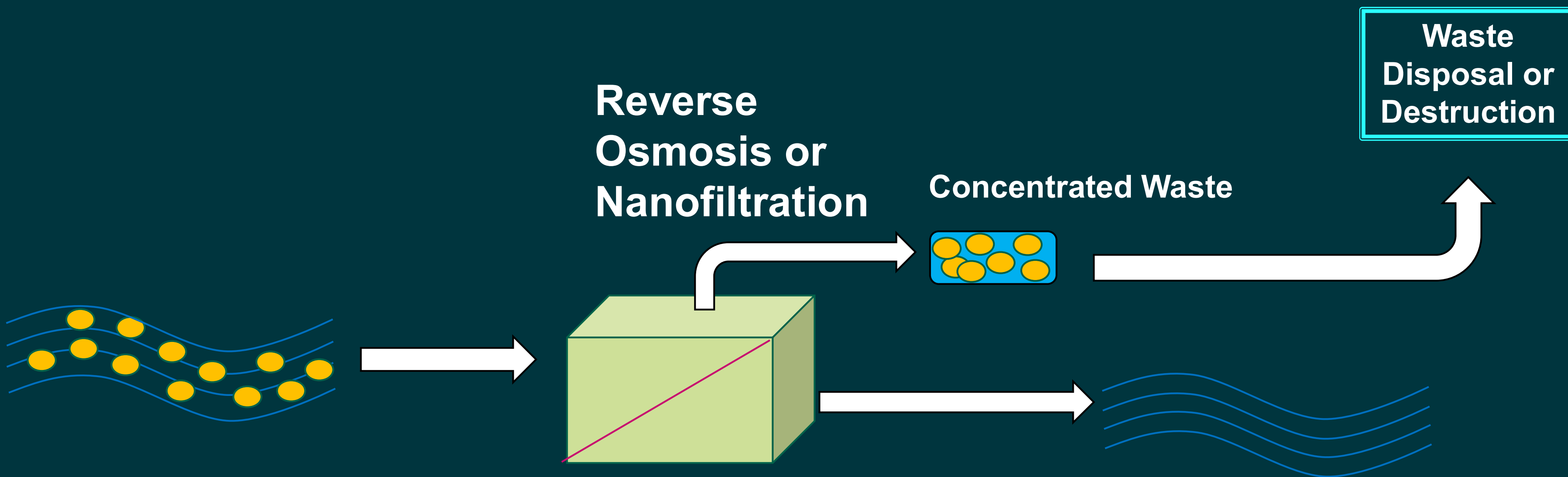
PFAS Separation Treatment Technology – Transfer PFAS



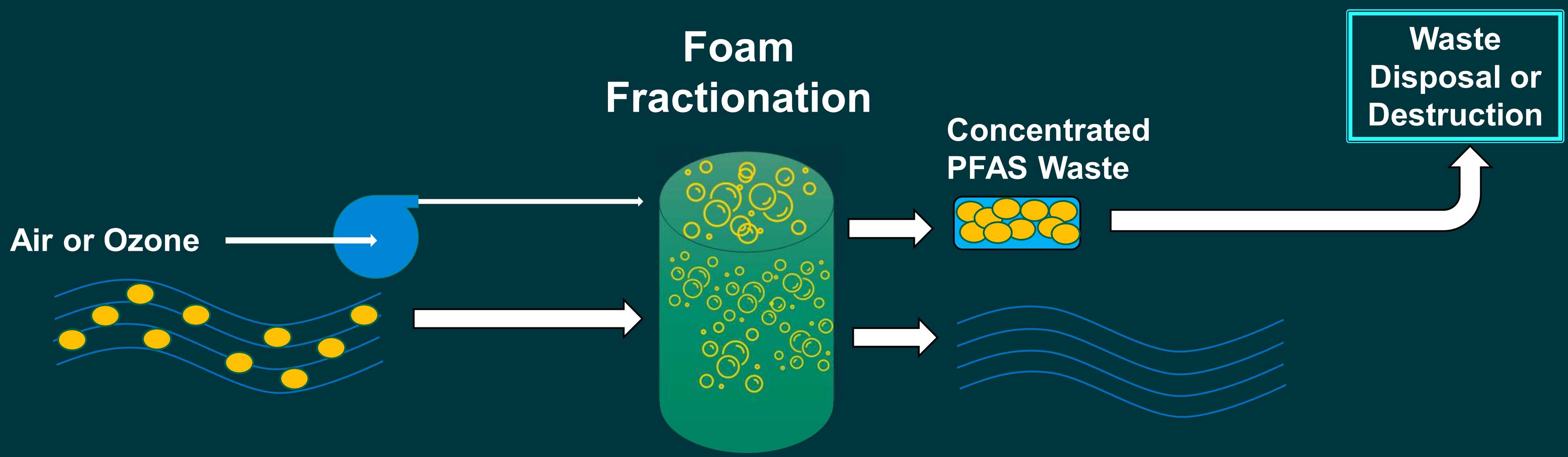
PFAS Separation Treatment Technology – Transfer PFAS



PFAS Separation Treatment Technology – Concentrate PFAS

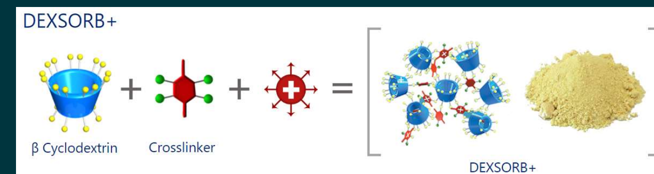


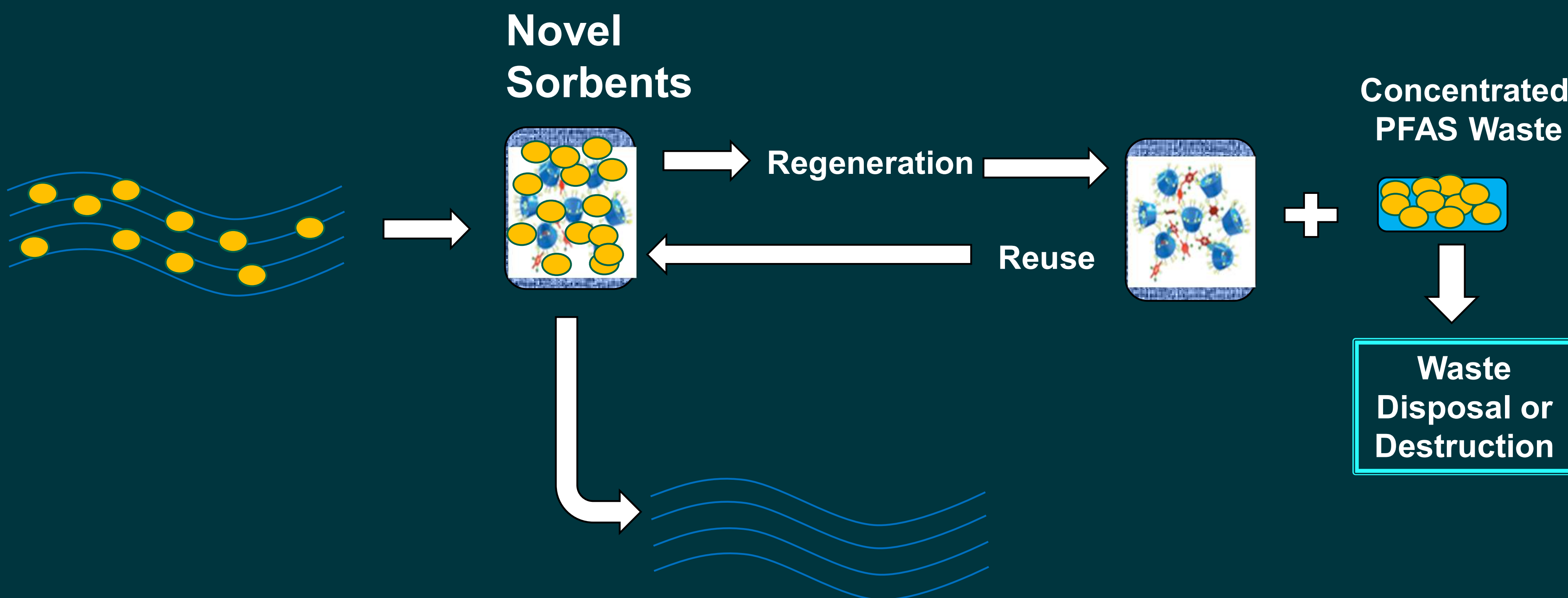
PFAS Separation Treatment Technology – Concentrate PFAS



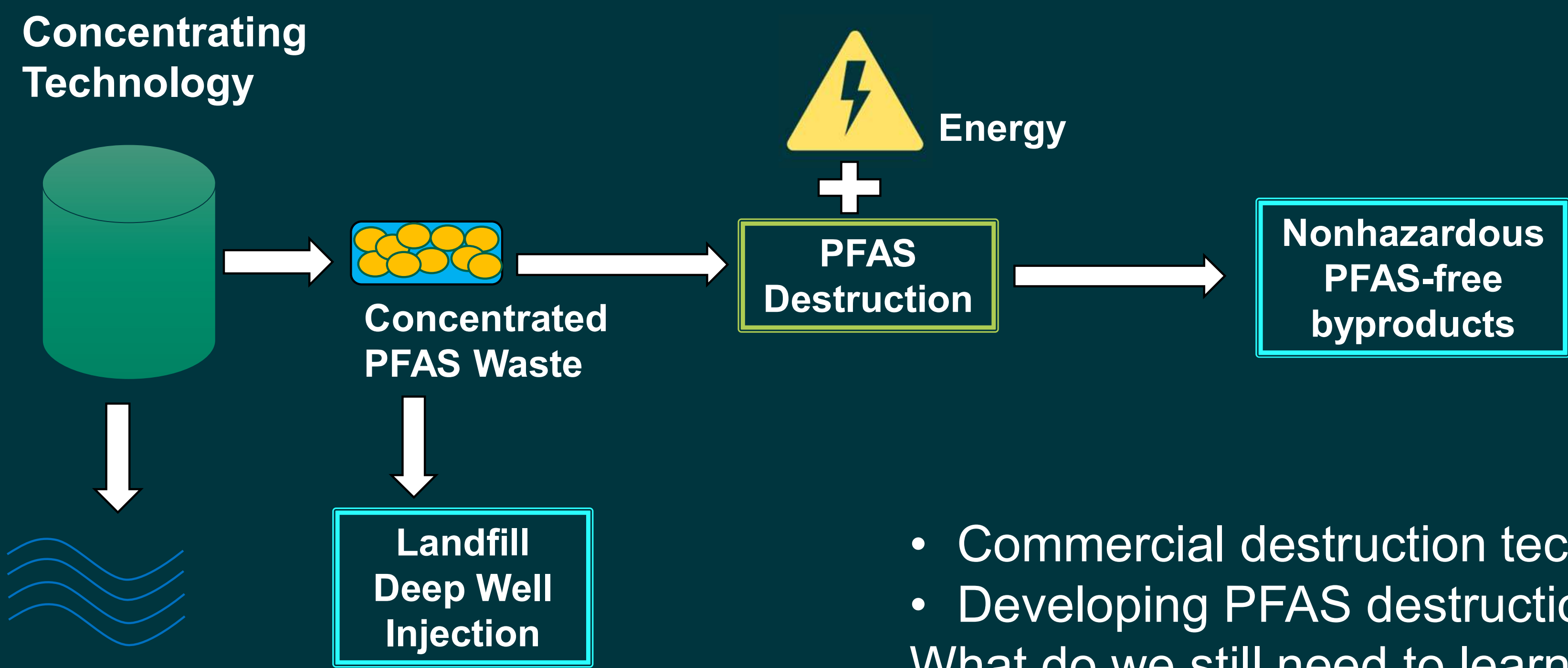
PFAS Separation Treatment Technology – Concentrate PFAS

- *Selective for PFAS only*
- *Resist fouling*
- *Higher PFAS capacity than other sorbents*
- *Nature-based and renewable*
- *Create a PFAS concentrated waste*
- *Preserve GAC or IX for polishing*





PFAS Treatment via Separation and Destruction



- Commercial destruction technologies
- Developing PFAS destruction technologies

What do we still need to learn?

PFAS Destruction: Lines of evidence checklist*

- ✓ Decrease in target PFAS concentrations in context of mass balance
  - Precursors and their transformation
  - Loss is not occurring (sorption, transfer, volatilization, dilution)
- ✓ Treatment mechanism consistent with previous studies
  - Mechanism supported by peer-reviewed publications
  - Detection of intermediates consistent with mechanism
  - Formation of fluoride
- ✓ Transformation products identified and quantified
  - Short-chain PFAS creation
  - Fluoride generation
  - Secondary water effects controlled

*Reference: SERDP ER18-16, Nov. 2021, Lines of Evidence and Best Practices to Assess the Effectiveness of PFAS Remediation Technologies

Destruction Treatment Technology - Thermal

- Thermal destruction is commercially available
  - Incinerators
  - Cement kilns
- Draft 2022 USEPA Guidance lists as viable disposal technology
- Usable for solid and liquid PFAS wastes
- Requires shipment to a fixed / permanent permitted facility
- High temperatures (>1,400 °C) necessary
- Questions have arisen about emissions from incomplete destruction and PFAS transformation

PFAS Destruction Treatment Technology – In Development

DoD funds research in PFAS destruction via: SERDP ESTCP

- Supercritical Water Oxidation (SCWO)
- Electrochemical Oxidation
- Plasma
- Hydrated Electrons in UV/Sulfite System
- Thermal oxidation

USEPA's PFAS Innovative Treatment Team (PITT) identified:

- Supercritical Water Oxidation
- Electrochemical oxidation
- Pyrolysis and gasification
- Mechanochemical degradation

Destruction Treatment Technology - Supercritical Water Oxidation

Raises water above its critical point (374 °C and 221 bar), injects air, rapidly oxidizes all organics

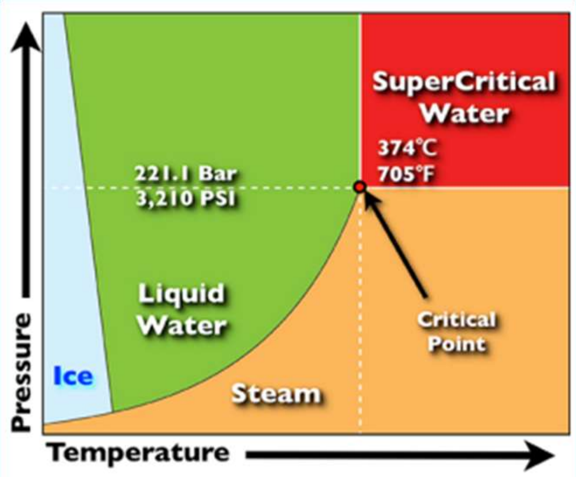


Figure 1. SCWO reactions occur above the critical point of water. Image credit: Jonathan Kamler.

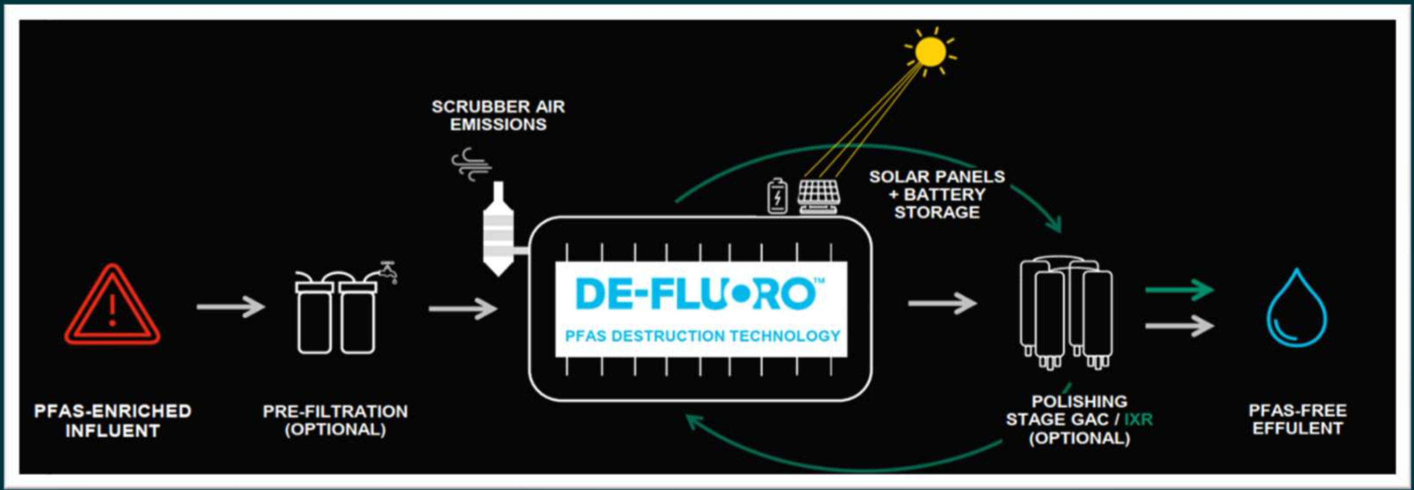
- Treats both liquid and solid wastes; demonstrated to reduce PFAS concentrations by 99.99%
- Several systems are deployed; full-scale applications are being actively developed
- Requires high energy input
- Reactors get plugged/fouled
- Uncertainty on the fate of fluorine in SCWO treatment

Ongoing evaluations for cost, efficiency, safety, and demonstration of complete destruction

Image credit: https://www.epa.gov/sites/default/files/2021-01/documents/pitt_research_brief_scwo_final_jan_25_2021_508.pdf

Destruction Treatment Technology - Electrochemical Oxidation

- Destroys PFAS via sequential, non-selective defluorination; target reductions of 99.99%
- Electrical current between anode and cathode creates oxidizing conditions
- Multiple concurrent designs – field demonstrations
- Electrode chemistry varies—affects durability, costs



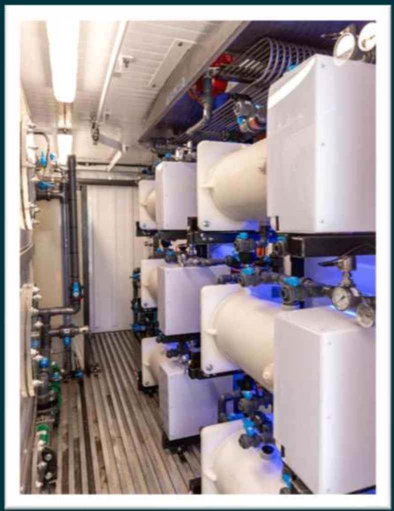


Image credit: AECOM

Destruction Treatment Technology - Plasma

Electrical discharge converts water into a plasma—a mix of highly reactive chemical species

Image credit: https://www.serdp-estcp.org/projects/details/790e2dda-1f7b-4ff5-b77e-08ed10a456b1/er20-5355-project-overview

- Rapid treatment of PFAS-laden liquid, such as Aqueous Film Forming Foam
- Demonstrated reduction in long-chain and precursors >99%
- In field demonstration stage
- Not viable for dilute PFAS, but for concentrates

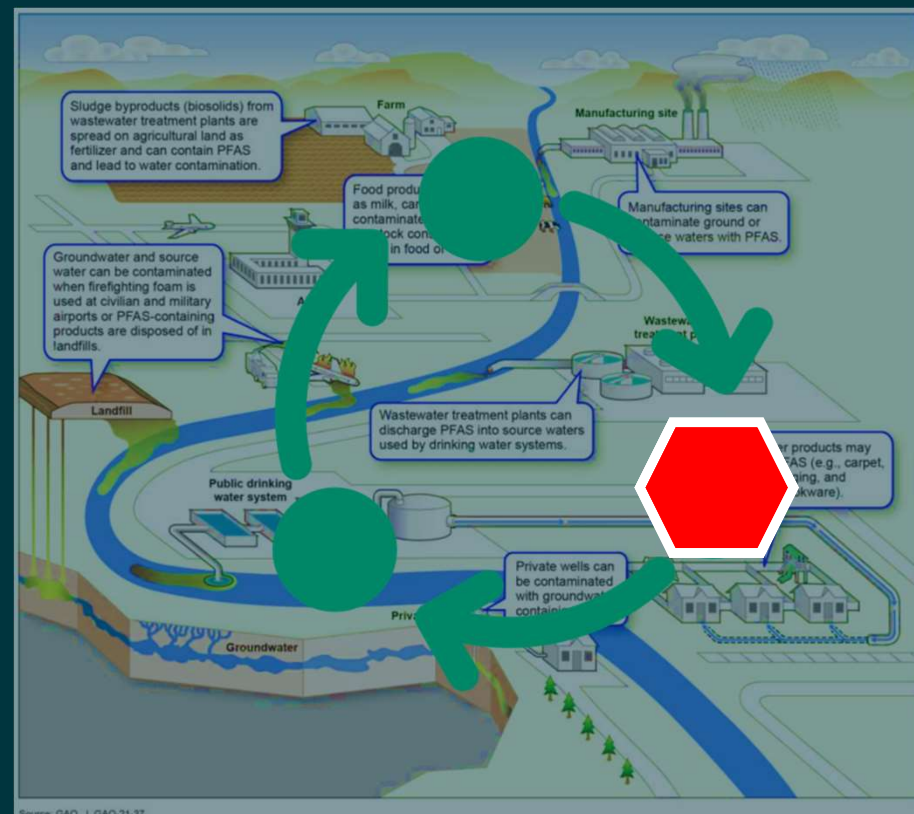
PFAS Solution: Eliminate from cycle

Protect drinking water
- Design/build PFAS removal systems using separation technologies (GAC, IX-R, RO)
- Focus research on improved methods

Protect water resources
- Eliminate sources
- Intercept in-situ

Disrupt PFAS from discharges/ WWTPs
- Invoke industrial pretreatment
- Manage biosolids

Treat separated and removed PFAS-laden waste
- Manage disposal
- Focus on developing commercially effective destruction technologies



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