The Forever Chemical: PFAS and Your Drinking Water



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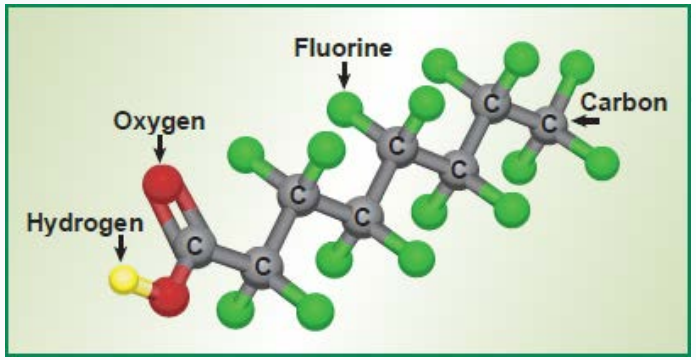
Agenda



- History and general overview of PFAS
- PFAS usage and the potential to impact the environment
- Current Massachusetts regulatory frameworks
- Case study

Why the Fuss?

PFAS = Per- and Poly-Fluoroalkyl Substances



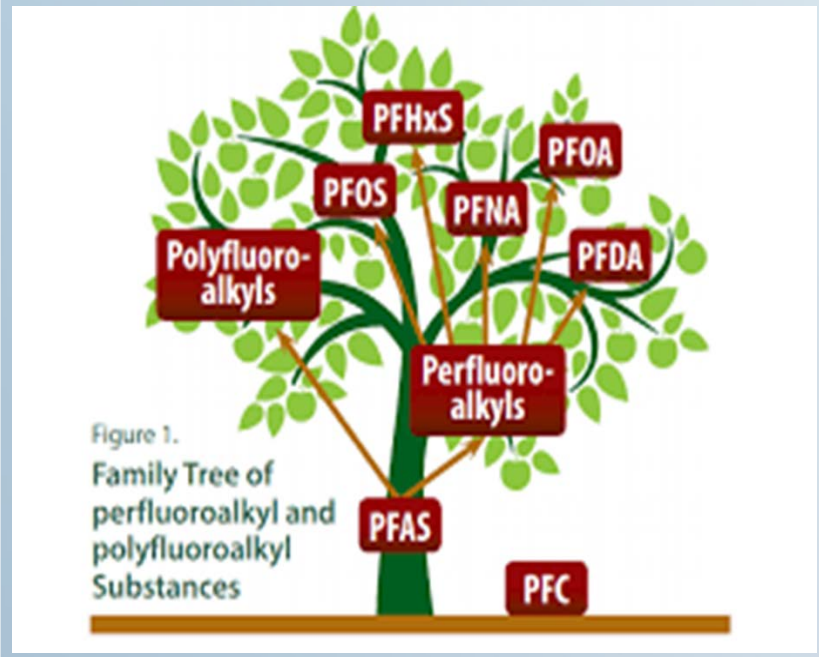
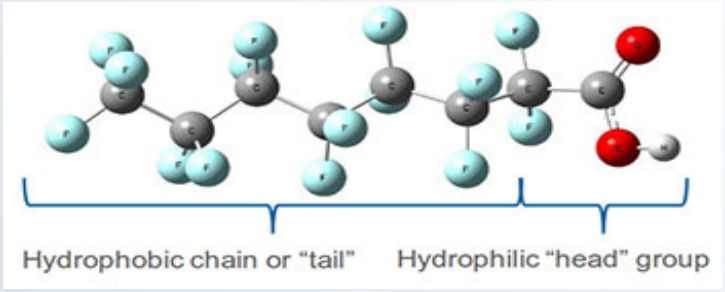


Figure 1.
Family Tree of perfluoroalkyl and polyfluoroalkyl Substances

- Man-made compounds
  - Thermally stable (strong C - F molecular bond)
  - Chemically stable (low reactivity)
- Persistent in the environment
- Found worldwide in all environmental media (and human blood)
- Half-life (2 to 35 years in humans)
- "Tail" end - they repel water (hydrophobic) and oil/fat (lipophobic)
- "Head" end - they attract/dissolve in water (hydrophilic)
  - Non-reactive
  - Non-stick

More than 6,000 PFAS compounds



History of PFAS

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production	Protective Coatings					
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)
Pre-Invention of Chemistry /			Initial Chemical Synthesis / Production			Commercial Products Introduced and Used		

2006 – EPA commitment to phase out PFOA & PFOS
2010 - 95% reduction of PFOA & PFOS
2015 – PFOA & PFOS - fully phased out

Source: ITRC Table 2 History and Use Fact Sheet

Sources of PFAS

- Fire-fighting foams
  - Airports, training facilities, terminals
- Industrial facilities
  - Electroplating (mist suppressants)
  - Semiconductor manufacturing
  - Aerospace & electronic applications
  - Automobile
- Consumer Products
  - Water Repellents
  - Stain-resistant textiles
  - Teflon cookware
  - Cosmetics
  - Food packaging
  - Pesticides
- Landfills
  - Consumer products
  - Leachate
- Wastewater treatment plants
  - Effluent discharges
  - Biosolids







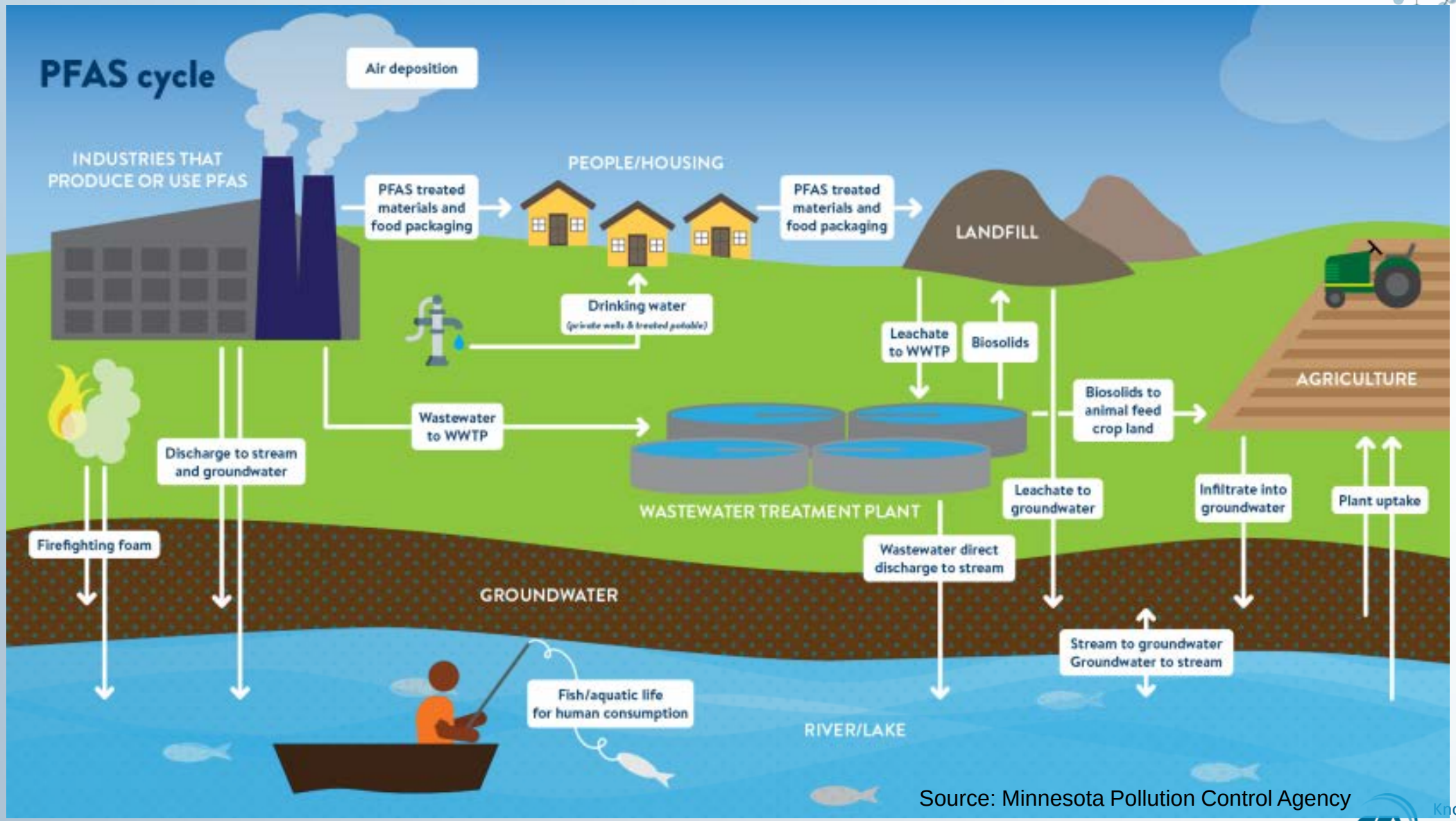








Fate & Transport



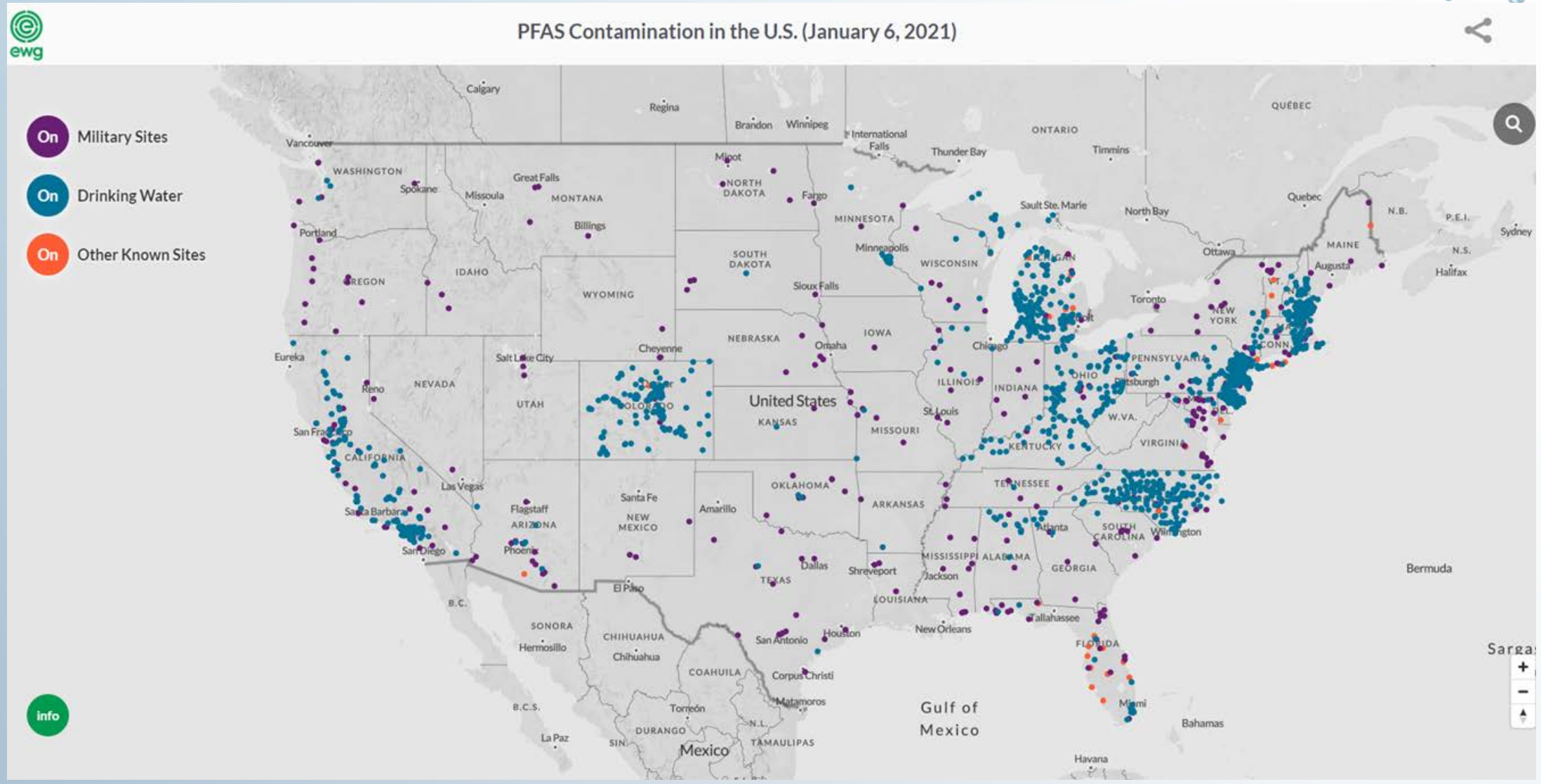
Source: Minnesota Pollution Control Agency

Spread of Sites with PFAS 2001-2018



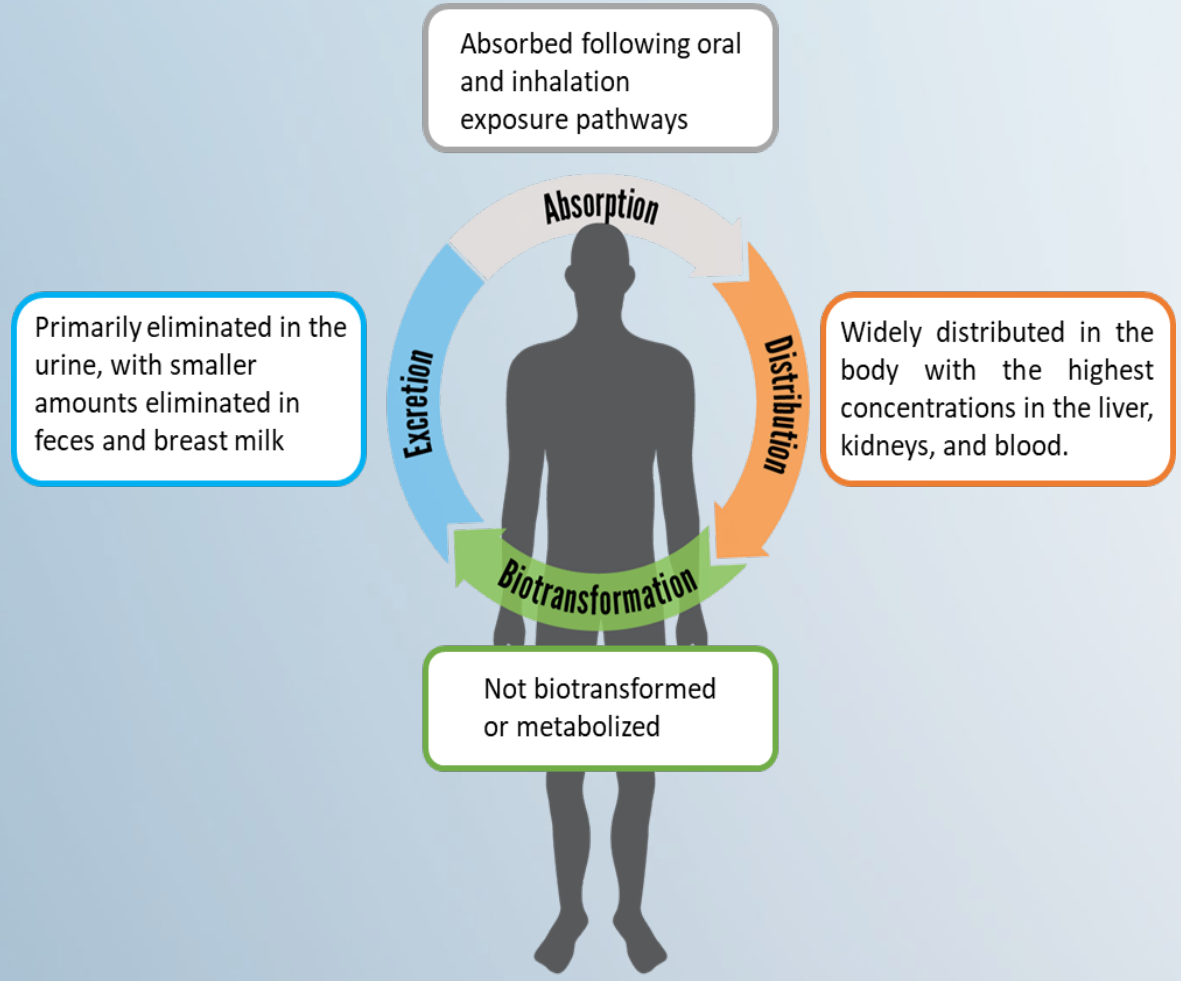
Source: EWG Interactive Map

PFAS Sites as of January 2021



Source: EWG Interactive Map

Toxicokinetics & Differences



A "safe" or threshold level is unknown for most PFAS compounds

Differences in PFAS compounds

Distribution:

- preferentially bind to proteins

Elimination:

- chemical composition, chain length, and branching impact the excretion rates of the PFAS compounds

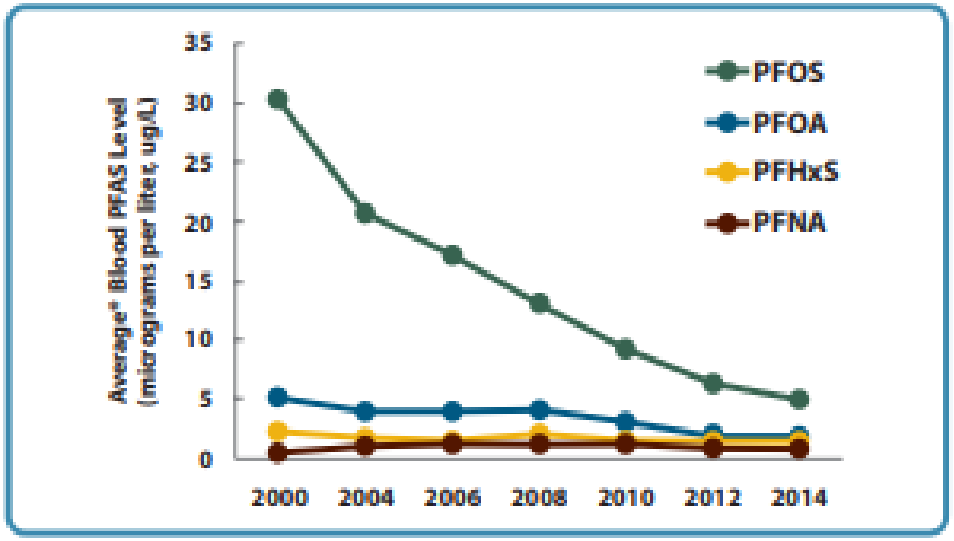
↑ Chain length Branching ↓ Elimination Rate

In general, long-chain compounds take YEARS to excrete, while short-chain compounds take DAYS to WEEKS

Human Health Effects Potentially Associated with PFAS

- Increased cholesterol
- Increased risk of diabetes
- Increased risk of cancer
- Reproductive/Developmental issues
  - Pregnancy-induced hypertension/pre-eclampsia
  - Decreased fertility
  - Decreased birth weight
- Growing, learning, and behavioral issues
- Reduced immune system function and vaccine response

Blood Levels of the Most Common PFAS in People in the United States from 2000-2014



* Average = geometric mean

Data Source: Centers for Disease Control and Prevention. Fourth Report on Human Exposure to Environmental Chemicals, Updated Tables, (January 2017). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

Sample Collection Challenges









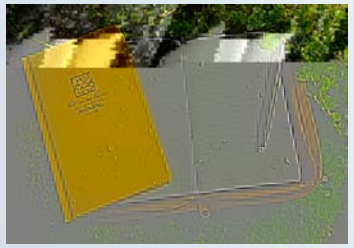
























Stringent sampling protocols are required to reduce potential cross-contamination and provide defensible data quality.

Measurements in the parts per trillion

- Quality control blanks:
  - Field blanks
  - Equipment blanks
- Use of only PFAS-free equipment
- Staff avoids contact with PFAS materials prior and during sampling
- Exclusion zones
- Current lab methods for drinking water only!

PFAS Remediation

Difficult to Treat:

- Wide range of compounds with different treatment properties
- C-F Bond difficult to break (degradation/destruction difficult)
- Highly soluble
- Large dilute PFAS groundwater plumes

Focus on “separation” for groundwater/drinking water

- Pump and treat using GAC or ion exchange
- Reverse osmosis

Limited in-situ technologies – currently mostly bench-scale

Reduce mass flux from source areas (removal/containment)

Exposure driven response to mitigate completed exposure pathway – point of use or wellhead treatment

PFAS Standards in MA – Reportable Concentrations

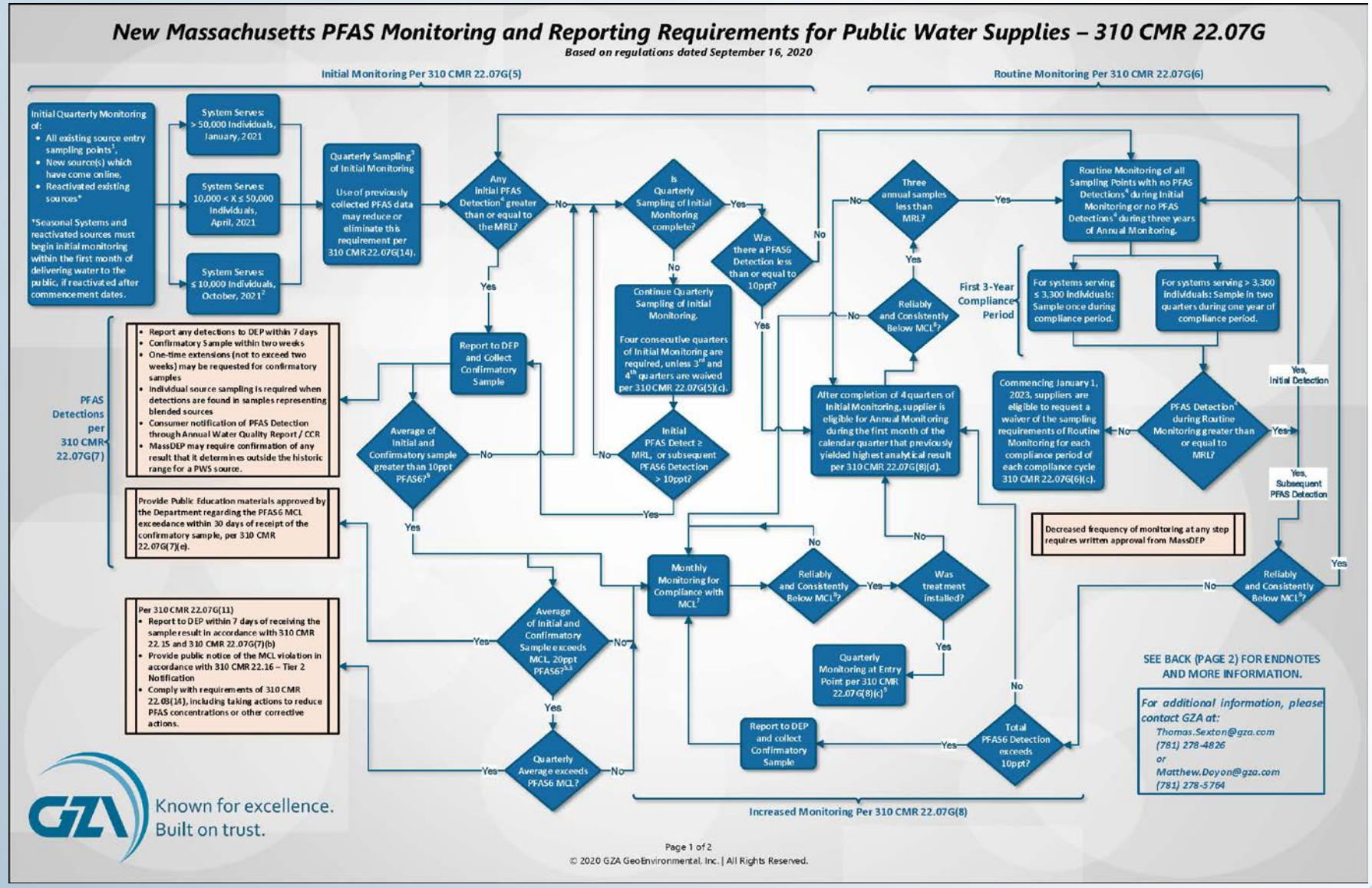


Compound	MCP Reportable Concentrations (parts per billion)	
	RCGW-1 (Drinking Water)	RCGW-2 (Non-Drinking Water)
PFDA	-	40,000
PFHpA	-	40,000
PFHxS	-	500
PFNA	-	40,000
PFOS	-	500
PFOA	-	40,000
PFAS6 (sum of above)	0.02	-

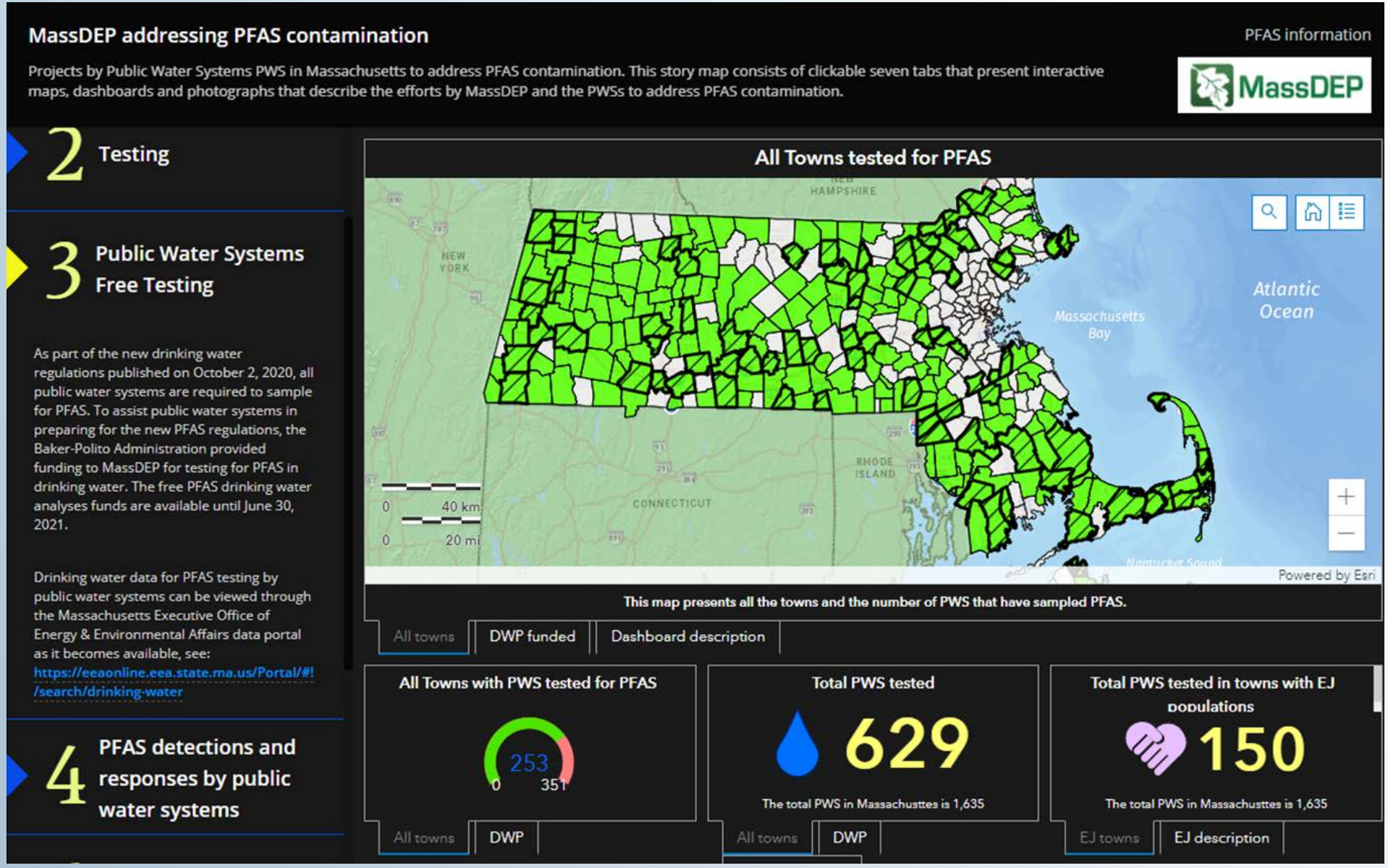
PFAS Standards in MA – Method 1 Standards

Compound	MCP Method 1 Standards (parts per billion)					
	GW-1	GW-3	S-1/GW-1	S-1/GW-3	S-2/GW-1 & S-3/GW-1	S-2/GW-3 & S-3/GW-3
PFDA	-	40,000	0.3	300	0.3	400
PFHpA	-	40,000	0.5	300	0.5	400
PFHxS	-	500	0.3	300	0.3	400
PFNA	-	40,000	0.32	300	0.32	400
PFOS	-	500	2	300	2	400
PFOA	-	40,000	0.72	300	0.72	400
PFAS6 (sum of above)	0.02	-	-	-	-	-

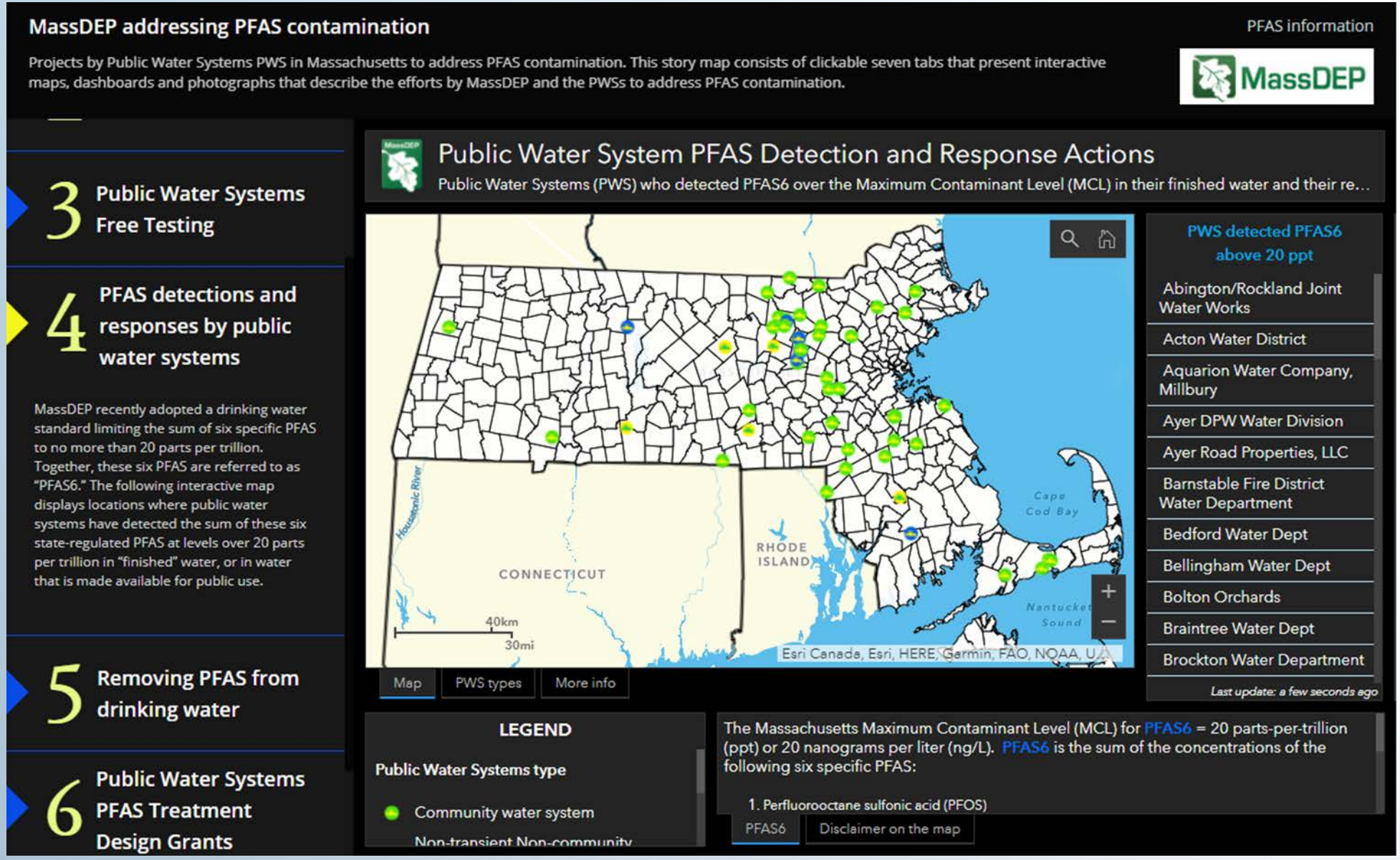
Massachusetts Drinking Water Regulations



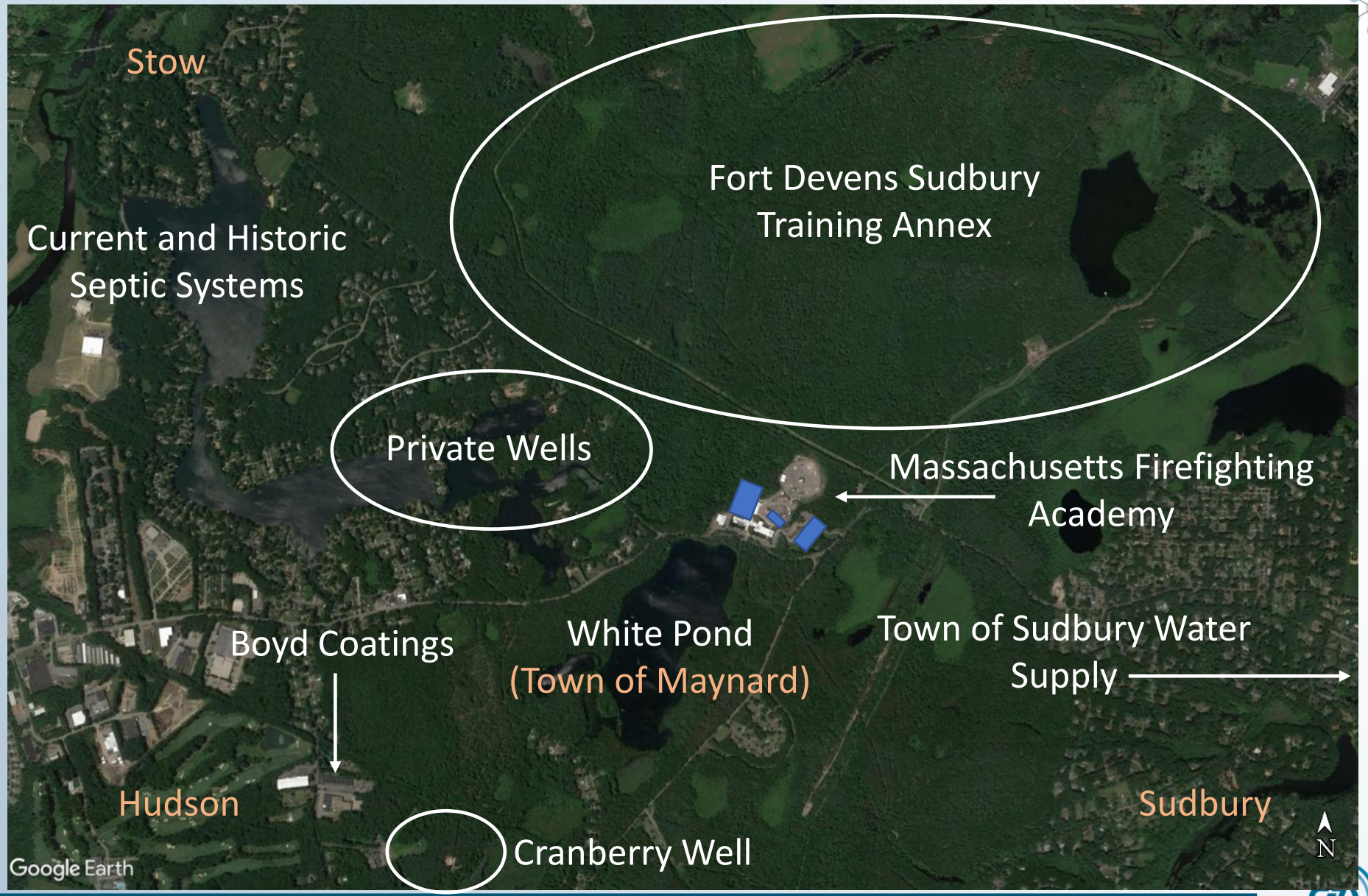
Massachusetts Public Water System Sampling



Massachusetts Public Water System Sampling



Case Study


Stow
Fort Devens Sudbury Training Annex
Current and Historic Septic Systems
Private Wells
Massachusetts Firefighting Academy
Boyd Coatings
White Pond (Town of Maynard)
Town of Sudbury Water Supply
Hudson
Sudbury
Cranberry Well
Google Earth
N

Questions and Discussion



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https://www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas

https://www.mass.gov/doc/massdep-fact-sheet-pfas-in-drinking-water-questions-and-answers-for-consumers/download

https://www.mass.gov/info-details/pfas-in-residuals

https://pfas-1.itrcweb.org/