Barr Engineering Co.

From Mine to Mill

What you need to know about per- and polyfluoroalkyl substances (PFAS)

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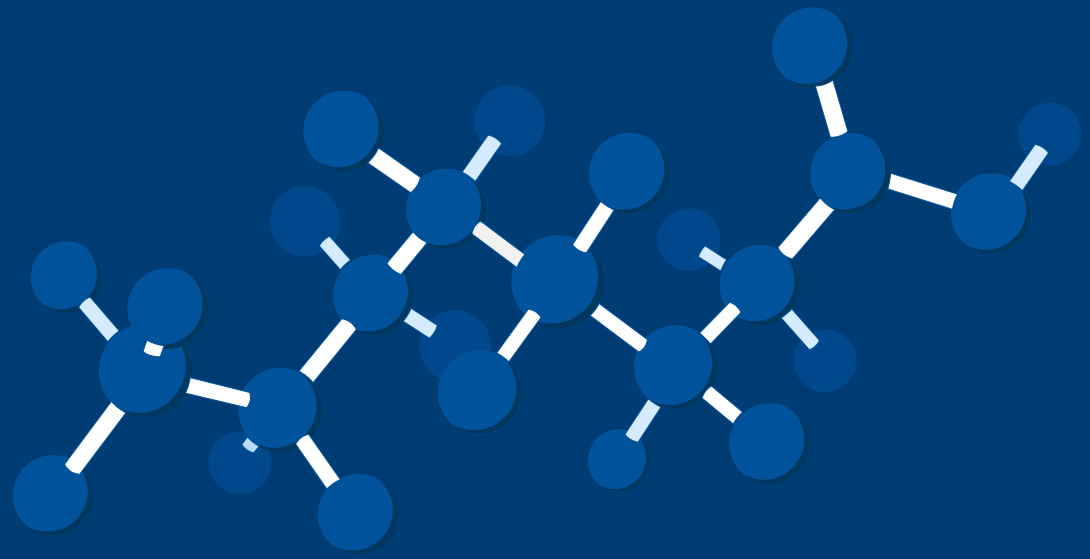
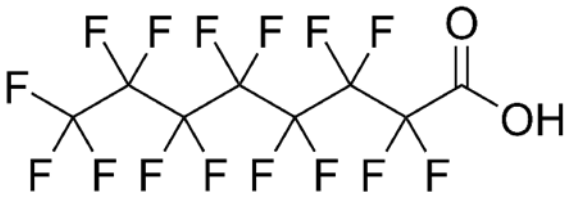
- What are PFAS?
- Regulatory and social drivers
- Remediation and treatment technologies
- Evaluation and strategies

What are PFAS?

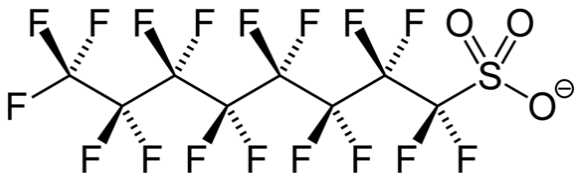


What are PFAS?

PFOA



PFOS



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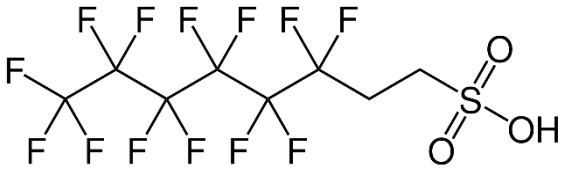


- Man made chemicals
- Approx. 4,000-6,000 compounds
- Per vs. Poly fluorinated
  - **P**- per
  - **F** – fluorinated
  - **X** – length of carbon chain
  - **A** or **S** – definition of functional group

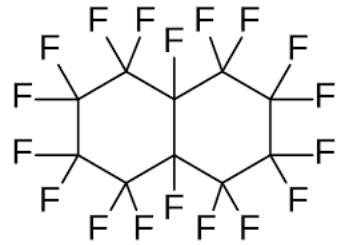
PFAS vs. PFCs

Perfluorcarbons
- Only carbon and fluorine atoms
- Potential green house gas

Perfluorinated chemicals

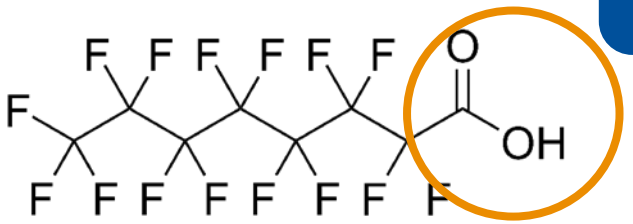
"PFCs"

Perfluorcarbons (also called "PFCs")



Per- and polyfluoroalkyl substances

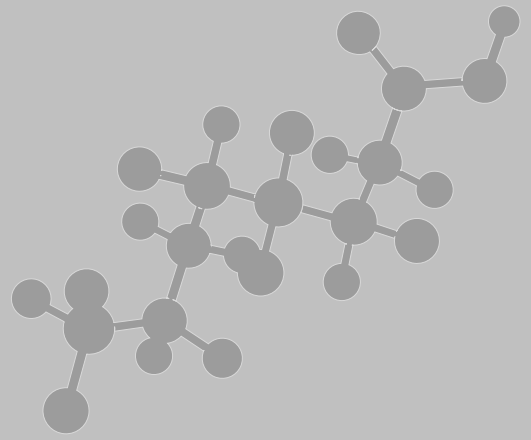
"PFAS"

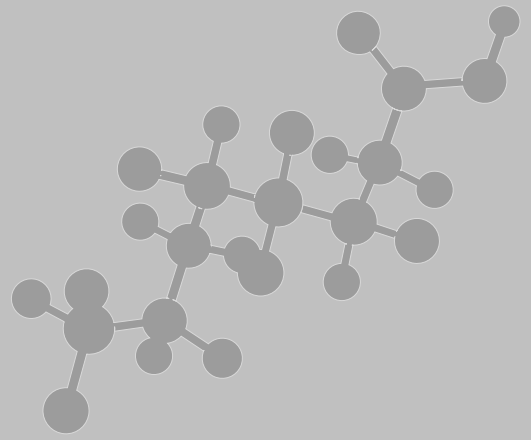


PFAS
- Oxygen, hydrogen, sulfur and/or nitrogen atoms in addition to carbon/fluorine
- PFOA, PFOS, and thousands more
- PFAS includes >6000 individual chemicals
  - PFOA and PFOS are individual compounds

PFAS properties

- Heat, oil, stain, and water resistant
- Resistant to biodegradation
- Destroyed at high temperatures
- Semi-volatile
- Miscible in water
- Some affinity for organic carbon

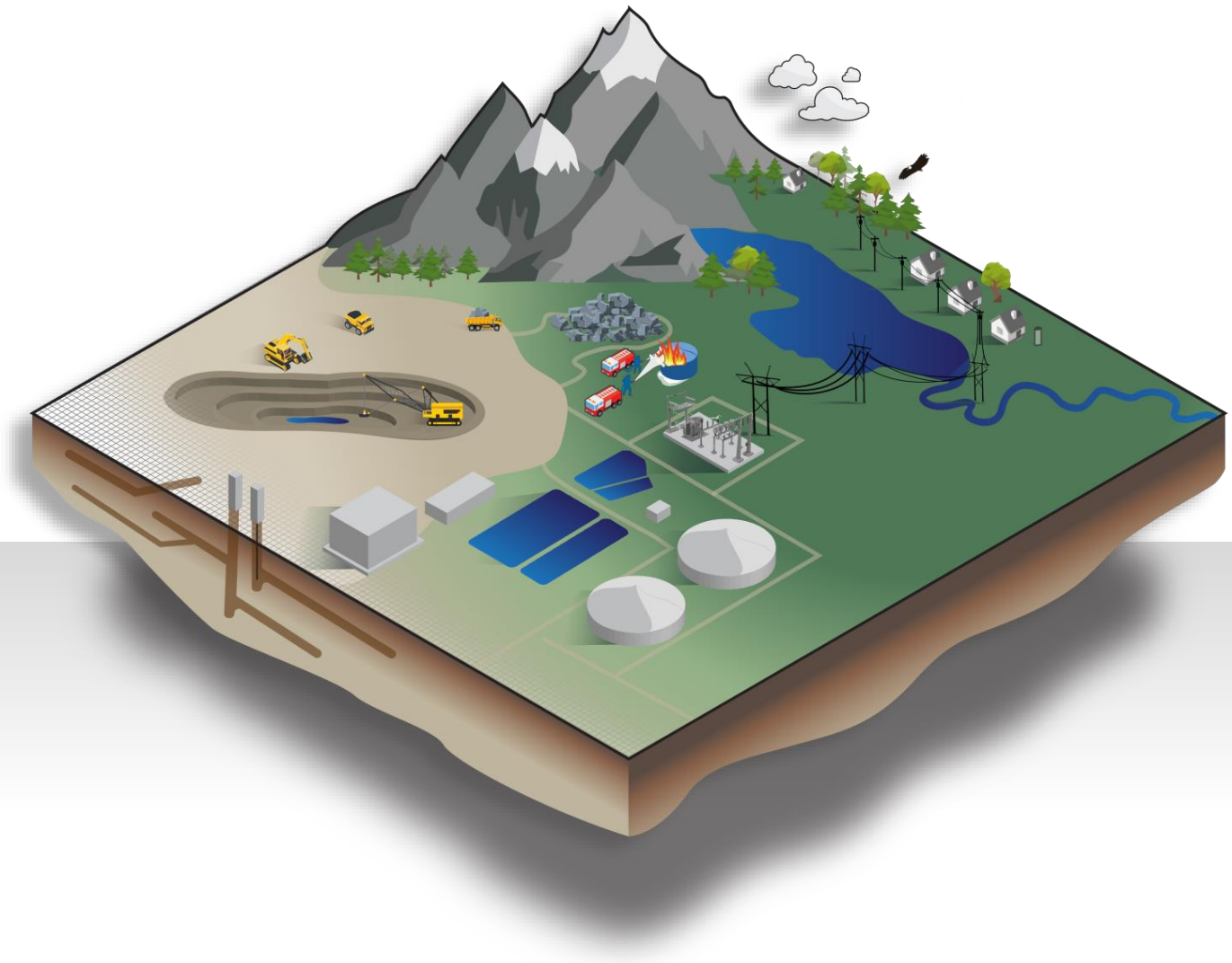




Uses and history

- Used in coating and waterproofing processes, fire suppression and to reduce surface tension
- Production of PFOA and PFOS phased out
  - Current products have different chemical makeup
- Historical chemicals were found to be persistent
- Historical production created PFAS mixture

Potential sources for PFAS at mine site



Potential sources for PFAS at mine site

AFFF primary source

Historic and current use and training

Photo credit: *In-mine study of high-expansion firefighting foam; Chasko; Conti; Derick; Krump; Lazzara, Ph.D. https://www.cdc.gov/niosh/mining/userfiles/works/pdfs/imsohe.pdf*

Potential sources for PFAS at mine site

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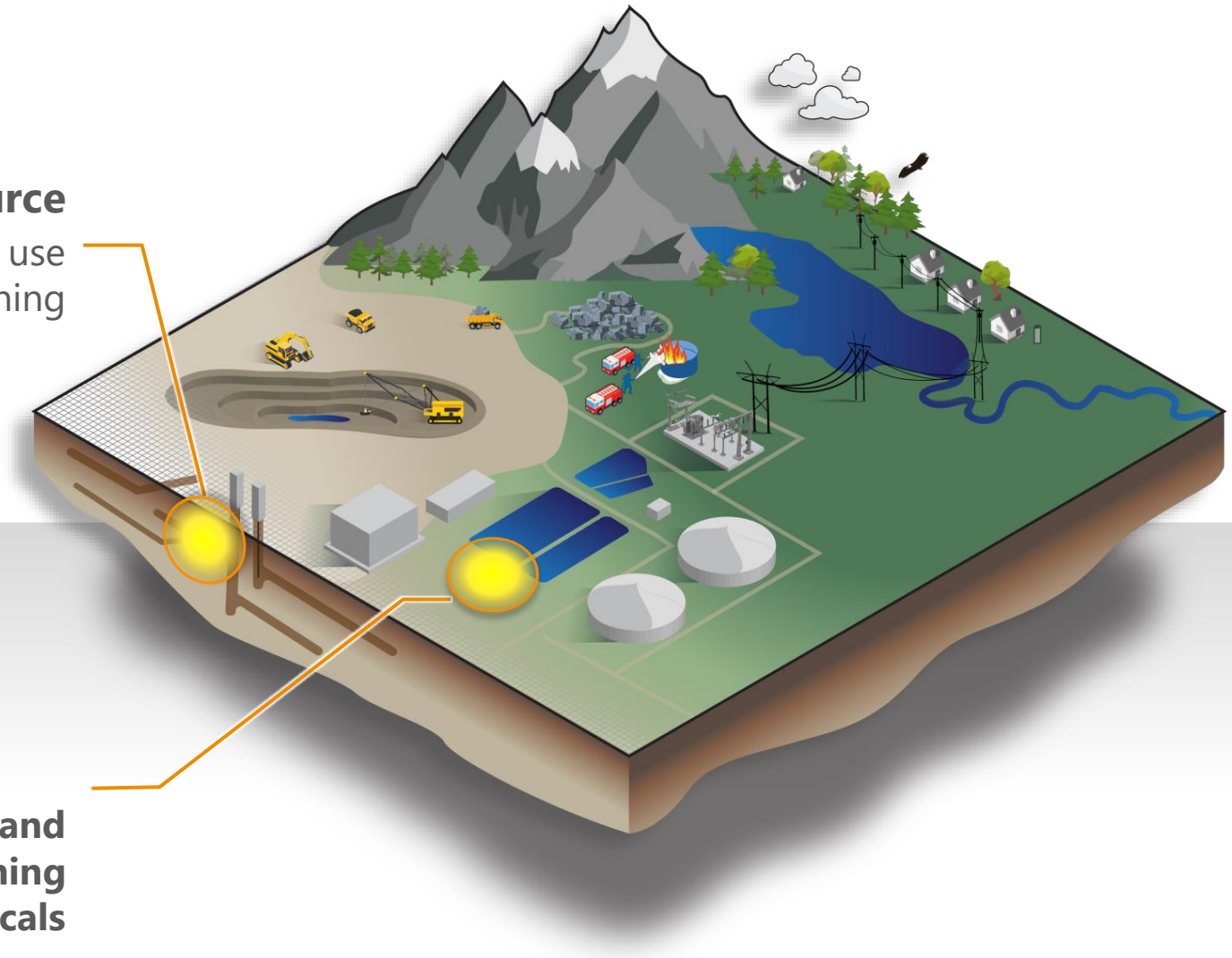
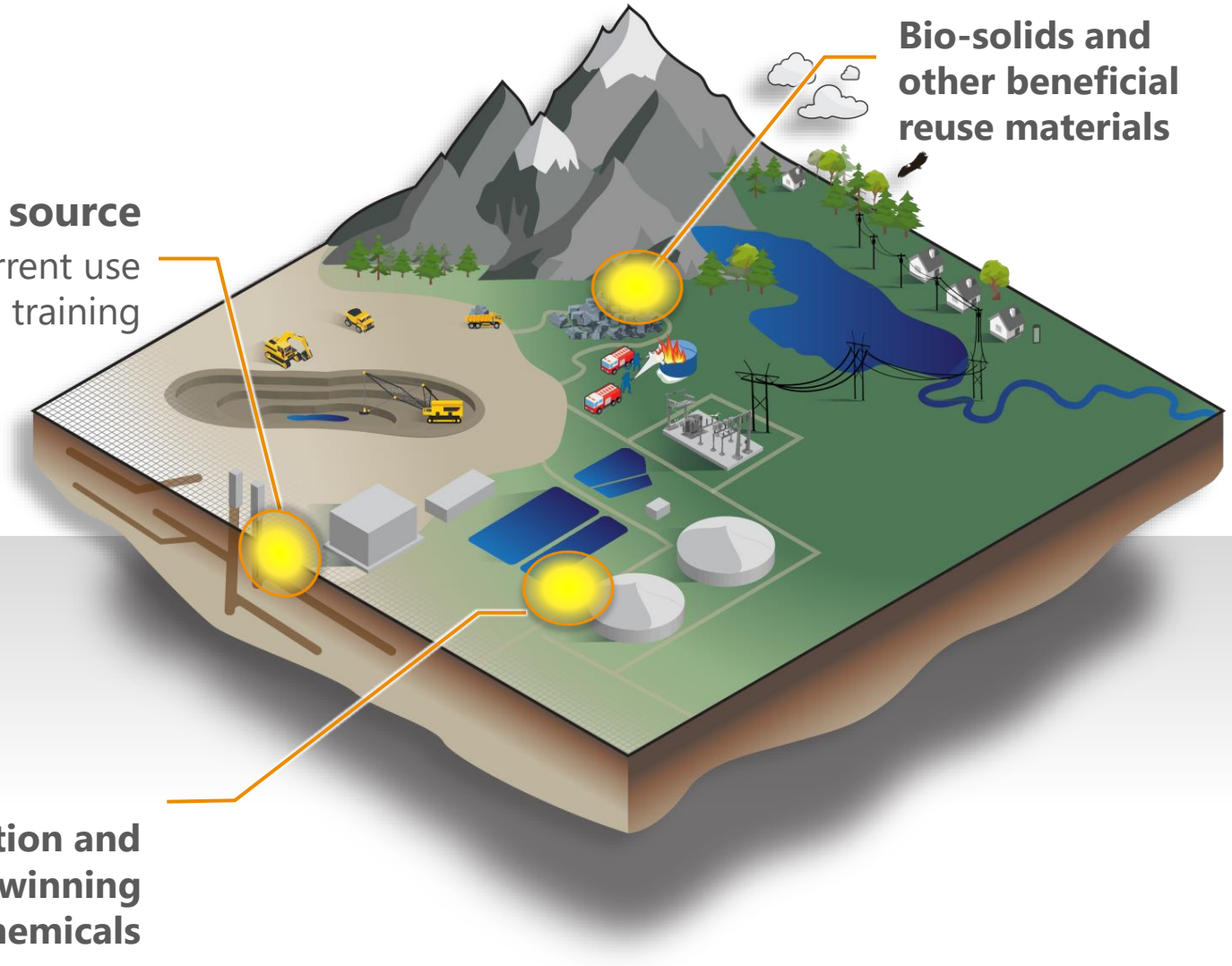


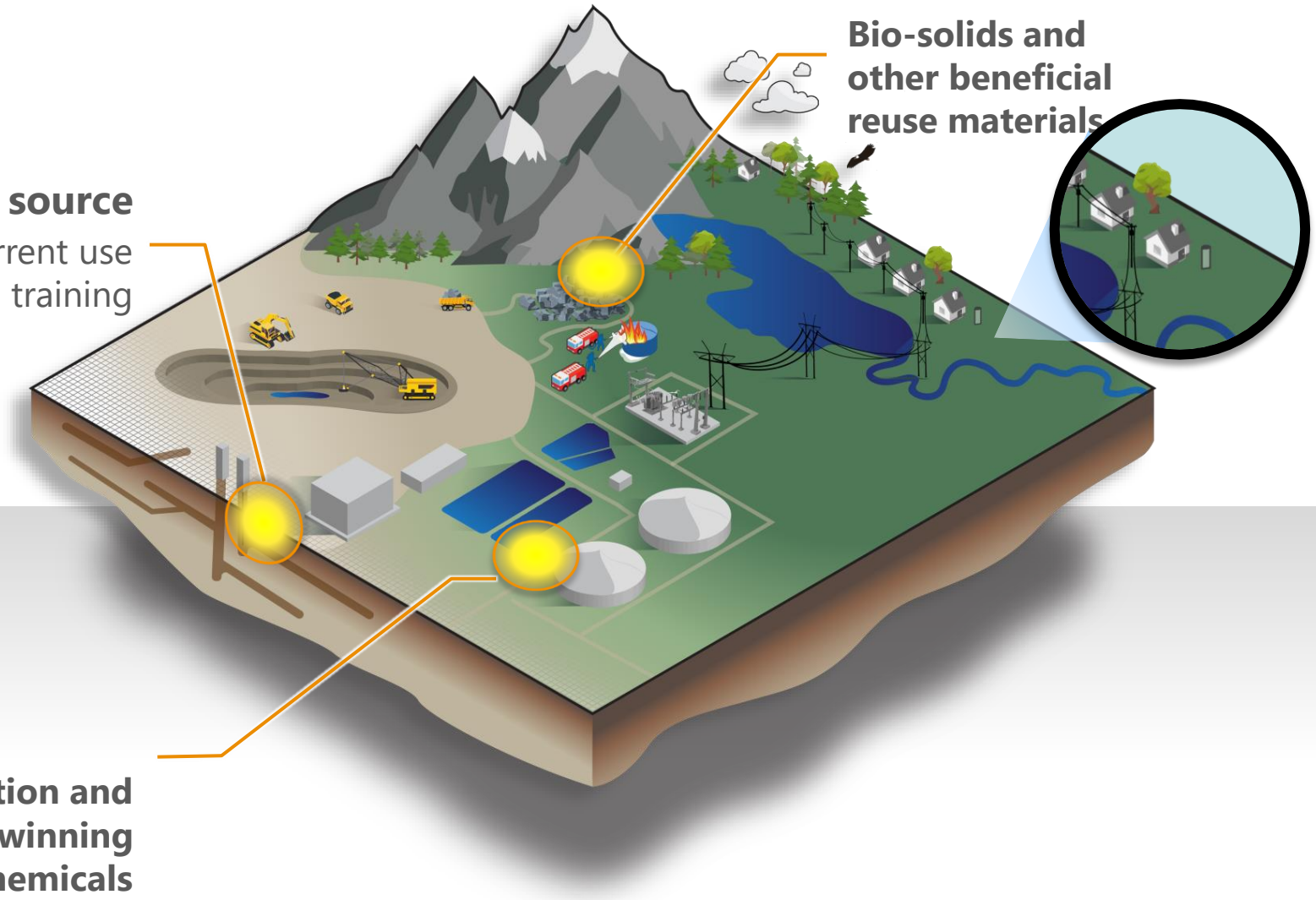
Flotation and electrowinning chemicals

Potential sources for PFAS at mine site

AFFF primary source
Historic and current use and training

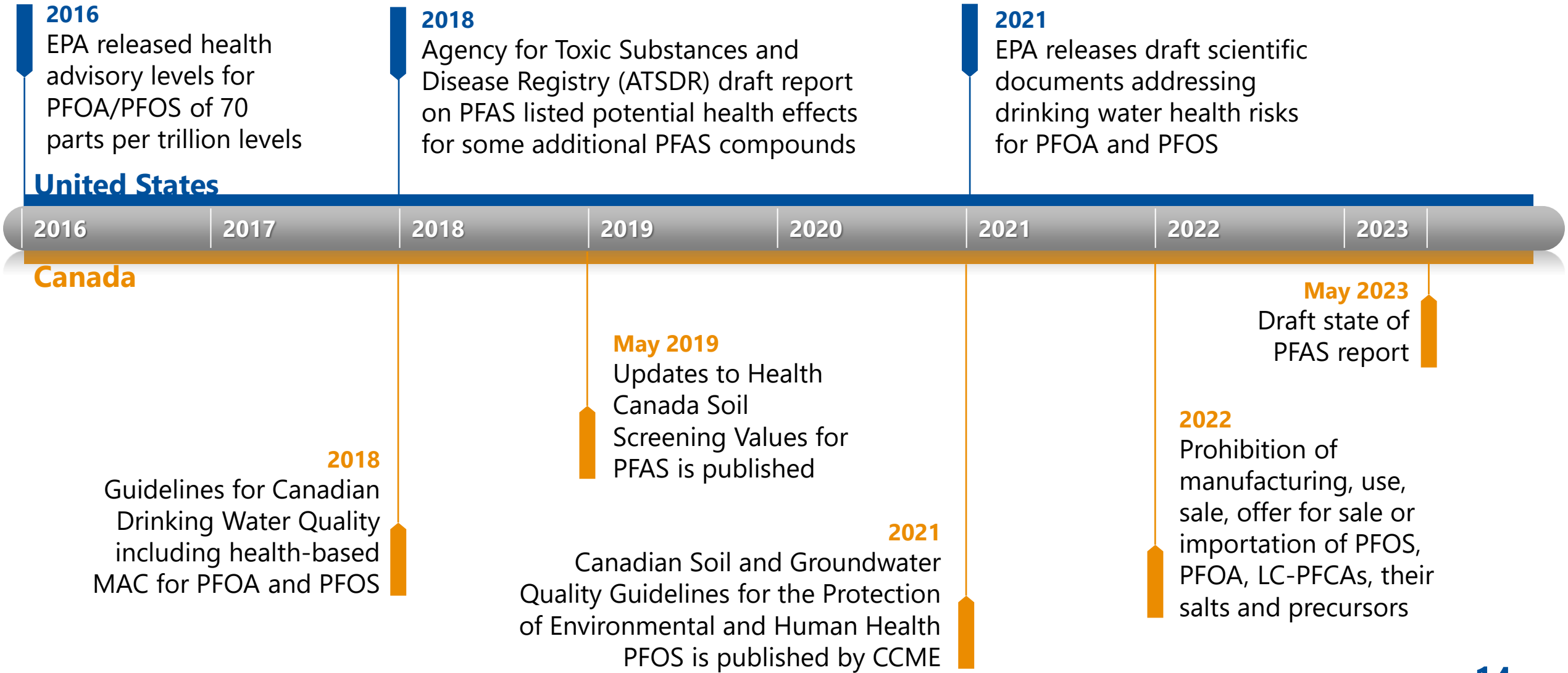


Potential sources for PFAS at mine site

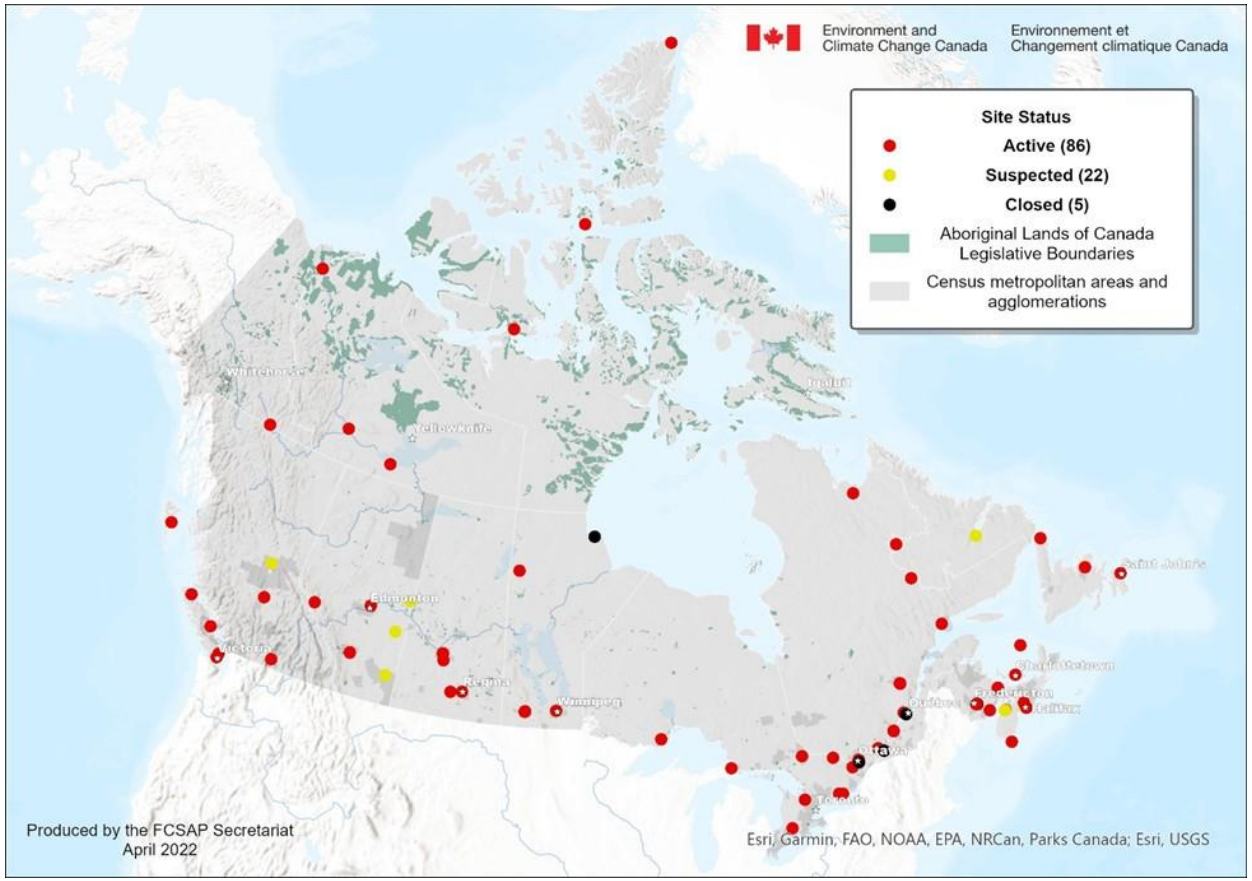


Regulatory and social trends

The Evolution of PFAS Regulation – U.S. and Canada



Social trends



Federal contaminated sites with confirmed or suspected PFAS contamination, as of April 2022. Site status (that is, Suspected, Active, and Closed) applies to the entire site and is not specific to PFAS contamination. Courtesy of the Government of Canada.

- Driven by community concerns
  - Drinking water
  - Fish and wildlife consumption
    - Potential of bioaccumulation biomagnification cited in the Draft State of PFAS Report (2023)
  - Subpopulations that may be more susceptible
    - Pregnant women and children, indigenous and northern communities in Canada, firefighters

Social trends

Quirks and Quarks

'Forever chemicals' can have far-reaching consequences, need more regulation in Canada, scientists say

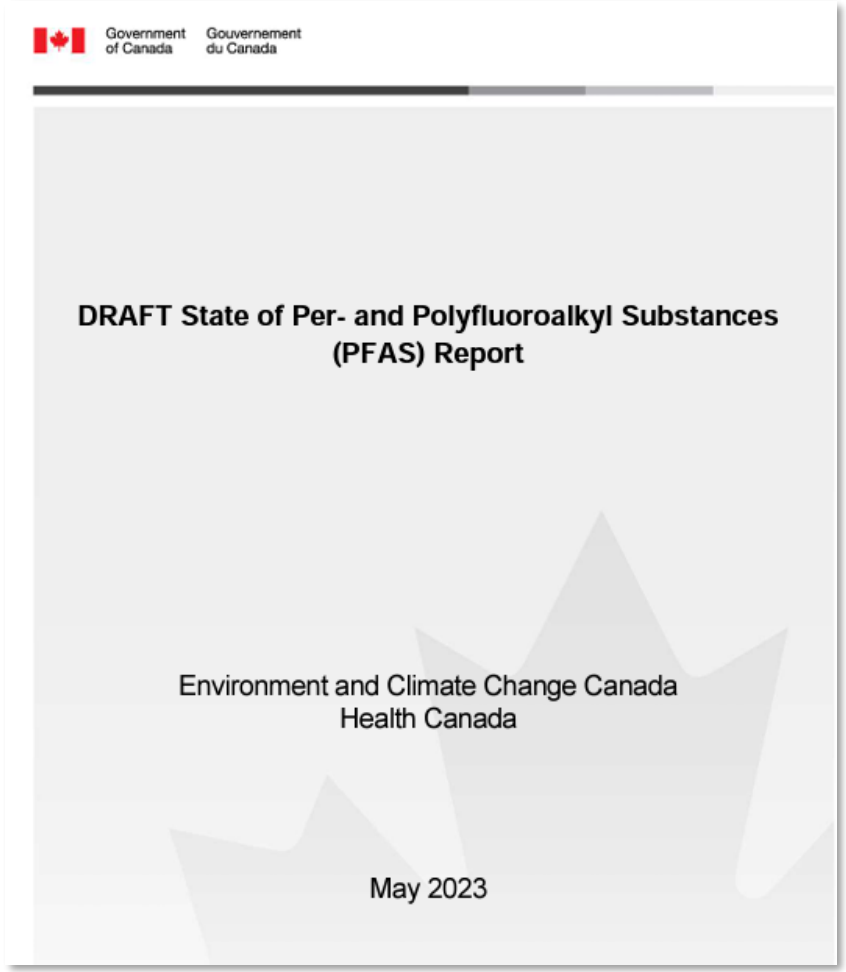
'Very significant legislative gap' for PFAS substances, says Environmental Defence's Muhannad Malas

CBC Radio · Posted: Nov 07, 2020 1:58 AM MST | Last Updated: July 23, 2021

Courtesy of CBC.ca

- Driven by community concerns
  - Drinking water
  - Fish and wildlife consumption
  - Social justice components
- Media attention
- Environmental groups
- Legislative response
- Global policy shifts

Draft State of PFAS Report



- PFAS are persistent and mobile and have been found in every environmental form.
- PFAS has been detected in blood and tissues of humans and wildlife.
- PFAS is becoming a priority worldwide.
- Canada needs to increase the list of PFAS included in CEPA exclusion list.

Federal PFAS water regulatory developments

- Guidelines for Canadian Drinking Water
  - Maximum acceptable concentration (MAC) levels for PFOA and PFOS since 2018.
  - PFAS is listed as a parameter for which Health Canada is developing or updating guidelines and guidance over the next few years.
    - Objective for Canadian Drinking Water Quality Per and Polyfluoroalkyl Substances published in early 2023.
      - Proposed 30 ng/L for the sum of total PFAS.
      - Proposed ALARA concentrations (US EPA is heading in this direction).
      - World-wide governments are moving toward using the lowest level.

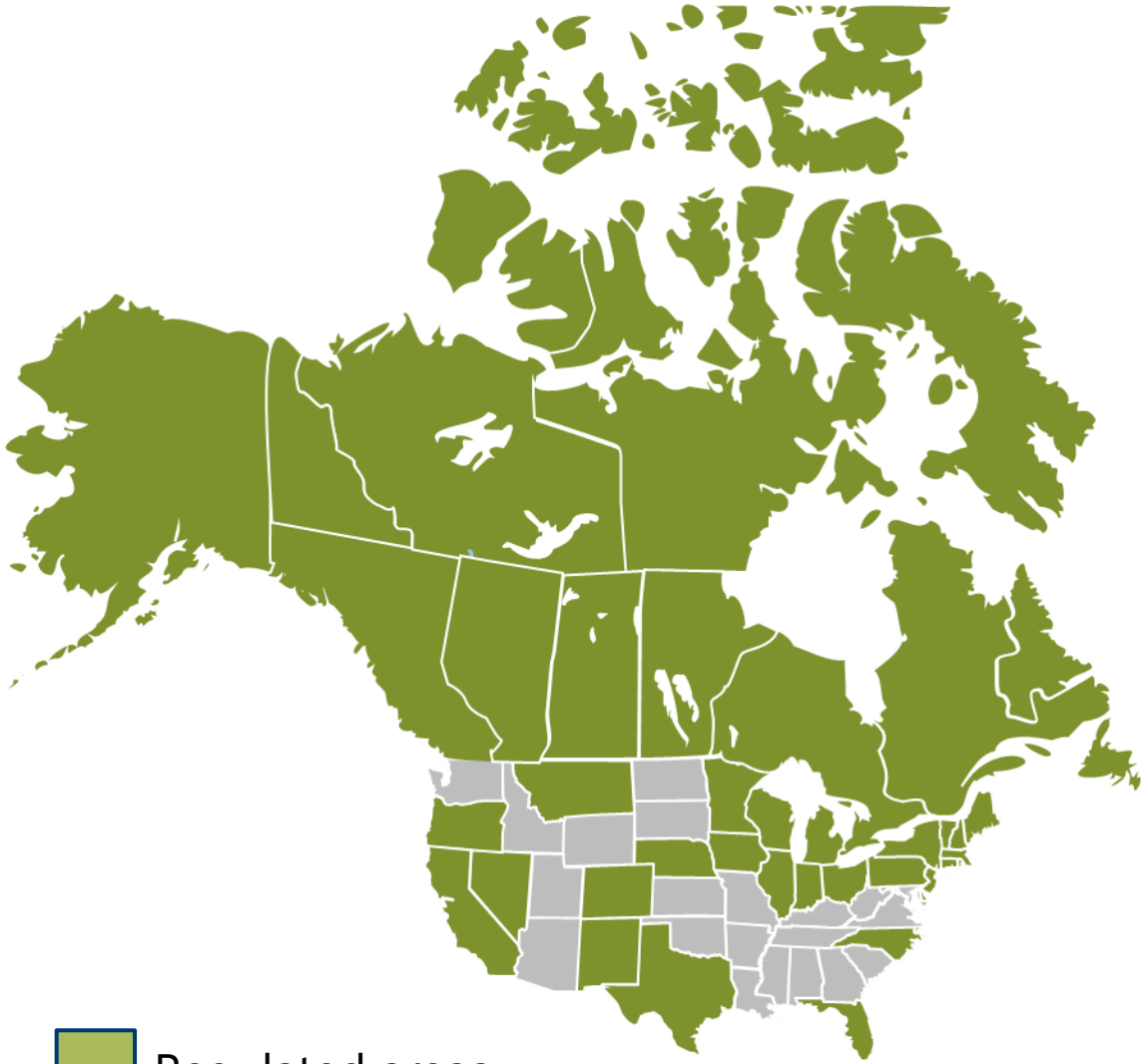
Soil and Groundwater PFAS Guidelines

- Health Canada Soil Screening Values for PFAS- updated in 2019
- CCME published Canadian Soil and Groundwater Quality Guidelines for the Protection of Environmental and Human Health for PFOS in 2021.

Waste PFAS Guidelines

- Waste is largely managed by provincial regulators.
- Noted that there are currently no efforts to classify and manage PFAS waste.
- Some leachate management practices could be impacted by soil and groundwater guidelines.

US/Canada actions



- Numerous states have implemented their own PFAS limits in a variety of media
- Numerous states have gone above/beyond health advisory limit of **70 ppt,** in absence of Federal (US EPA) Rule

PFAS and Mine Sites

- Numerous states have implemented their own PFAS limits in a variety of media
  - Minnesota sampling plan includes two mining landfills
  - Illinois coal mine

Remediation and treatment technologies

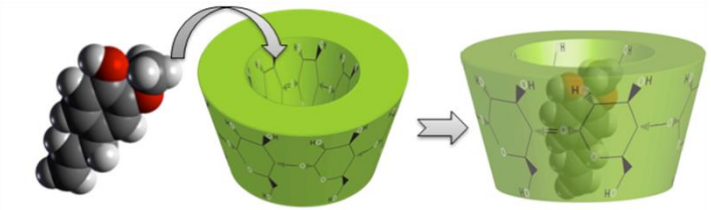
Challenges in sampling and analyzing for PFAS

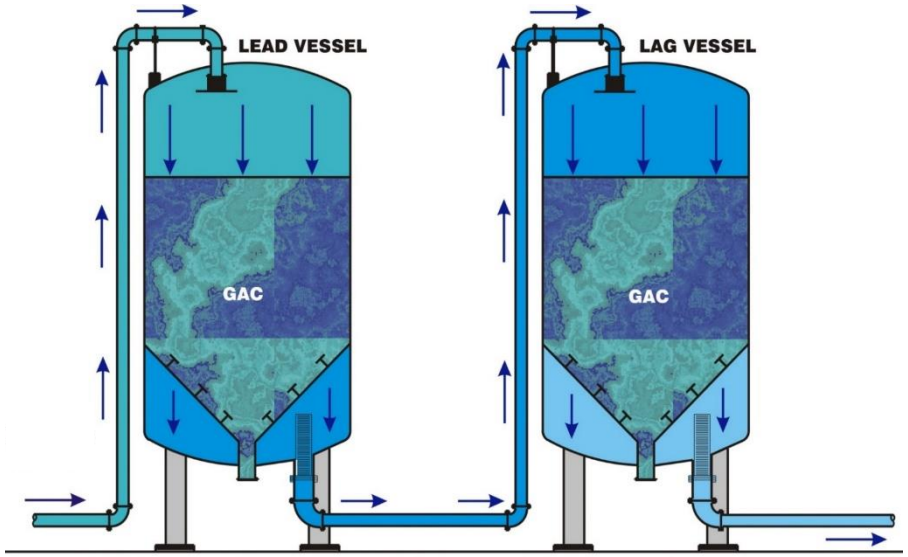
- Rinse/equipment blanks are necessary
- Multiple materials commonly-used in investigations may contain PFAS
- Drinking water methods
  - US EPA 533
  - US EPA 537.1
- Development of methods continue
- Analytical testing is more expensive and taking longer to receive results

Soil remediation

- **Soil treatment** techniques include stabilization and thermal destruction (>950 °C)
- **In-situ** techniques include, capping, groundwater cutoff and containment and activated carbon injection

Water treatment: primary treatment technologies



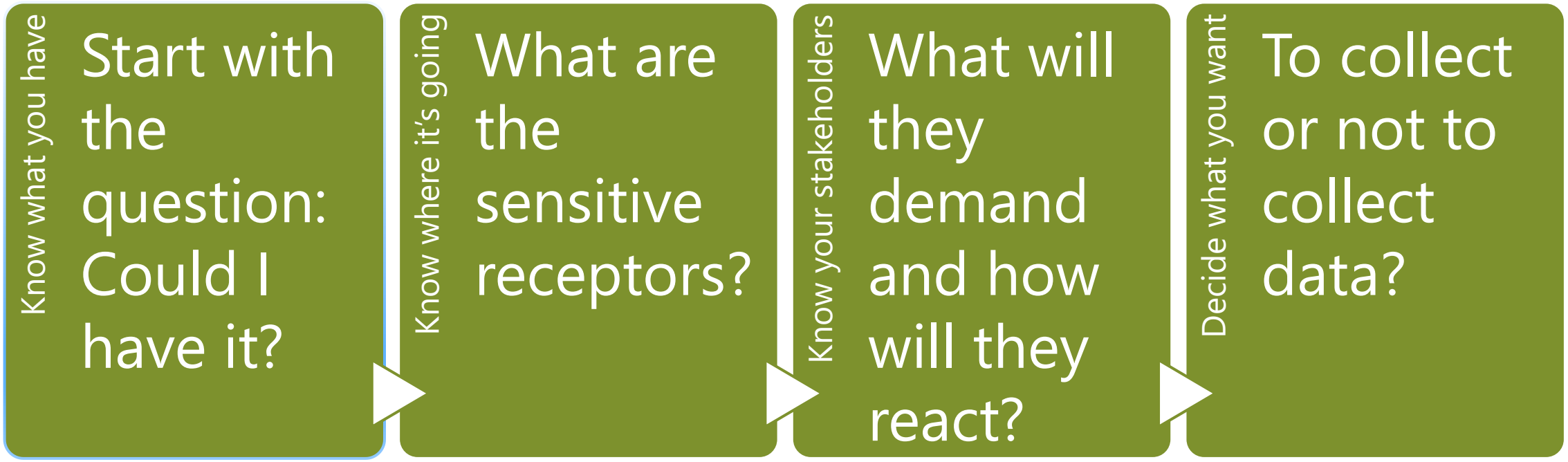


Waste disposal

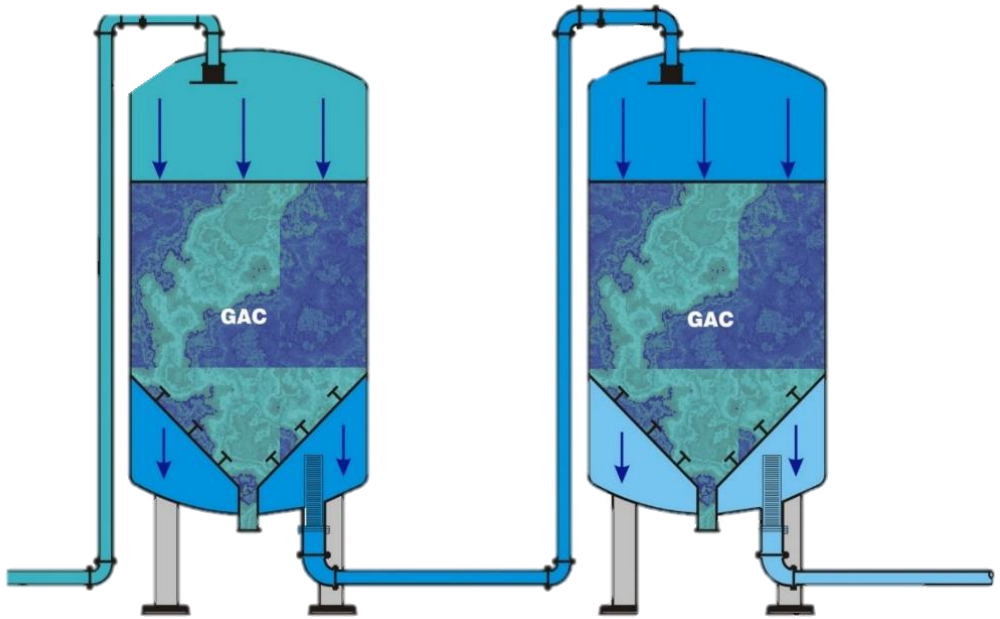
- PFAS- not a regulated hazardous substance
  - General waste guidelines- CEPA Division 8 and Schedule 5.
- Incineration
- Deep-well injection
- Liability profile

Evaluation and strategies

What can I do about it?



Regulatory/remediation strategy



- Potential actions:
  - Source control
  - Excavation: in-situ or removal
  - Water treatment: decision tree
- Regulatory interaction:
  - Establish boundaries
  - Be deliberate when collecting data

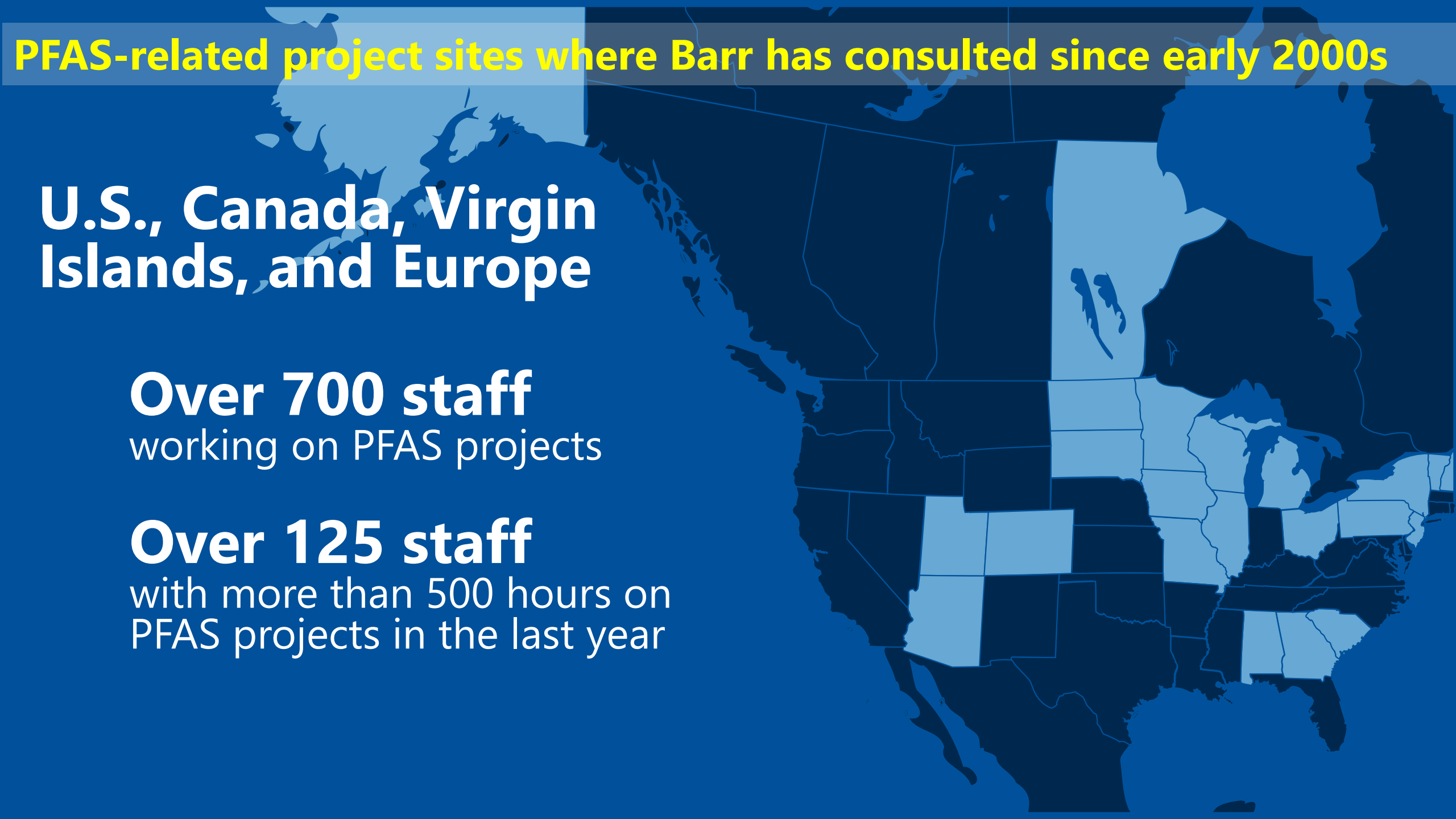
Key takeaways

Continued focus on PFAS

Identify and evaluate

Decide and develop a plan

PFAS-related project sites where Barr has consulted since early 2000s

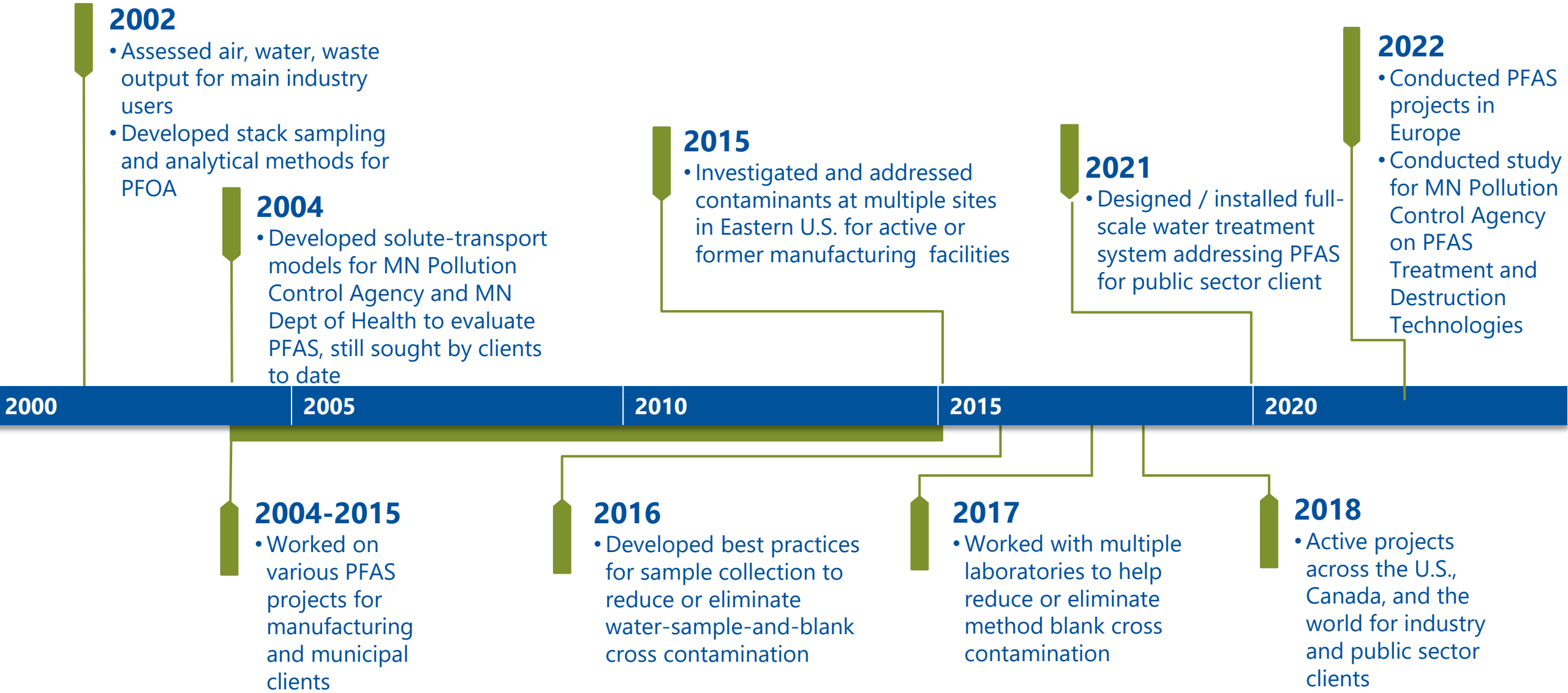


U.S., Canada, Virgin Islands, and Europe

Over 700 staff
working on PFAS projects

Over 125 staff
with more than 500 hours on PFAS projects in the last year

Two decades of PFAS experience



Questions?

Thank You

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