Starting Soon: PFAS Roundtable Session 3

- Download slides for today
  - CLU-IN training page at: https://clu-in.org/conf/itrc/PFAS-Round3/ under "Download Training Materials"
- Using Adobe Connect
  - Related Links (on right) - Select name of link, then click "Browse To"
  - Full Screen button near top of page

Audio Troubleshooting Hints

- Turn up the volume on your speakers
- Turn on the volume in Adobe Connect (if the speaker symbol is white, click on it so it turns green)

- Turn up the speaker volume in Adobe Connect by clicking "adjust speaker volume"
- If you use headphones or a separate speaker, select the correct speaker in Adobe Connect by clicking "Select Speaker"
- Disconnect from VPN
- For continued audio issues, request a call-in number via the Q&A pod

Advancing Environmental Solutions

ITRC PFAS Team

ROUNDTABLE WEBINAR SESSION 3:

Treatment Technologies
Aqueous Film Forming Foam (AFFF)

Sponsored by: Interstate Technology and Regulatory Council (www.itrcweb.org)
Hosted by: US EPA Clean Up Information Network (www.cluin.org)

PFAS Roundtable Webinar

- Introduction
- ITRC PFAS Resources
  - Find everything online at: https://pfas-1.itrcweb.org
- Roundtable format
- Roundtable Q&A

Thank you for joining this ITRC PFAS Roundtable!

ITRC – Shaping the Future of Regulatory Acceptance

- Host Organization — ECOS
- Network - All 50 states, PR, DC
- Federal Partners — DOE, DOD, EPA
- ITRC Industry Affiliates Program — IAP
- Academia
- Community Stakeholders

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PFAS Technical and Regulatory Guidance

- Web document (April 2020, editorial revisions September 2020)

What are PFAS?	How do they behave in the environment?	Why are we concerned about PFAS?	How do we evaluate PFAS in the environment?	How do we remediate PFAS?	What are the major concerns and how do we share what we know?
• Introduction • History and use • Naming conventions • PFAS releases to the environment • Firefighting foams	• Physical and chemical properties • Fate and transport processes • Media-specific occurrence	• Human and ecological health effects • Site risk assessment • Regulations, guidance and advisories	• Site characterization • Sampling and analytical methods • Case studies	• Treatment technologies • Case studies	• Stakeholder perspectives • Risk communication

- 11 Fact Sheets (2017/2018, August 2020)
- Ten video training modules published on YouTube (April 2020)
- Risk Communication Toolkit (published June 2020) https://rct-1.itrcweb.org

ITRC. 2020. *PFAS Technical and Regulatory Guidance Document and Fact Sheets* PFAS-1. Washington, D.C.. https://pfas-1.itrcweb.org/.

Document Information: External files

- Twelve external files for additional detailed information
  - PFAS Water and Soil Values – updated regularly, includes US and some International values
  - Basis for PFOA and PFOS drinking water values in the US
  - Physical and chemical properties
  - Bioconcentration factors tables
  - Ecological toxicity data summary
  - Toxicological effects in mammalian species for some PFAS
  - Analytical methods
  - Treatment technologies
  - Water treatment case studies operation summaries
  - Social Factors vision board

Session 3 - Topics

- Treatment Technologies
- AFFF

- Past sessions
  - Recordings available on Clu-In
  - Q&A digests available on itrcweb.org

Roundtable Webinars

JULY 2020:
Naming Conventions, History & Environmental Sources, Sampling & Analysis

OCTOBER 2020:
Physical & Chemical Properties; Site Characterization; Fate & Transport

APRIL 2021:
Aqueous Film Forming Foam (AFFF); Treatment Technologies

JUNE 2021:
Human & Ecological Health Effects; Risk Assessment & Regulation; Risk Communication; Stakeholder Perspectives

Housekeeping

- Session time is 2 hours
- Participants are on mute
- This event is being recorded
- Download slides for today at the CLU-IN training page
  https://clu-in.org/conf/itrc/PFAS-Round3/
  Under "Download Training Materials"
- Need confirmation of your participation today?
  - Fill out the online feedback form and check box for confirmation email and certificate

Technical Difficulties?

Request support through the Q&A Pod

Roundtable Format

- The moderator will read questions for a response by the panelist(s)
- Questions are selected from those submitted with:
  - participant registration
  - prior PFAS training classes
  - PFAS team members
- Today you may submit additional questions by typing in the Q&A pod
- It may not be possible to answer all questions during the live webinar
- A Q&A digest with references to the PFAS Technical and Regulatory Guidance Document will be made available

INTERSTATE TECHNOLOGY REGULATORY COUNCIL (ITRC)

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Session 3 Panelists

Session 3 - Topics

- Treatment Technologies
- AFFF

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Session 3

Treatment Technologies

https://pfas-1.itrcweb.org

Document Information: Treatment Technologies

Treatment Technologies

Field Implemented

demonstrated under full-scale conditions at multiple sites by multiple practitioners and multiple applications well documented in peer-reviewed literature

Limited Application

implemented on a limited number of sites, by a limited number of practitioners, and may not have been documented in peer-reviewed literature

Developing

researched at the laboratory or bench scale, but these technologies have not been field demonstrated

Liquids Treatment - Field-Implemented Technologies

Developing	Description
Carbon Sorption	Carbon sorption is a physical and chemical process by which one substance becomes attached to another. Regulated PFAS sorb well to carbon; some unregulated ones do not. Reactivation or disposal is needed for spent carbon.
Ion Exchange Sorption	Ion exchange media can be more effective sorbents for PFAS than carbon per unit volume of sorptive media. Some IX resins can be regenerated on site. Single use resins must be incinerated or disposed.
Membrane Filtration	Membrane Filtration, including **reverse osmosis**, uses a partially permeable membrane to remove ions, such as PFAS. Can be effective but can have high energy usage. Reject water (10-20% flow) needs further treatment or disposal.
Deep Well Injection	Injection of liquid wastes in on-site or off-site deep Class I wells can be considered for PFAS.

Water Treatment for PFAS

GAC

Photo used with permission, Dora Chiang, CDM Smith

Anion Exchange Resin

Photo used with permission, Dora Chiang, CDM Smith

Reverse Osmosis

Photo used with permission, Bill DiGuiseppi, Jacobs

Liquids Treatment - Limited Application Technologies

Developing	Description
Novel Sorbents	Colloidal activated carbon, polymers, clays, and biochar have been applied for liquids treatment in limited applications.
Coagulation/ Flocculation	Coagulation/flocculation is addition of polymers that clump small, destabilized particles together into larger aggregates to settle out from the water. Best for high concentration PFAS. Requires large settling tanks or ponds.
Redox Manipulation	Involves adding chemical reagents either aboveground or into the subsurface to destroy organic contaminants through oxidative or reductive chemistry. The mechanisms involving multiple species of free radicals or solvated electrons are not well understood.
Physico-chemical Destruction	Oxidation or reduction through electrochemical, sonochemical, non-thermal plasma, doped ZVI, alkaline metals, and electron-beam technologies have been demonstrated at the bench scale.
Foam Fractionation	Separation of PFAS from liquids by bubbling air, or ozone + air, has been demonstrated at full-scale in limited applications.

Liquid Technologies Table

Remediation Technology Group	Remediation Technology Document Sections included	What PFAS Demonstrated On? What Concentrations/Removal Reported?	Strengths (Includes Co-Contaminants, Sustainability, Scalability)	Challenges/Limitations (Includes Co-Contaminants, Sustainability, Scalability)	Waste Management/Life Cycle	Future Data Needs	PFAS Demonstration Maturity (Lab, Field Pilot, Full-Scale, Commercialized)	References
Sorption (Separation)	12.2.1.1 Granular activated carbon (GAC)	Demonstrated for all PFAS tested to date at parts per trillion to parts per billion concentrations for aboveground activated carbon treatment	Treats all tested PFAS to date with high removals prior to breakthrough. Design flexibility to increase removal. Simple to operate. Multiple vendors. Off-site reactivation/regeneration available for PFAS.	Possible faster breakthrough times for shorter chain versus longer chain PFAS under certain influent and other conditions. Becomes less economical at higher influent concentrations (for example, >10–100 ppb). Competitive adsorption w/ other species. Precursors and other PFAS not analyzed for can increase GAC loading and accelerate changeout frequencies. No destruction of PFAS, unless it is reactivated or incinerated at high temperature (>1,100°C). ***Pretreatment may be necessary.***	Spent activated carbon must be removed for offsite disposal, or reactivation/regeneration.	More comprehensive shorter chain adsorption capacity data. Competition with other contaminants and aqueous species. Regulation of individual PFAS in addition to PFOA and PFOS. Impact on PFAS precursors.	FI	(Dickenson and Higgins 2016; Brewer 2017; Cummings et al. 2015; Appleman et al. 2013; Szabo et al. 2017; Burdick et al. 2016; Woodard, Berry, and Newman 2017; Hohenstein 2016; Xiao et al. 2017; AWWA 2016; Mimna 2017; McNamara et al. 2018; Westreich et al. 2018; Liu, Werner, and Bellona 2019)

Updates coming in 2021

PFAS-1, Table 12-1 Liquid Technologies Table

Solids Treatment - Field-Implemented Technologies

Developing	Description
Sorption and Stabilization	Stabilization involves mixing waste with binding agents like clays, or other proprietary blends to make them less likely to be released into the environment. Questions remain about permanence. Soil (and liability) remains on site in perpetuity.
Excavation and Disposal	Excavation and transport offsite to a permitted landfill. Landfills starting to refuse PFAS wastes. Liability is potentially transferred to landfill. Future regulatory changes (e.g., hazardous substance) may affect options for disposal.
Excavation and Incineration	Incineration is the process of heating PFAS soils to temperatures high enough to destroy contaminants (>1,100 C). Limited facilities available that are permitted for PFAS. Complete destruction not well documented yet.

Solids Treatment - Limited Application Technologies

Developing	Description
Thermal Desorption	Thermal desorption utilizes heat to increase the volatility of contaminants such that they can be removed (separated) from the solid matrix (typically soil, sludge or filter cake). Demonstrated in field; offers potential for on-site destruction.
Size Segregation/ Soil Washing	Size segregation can be as simple as dry sieving to separate coarse materials, which does not typically sorb PFAS, from fine material (e.g., clays and organics) which do sorb PFAS. Soil washing is a more involved process through rinsing, chemical separation, etc. Soil washing requires treatment of multiple waste streams to address "end of life" pathway.

Session 3

AFFF

https://pfas-1.itrcweb.org

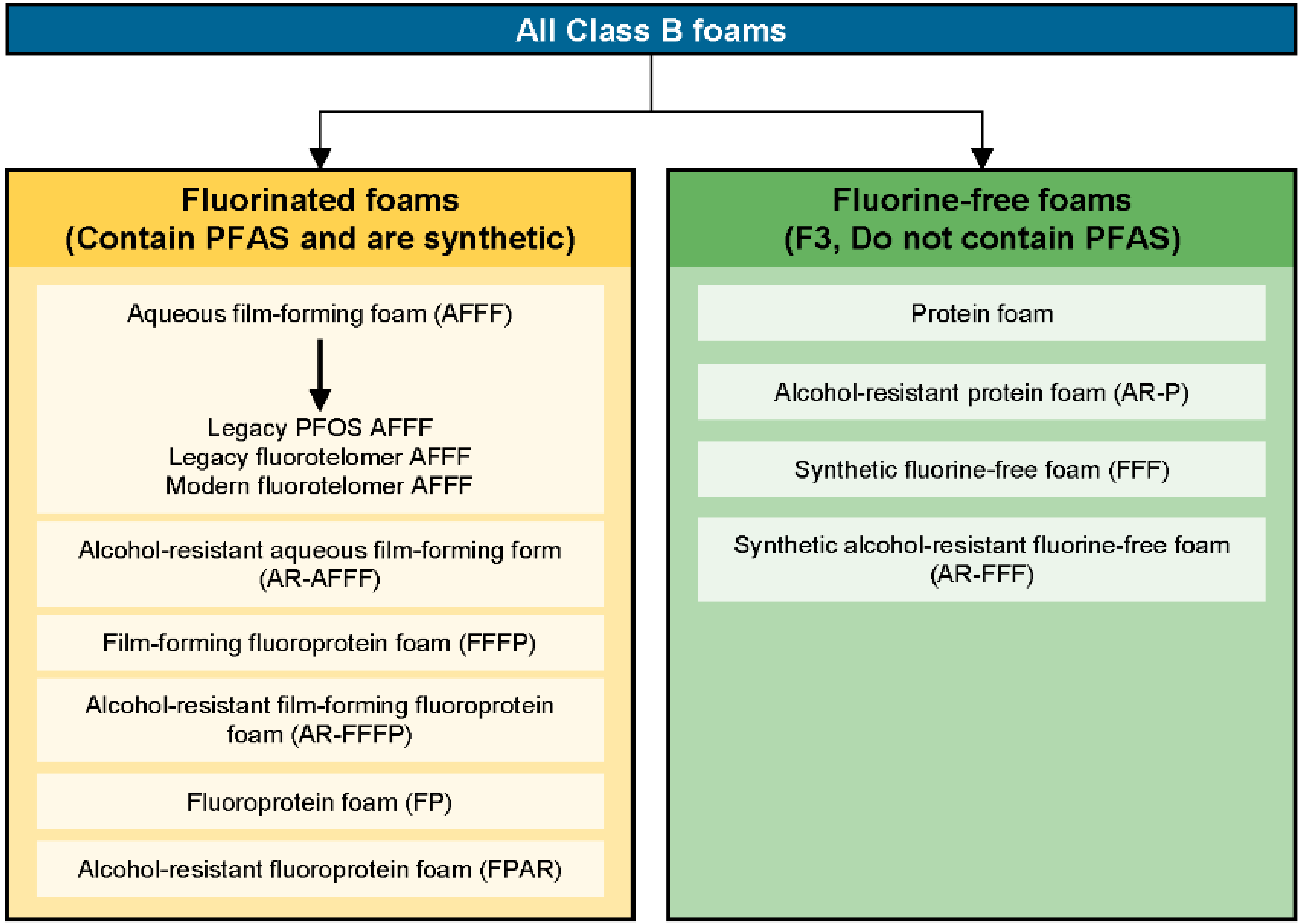
Classes of Firefighting Foams

- CLASS A Foams- Developed in the 1980s for fighting wildfires and used structure fires.
  - Do not contain PFAS
- CLASS B Foams- Used to fight fires involving flammable, combustible liquids and gases; petroleum greases, tars, oils and gasoline; and solvents and alcohols

Several Class B foams contain PFAS

AFFF are the primary Class B foam that contain fluorosurfactants

Types of Class B foams



PFAS-1, Figure 3-2. Types of Class B Foams
Source: S. Thomas, Wood plc, used with permission

Typical Composition of AFFF

AFFF products contain other surfactants, solvents, additives

- 3% AFFF concentrate contains:
  - More than 60% water/diluent
  - Up to 20% is solvents
  - As much as 18% is surfactants ***of which less than 2% is fluorosurfactants.***

PFAS-1, Figure 3-3. Typical composition of 3% AFFF concentrate.
Source: S. Thomas, Wood plc, adapted from Kempisty, Xing and Racz 2018

Life Cycle Considerations for AFFF

PFAS-1, Figure 3-1. Life cycle considerations for AFF
S. Thomas, Wood plc, used with permission

Types: Legacy PFOS AFFF

- Electrochemical Fluorination (ECF) chemistry
  - Homologous series (C2-C13)[1]
  - Branched & linear isomers (30:70)[2]
    - If exclude branched isomers, concentrations underestimated (biased low)
  - Crude synthesis, many side products
  - PFAS composition
    - 89% PFSAs (e.g., PFOS) in 3M AFFF
    - 1.6% PFCAs (e.g., PFOA)
    - 9.4% other forms with multiple charged groups
      zwitterionic (+/-)

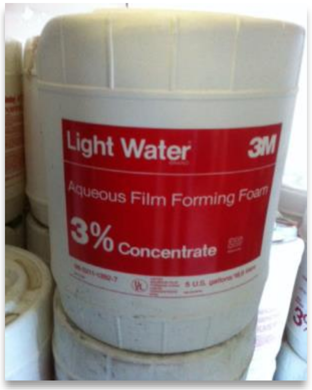


Photo courtesy of J. Field
Oregon State Univ.

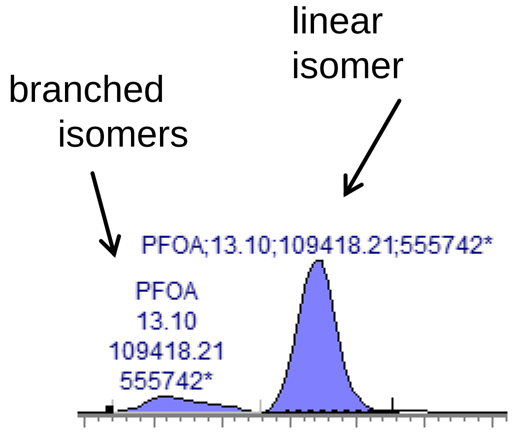
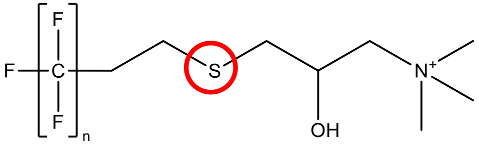


Figure courtesy C. Higgins, Colorado School of Mines

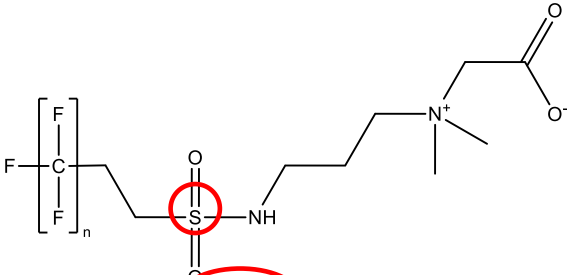
[1]Barzen-Hansen et al., 2015. *ES&T Letters* 2: 95-99; [2]Benskin, 2010. Rev Environ Contam Toxicol

Types: Legacy Fluorotelomer AFFFs[1]

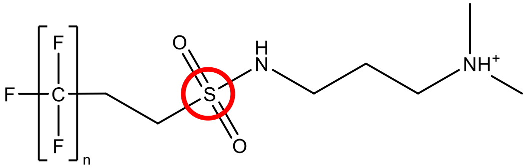
- *Poly*fluorinated forms
- Do not contain PFOS or degrade to PFOS
- None listed on UMCR3 or Method 537 lists
- Precursors with -S- degrade to fluorotelomer sulfonates and PFCAs[1,2]



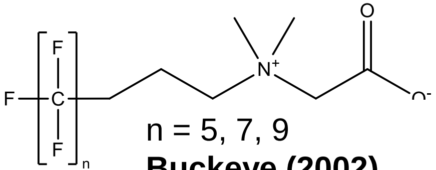
n = 6, 8
Angus (1994)



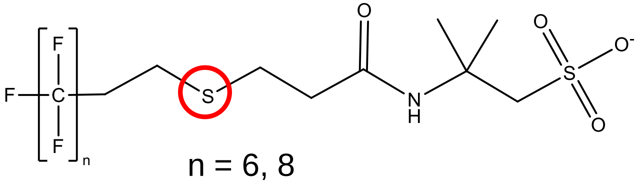
n = 4, 6, 8, 10, 12 **National Foam (1976), Fire Service Plus (2002)**



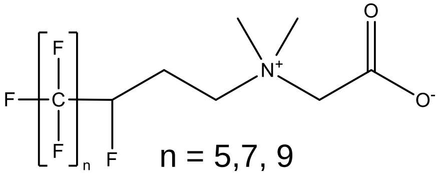
n = 6, 8
National Foam (1976), Fire Service Plus (2002)



n = 5, 7, 9
Buckeye (2002)



n = 6, 8
Ansul (1970), Angus (1994), Chemguard (2002)



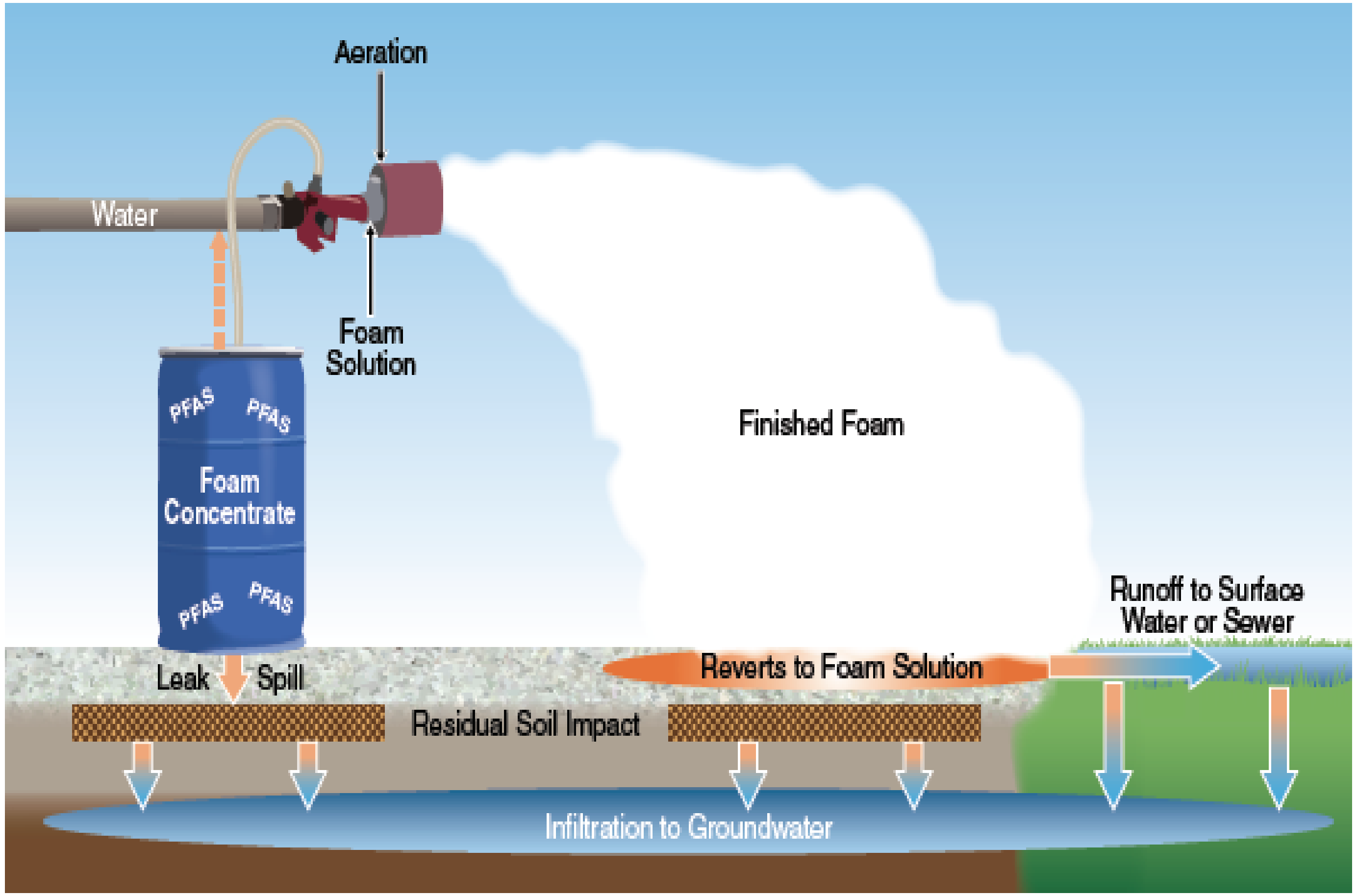
n = 5,7, 9
Buckeye (2002)

[1]Place and Field, 2012. *ES&T* 46: 7120-7127; [2]Weiner et al., 2013. Environ Chem 10:486-493; [3]Harding-Marjanovic et al., 2015. *ES&T* 49:7666-7674

Photo and diagrams used with permission from J. Field, Oregon State Univ.

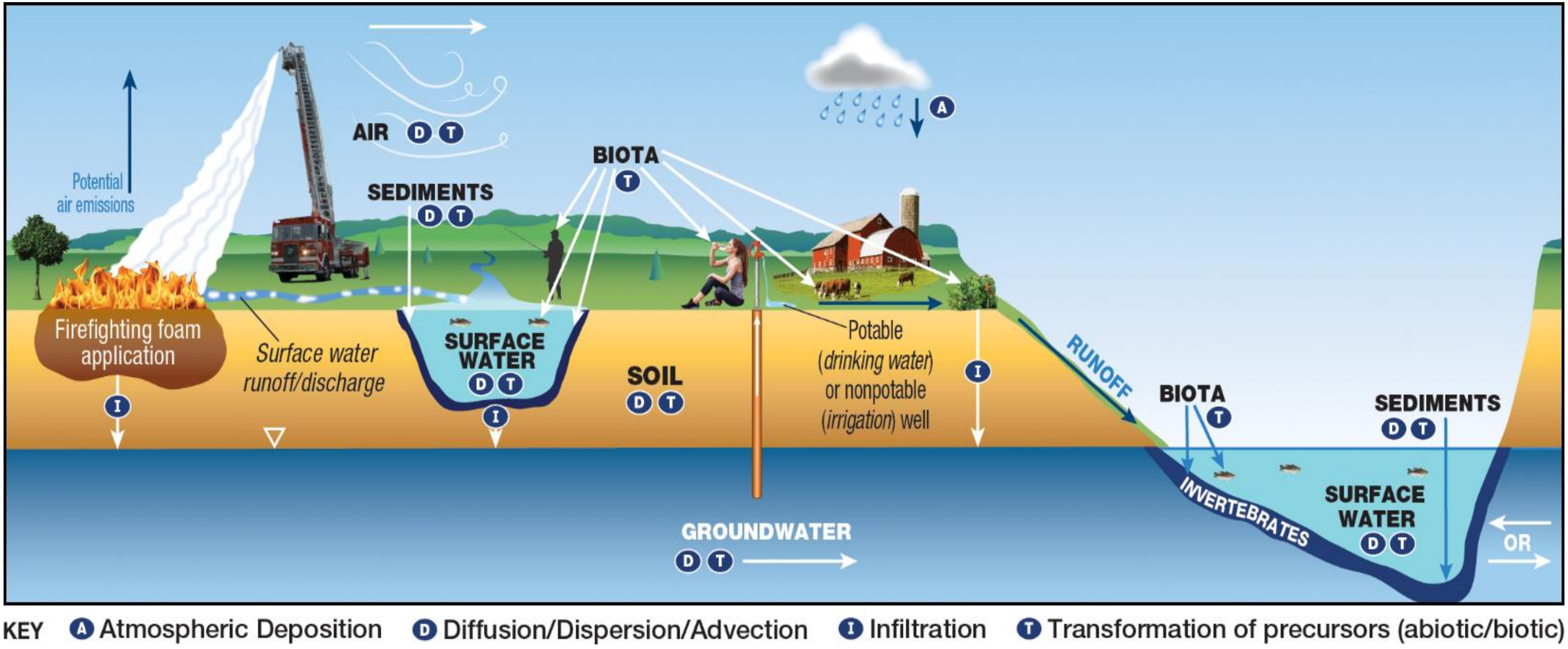
Mechanisms for Release to Environment

- AFFF is applied by mixing concentrate with water
- The foam solution is aerated at the nozzle
- Once released, it can contaminate soil, surface water and groundwater
- Co-contaminants often present



Source: Adapted from figure by J. Hale, Kleinfelder, used with permission. ITRC History and Use fact sheet.

CSM for AFFF Application Sites



PFAS-1, Figure 2-17. CSM for fire training areas
Figure Adapted from figure by L. Trozzolo, TRC, used with permission

Foam Research and Development

SERDP-ESTCP Research (https://serdp-estcp.org/)

- Novel Fluorine-free Replacement for AFFF – NRL (completion August 2018)
- Fluorine-free Foam - National Foam (completion September 2019)
- Fluorine-free Foams with Oleophobic Surfactants and Additives for Effective Pool Fire Suppression - NRL (completion December 2020)

Additional on-going research efforts are also being done by others globally in government and industry.

State Regulations and Guidance for AFFF

Table 3-1. Representative state AFFF regulatory and legislative activity

State	Regulation or Bill	Initial Effective Date	What is Regulated?	Specific Requirement	Reference
New York	6NYCRR Part 597	March 2017	PFOS, PFOA, and Class B foams	PFOS and PFOA are hazardous substances. Storage and registration requirements for class B foams if those foams contain at least 1% by volume of PFOS and PFOA (acid and salt) and prohibit the release of 1 pound or more of each into the environment during use. If a release exceeds the 1-pound threshold, it is considered a hazardous waste spill and must be reported. Clean-up may be required under the state's superfund or brownfields program (NYDEC 2017). New York's Chemical and Bulk Storage regulations may also trigger further registration and storage requirements for foams that contain one of the four PFAS designated as hazardous substances (NY CRR Parts 596-599).	(NY DEC 2017a ▻)
Washington	WAC 296-24-33001	July 2020	Class B foams	Class B firefighting foams cannot be used or discharged for training purposes, and manufacturers of firefighting personal protective equipment must provide written notification to purchasers if the equipment contains PFAS. Beginning July 1, 2020, manufacturers of class B firefighting foams may no longer manufacture, sell, or distribute for sale PFAS-containing class B firefighting foams except for the following uses: applications where the use of a PFAS-containing firefighting foam is required by federal law, including but not limited to the requirements of 14 CFR 139.317 (such as military and FAA-certfied airports). Other exceptions include: Petroleum Terminals (as defined in RCW 82.23A.010), Oil Refineries, Chemical Plants (WAC 296-24-33001)	(Washington State Legislature 2018c ▻)
Virginia	House Bill 2762ER	January 2020	PFAS-containing AFFF	Virginia Department of Fire Programs and the Virginia Fire Services Board begin assisting municipal fire departments to transition to fluorine-free foams, where possible. Effective the same date, the bill bans the discharge or use of PFAS-containing AFFF foams for testing or training unless the facility has implemented containment, treatment, and disposal measures to prevent release to the environment.	State of Virginia, 2019

New Regulatory Programs table coming in 2021

Session 3 - Topics

- Treatment Technologies
- AFFF

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PFAS Technical and Regulatory Guidance

- Web document (April 2020, editorial revisions September 2020)

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PFAS Team Schedule – through December 2021

- Continue work on updating technical information and regulatory approaches in this rapidly evolving subject
  - Guidance Document Updates
    - June 2021 and December 2021
    - Periodic small updates and reference additions
  - Roundtable Webinars, Virtual Workshops, and Outreach

Thank you for attending!

- Email further questions on today's session to: training@itrcweb.org
- Feedback Form: https://clu-in.org/conf/itrc/PFAS-Round3/feedback.cfm
  - *Please use the Feedback Form to ask questions for future PFAS Roundtables*

Future PFAS Roundtable

Session 4 (JUNE 10, 2021)

- Human & Ecological Health Effects
- Risk Assessment & Regulations
- Risk Communication
- Stakeholder Perspectives

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