

1 Introduction

Aqueous film-forming foam (AFFF) is a highly effective firefighting product intended for fighting high-hazard flammable liquid fires. AFFF products are synthesized by combining hydrocarbon foaming agents with fluorinated surfactants to achieve a product that has been used at military installations, civilian airports, petroleum refineries, bulk storage facilities, and chemical manufacturing plants (Hu et al. 2016; CONCAWE 2016).

This fact sheet targets local, state, and federal regulators and tribes in environmental, health and safety roles, as well as AFFF users at municipalities, airports, and industrial facilities, and is not intended to replace manufacturer specifications or industry guidance for AFFF use. The information provided is a high-level summary on AFFF use, the associated hazards, and how to reduce and eliminate potential harm to human health and the environment. Additional information is available in the Guidance Document.

2 What is AFFF?

Class B firefighting foams are commercial surfactant solutions that are designed and used to combat Class B flammable fuel fires. For the purpose of this fact sheet, Class B foams can be divided into two broad categories: fluorinated foams that contain PFAS and fluorine-free foams (F3) that do not contain PFAS.

There are six groups of Class B foams that contain PFAS and four groups of Class B foams that do not. Figure 1 illustrates all categories of Class B foams. This fact sheet addresses only AFFF because it is the most widely used and available type of Class B foam.

ITRC has developed a series of fact sheets that summarize recent science and emerging technologies regarding PFAS. The information in this and other PFAS fact sheets is more fully described in the **ITRC PFAS Technical and Regulatory Guidance Document (Guidance Document)** (<https://pfas-1.itrcweb.org/>).

This fact sheet outlines methods to properly identify, handle, store, capture, collect, manage, and dispose of AFFF to limit potential environmental impacts, and includes:

- Definition of AFFF
- Best Management Practices for AFFF use
- Regulations Affecting Sale and Use
- Foam Research and Development

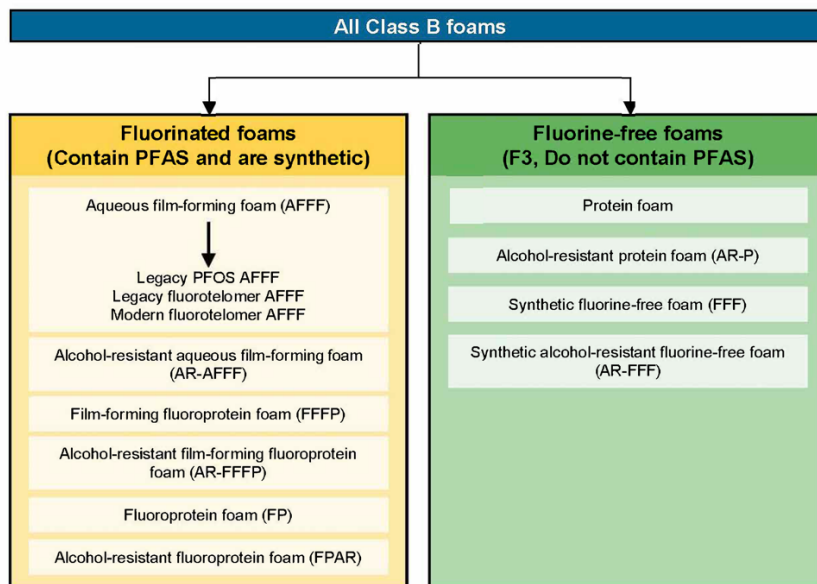


Figure 1. Types of Class B foams.

Source: S. Thomas, Wood, PLC. Used with permission. PFAS-1, Figure 3-2.

Aqueous Film-Forming Foam (AFFF) *continued*

AFFF is considered a fluorinated foam and when mixed with water, the resulting solution achieves the interfacial tension characteristics needed to produce an aqueous film that spreads across the surface of a hydrocarbon fuel (petroleum greases, tars, oils, and gasoline; and solvents and alcohols) to extinguish the fire and to form a vapor barrier between the fuel and atmospheric oxygen to prevent re-ignition. This film formation is the defining feature of AFFF.

AFFF has been used at chemical plants, flammable liquid storage and processing facilities, merchant operations (oil tankers, offshore platforms), municipal services (fire departments, firefighting training centers), oil refineries, terminals, and bulk fuel storage farms, aviation operations (aircraft rescue and firefighting, hangars), in some industrial fire extinguishers, and military facilities.

There are three types of AFFF. Each is presented in Figure 1:

- legacy PFOS AFFF (manufactured in the US from the late 1960s through 2002)
- legacy fluorotelomer AFFF (contain some long-chain PFAS) (manufactured in the US from the 1970s until 2016)
- modern fluorotelomer AFFF (short-chain PFAS became the predominant fluorochemicals used in manufacturing in response to USEPA 2010/2015 voluntary PFOA Stewardship Program)

Most foam manufacturers now produce Class B F3s, and evaluation of the performance of these foams is an important consideration for future purchase decisions. As part of preplanning for replacement foams, it is important to ensure that the Class B F3 is not considered a regrettable substitution over AFFF and can achieve the required performance specifications for the target flammable liquid hazards (FFFC 2016). The 2022 National Defense Authorization Act (NDAA) requires a new Military Specification (Mil-Spec) for PFAS-free foams by January 2023. As of May 2022, F3s do not meet the performance requirements of the current Mil-Spec and are not used at federal- and FAA-regulated facilities (FAA 2021).

The NDAA of fiscal year 2020 (signed into law Dec 20, 2019) requires the DOD to phase out its use of AFFF at all military installations by Oct. 1, 2024, with limited exceptions, and immediately stop military training exercises with AFFF. The secretary of the Navy must publish specifications for PFAS-free firefighting foam at all military installations and ensure that the foam is available for use by Oct. 1, 2023. The NDAA of fiscal year 2022 also addresses AFFF, specifically requiring new reviews and guidance to prevent and mitigate AFFF spills. In October 2021, the USEPA published the PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024 (USEPA 2021 Ref#2223). The USEPA's stated goals for addressing PFAS are focusing on research, restriction, and remediation. The strategic roadmap includes actions across the different divisions of USEPA. More information about USEPA's actions in 2021 to address PFAS are available on their website (USEPA 2021 Ref#2223).

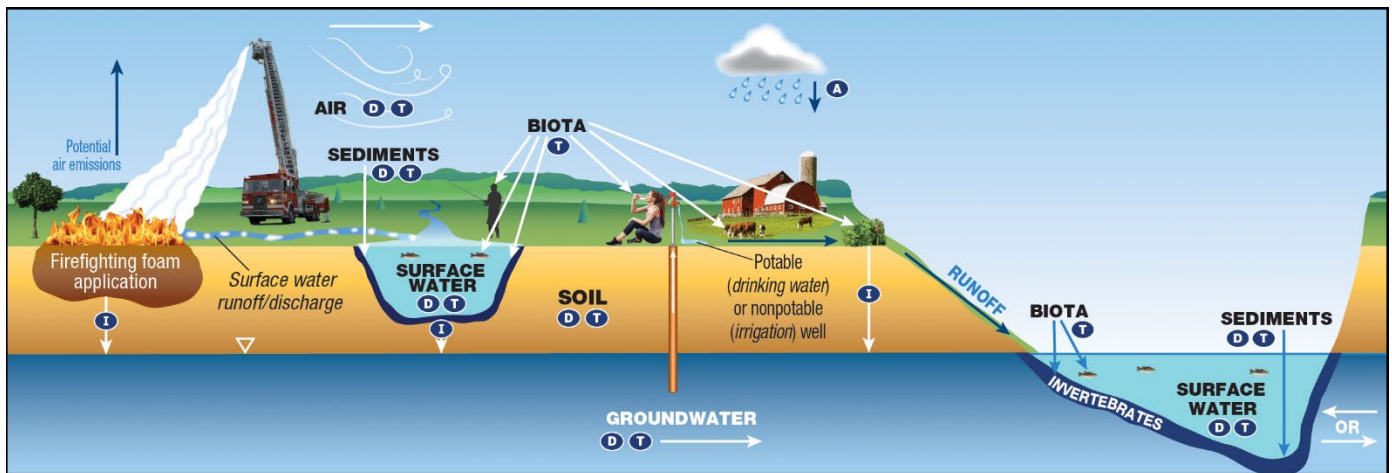
3 Best Management Practices (BMPs) for Class B AFFF Use

Firefighting foams are an important tool to protect human health and property from flammable liquid fire threats. Proper management and usage strategies combined with the ongoing refinement of environmental regulations will allow an informed selection of the viable options to sustainably use firefighting foams. BMPs should be established for the use of any firefighting foam to prevent possible releases to the environment that can lead to soil, groundwater, surface water, and potentially drinking water contamination. The discharge of firefighting foams to the environment is of concern because of the potential negative impact they can have on ecosystems and biota. AFFF, due to the presence of PFAS, poses a unique challenge to protecting the environment when it is released. Specifically, for AFFF, the amount of PFAS from foam that may enter groundwater depends on the type and amount of foam used, the degree of containment, when and where the foam was used, the type of soil and the depth to groundwater. AFFF is typically discharged on land but can run off into surface water or stormwater or infiltrate to groundwater. A conceptual site model (CSM) is presented in Figure 2.

BMPs start with pre-planning and deciding which foam to keep in stock. The team should consider key factors such as these:

- Whether F3 alternatives can meet site-specific performance requirements
- Site-specific evaluation of likely fire hazards and potential risks for life, public safety, and property
- Potential environmental, human health, and financial liabilities associated with AFFF releases
- Site constraints, including existing equipment retrofit requirements to adapt to alternate foams

Aqueous Film-Forming Foam (AFFF) *continued*



KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

Figure 2. CSM for fire training areas.

Source: Adapted from figure by L. Trozzolo, TRC. Used with permission. PFAS-1, Figure 2-19.

BMPs should consider the entire life cycle for AFFF, Figure 3, including procurement and inventory, foam systems and operations, emergency firefighting operations, immediate investigative and clean-up actions, treatment and disposal and system replacement.

The procurement and inventory of foam should be carefully considered. Foams should be selected that meet the performance specification requirements governing the use. Foams procured should be documented, labelled clearly and adequately contained. Foam use and disposal should be carefully tracked and recorded.

When evaluating foam systems and operations, from fixed-system testing, mobile firefighting equipment testing and appropriate training exercises, engineering and administrative controls as well as personal protective equipment (PPE) should be carefully evaluated. During emergency firefighting operations following a release of firefighting foam, PPE should be used correctly, maintained, and decontaminated routinely. Immediate investigative and clean-up actions include initial mitigation efforts such as source control, containment tactics, and recovery tactics.

The treatment and disposal of AFFF products and environmental media impacted with PFAS can be complex, time consuming, and costly. Practitioners should be aware of approved and available disposal options prior to the generation of PFAS-impacted waste or the start of an AFFF replacement project to avoid potentially lengthy waste storage timeframes. Currently, available disposal options for AFFF and PFAS-impacted materials are limited and each option has its advantages and disadvantages. More information is in the Guidance Document, as well as in the PFAS Regulatory Programs Summary Table (see the External Data Tables on <https://pfas-1.itrcweb.org>).

Firefighting foam replacement is complex and could require a complete system review and, potentially, redesign and modification of system components to meet the new objectives or material and performance requirements. Foam replacement should include an evaluation of specific hazards and application objectives, a review of applicable performance standards, an understanding of engineering requirements for foam product storage and application, and a check to ensure that the foam product is approved for use for the specific hazards being mitigated.



Figure 3. Life cycle considerations for AFFF.

Source: S. Thomas, Wood, PLC. Used with permission. PFAS-1, Figure 3-1.

4 Regulations Affecting the Sale and Use of AFFF

There are many State, Federal, and International regulations and guidance documents governing the procurement, use, and disposal of AFFF. Activities range from AFFF take-back programs and prohibition of manufacture, sale, use, and import of AFFF through to restrictions and requirements for disposal. More information is in the Guidance Document, as well as in the PFAS Regulatory Programs Summary Table (see the External Data Tables on <https://pfas-1.itrcweb.org>).

5 Foam Research and Development

A substantial amount of research related to AFFF alternatives and replacement chemistries has recently been completed or is being considered at the time of publication. Several organizations globally have made investments in research and development around AFFF from the assessment of their use, environmental impacts, as well as socioeconomic impacts of transition to and performance specifications of F3 alternatives. For more information related to this topic, please refer to the Guidance Document.

6 References and Acronyms

The references cited in this fact sheet and further references can be found at <https://pfas-1.itrcweb.org/references/>. Reference numbers are included in this fact sheet for non-unique citations in the Guidance Document reference list.

The acronyms used in this fact sheet and in the Guidance Document can be found at <https://pfas-1.itrcweb.org/acronyms/>.



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