Chapter 9: **Per- and Polyfluoroalkyl Substances (PFAS)**

Emerging contaminants of concern bring unique challenges to the Savannah River Site (SRS) as changing regulatory requirements compel the reevaluation of historical and current practices to maintain regulatory compliance and continue to protect human health and the environment. SRS responds to this by

- Ensuring transparency with regulators and the public
- Being proactive and responsive in anticipating regulatory changes
- Collecting data and information to assess and determine further appropriate actions

2023 Highlights

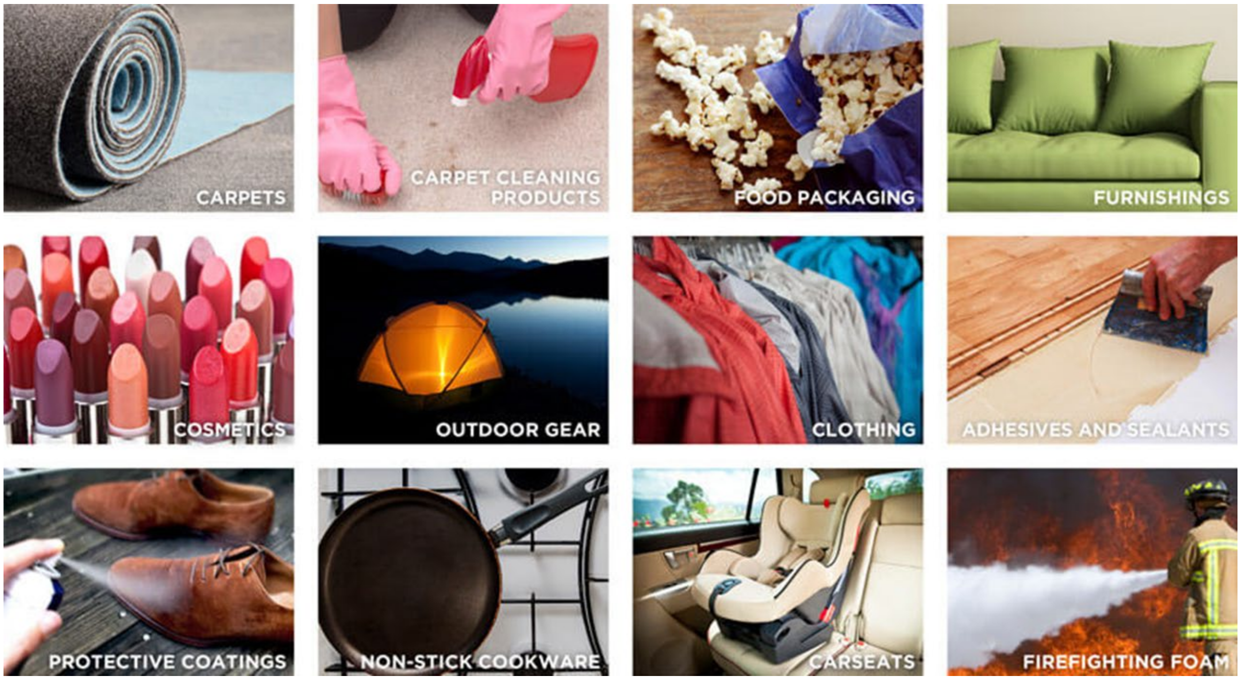
- The U.S. Department of Energy (DOE), led by the Office of Environment, Health, Safety, and Security, continues to actively assess and understand per- and polyfluoroalkyl substances (PFAS) presence at DOE sites and to take actions to manage risk.
- The SRS PFAS Working Group (PWG) continued working with DOE-Headquarters (HQ) by reviewing draft guidance documents and commenting on proposed U.S. Environmental Protection Agency (EPA) rulemaking and initiatives.
- In October, DOE-Savannah River (DOE-SR) began reviewing the *SRS PFAS Implementation Plan*, Revision 1. SRS had submitted the draft document in December 2022 as a DOE PFAS Strategic Roadmap commitment.
- In October and November, SRS sampled 65 wells and 10 surface water stations in D Area for PFAS constituents as part of an ongoing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation.
- In November, SRS briefed the SRS Citizens Advisory Board on SRS PFAS activities during its Full Board Meeting.

9.1 INTRODUCTION

Increasing national attention on the topic of per- and polyfluoroalkyl substances (PFAS) has prompted calls for action from federal, state, and local government. It is important to understand the nature and use of PFAS to comprehend the scope of these responses.

PFAS are carbon atoms linked to each other and bonded to fluorine atoms. The fluorination imparts properties to the molecule. The carbons may be partially fluorinated (polyfluorinated) or fully fluorinated (perfluorinated). PFAS are a group of more than 9,000 man-made synthetic chemicals that have been used worldwide in industry and consumer products for more than 70 years. PFAS compounds have numerous different properties and applications depending on the compound chemical structure.

Because of their wide range of properties, PFAS use is ubiquitous and pervasive from both a consumer product and industrial application, as shown in the examples below.



PFAS Use is Common In a Variety of Consumer and Industrial Products.

PFAS have followed a pattern of emergence and awareness similar to many other regulated environmental contaminants, such as 1,4-dioxane. Figure 9-1 provides a general timeline of PFAS manufacturing, use, and awareness.

PFAS are a broad group of man-made chemicals with numerous properties and applications. They include 3,000 to 5,000 individual chemicals. The most-studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). PFOA and PFOS are chemically very inert, resistant to high temperatures, reduce surface tension, and are water- and dirt-repellent and grease-proof. The very properties that have made these materials into an industrial success also have led to persistency, bioaccumulation, and, in some cases, their toxicity in the environment. These compounds do not readily degrade by most natural processes. They are thermally, chemically, and biologically stable and are resistant to biodegradation, atmospheric photooxidation, direct photolysis, and hydrolysis. The structure of perfluorochemicals increases their resistance to degradation; the carbon-fluorine bonds require a lot of energy to break down, and the fluorine atoms shield the carbon backbone. Although PFOA and PFOS are no longer manufactured in the United States, they may exist in legacy products and imports.

Due to their widespread production and use, as well as their ability to move and persist in the environment, surveys conducted by the Centers for Disease and Prevention show that most people in the United States have been exposed to PFAS. Figure 9-2 shows the following exposure pathways:

- Occupational exposures—PFAS manufacturing resulting in inhalation and dermal contact
- Nonoccupational exposure
  - Drinking water contaminated with PFAS
  - Eating foods, such as fish caught in PFAS-contaminated water, or crops grown in PFAS-contaminated soil
  - Breathing air containing PFAS
  - Inhaling and ingesting house dust containing PFAS
  - Having direct contact with consumer products treated or packaged with PFAS

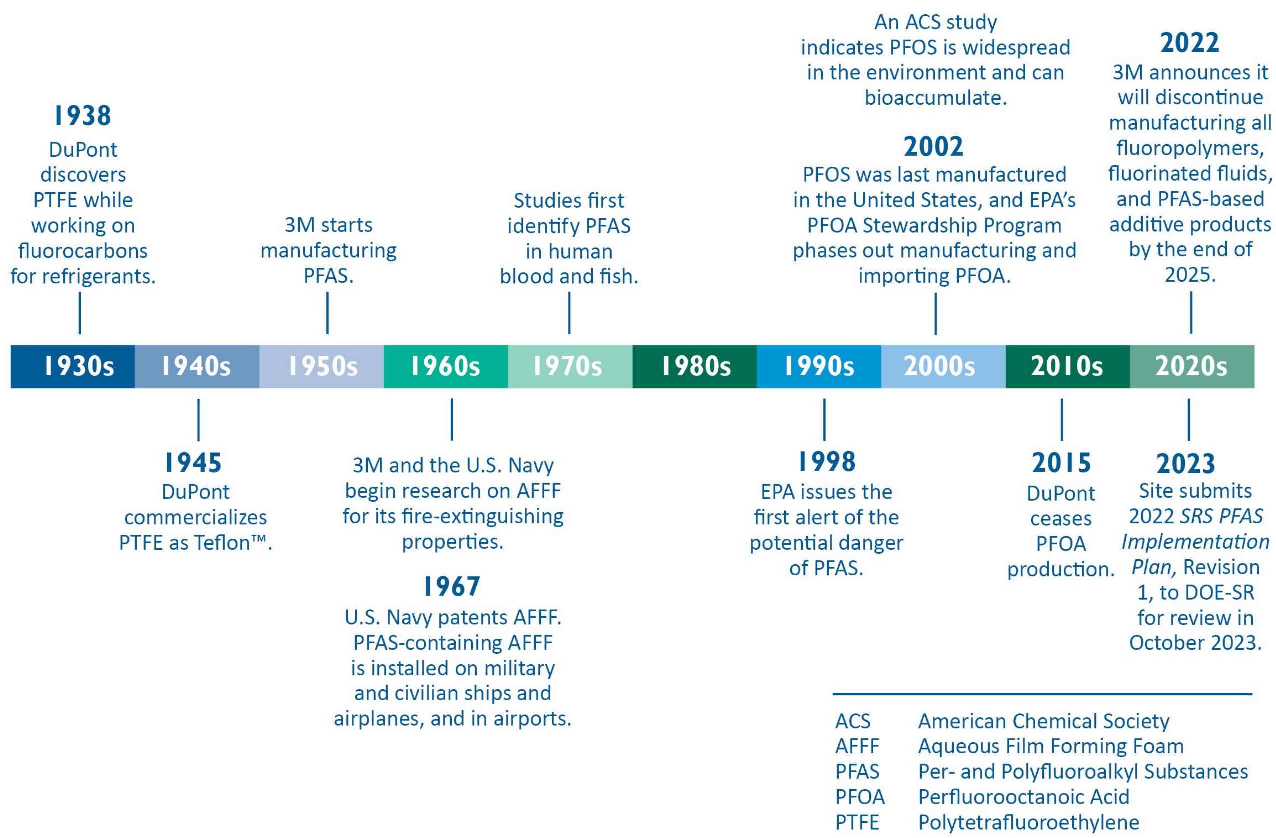


Figure 9-1 Key Dates in the Development and Regulation of PFAS in the United States

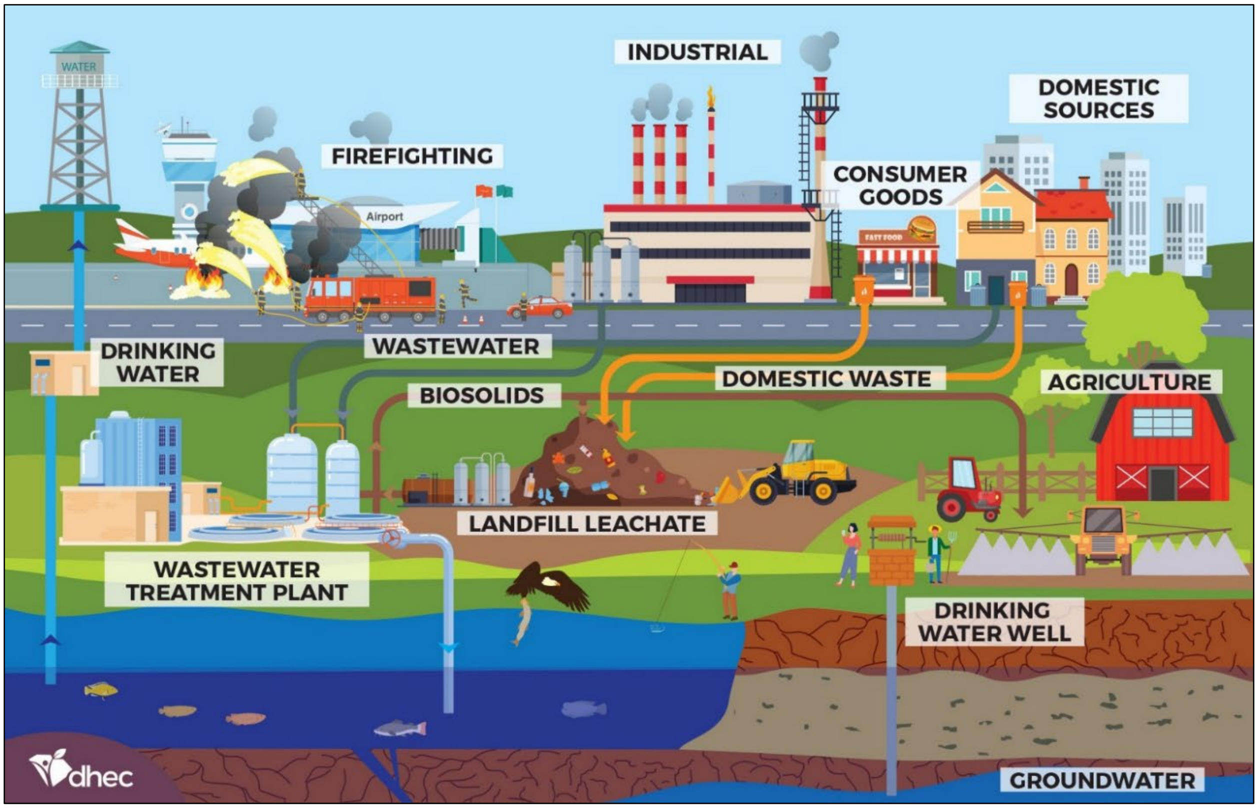


Figure 9-2 PFAS Exposure Pathways

Terminology is one of the confusing points when discussing PFAS both within the scientific community and with the public. Because there are thousands of chemicals within this group, they do not all have the same properties and associated concerns. For example, stating that PFAS can cause cancer is misleading, because only a small portion of the thousands of PFAS have been studied. Health effects from peer-reviewed scientific studies have shown that exposure to certain PFAS chemicals may lead to

- Reproductive effects, such as decreased fertility or increased high blood pressure in pregnant women
- Developmental effects or delays in children, including low birth weight, accelerated puberty, bone variations, or behavioral changes
- Increased risk of some cancers, including prostate, kidney, and testicular cancers
- Reduced ability of the body's immune system to fight infections, including reduced vaccine response
- Interference with the body's natural hormones
- Increased cholesterol levels and the risk of obesity

9.2 STATUS OF PFAS REGULATIONS AND GUIDANCE

9.2.1 U.S. Environmental Protection Agency (EPA)

The EPA's *PFAS Strategic Roadmap* is the driver for all the regulatory actions pertaining to PFAS. The agency developed this plan to attack the problem on multiple fronts while leveraging the full range of statutory authorities to confront the human health and ecological risks of PFAS. The EPA made specific commitments to action for 2021 through 2024. The planned actions represent important and meaningful steps to safeguard communities from PFAS contamination. Cumulatively, these responses will build on one another and lead to more enduring and protective solutions.

The EPA's integrated approach to PFAS focuses on three central directives:

- Research—Invest in research, development, and innovation to increase understanding of PFAS exposures and toxicities, human health and ecological effects, and effective interventions that incorporate the best available science
- Restrict—Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment
- Remediate—Broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems

2023 highlights of the EPA's regulatory initiatives include the following:

- Adding nine PFAS chemicals to the Toxic Release Inventory list starting in reporting year 2023 (due July 1, 2024)
- Publishing Proposed National Primary Drinking Water Regulation for six PFAS chemicals (PFOA, PFOS, perfluorononanoic acid [PFNA], hexafluoropropylene oxide dimer acid [HFPO-DA, commonly known as GenX Chemicals], perfluorohexane sulfonic acid [PFHxS], and perfluorobutane sulfonic acid [PFBS]) (*Federal Register*, March 29, 2023)
- Requiring all manufacturers and importers of PFAS and PFAS-containing articles to report information on uses, production volumes, disposal, exposures, and hazards in any year since 2011. For most manufacturers and importers, the report must be submitted to the EPA in 2025.
- Announcing a framework for evaluating PFAS to ensure that new PFAS, or new uses of existing PFAS, do not pose risks to human health or the environment before they are approved for use.

9.2.2 U.S. Department of Energy

In response to the EPA's roadmap, the U.S. Department of Energy (DOE) issued its own PFAS Strategic Roadmap, DOE Commitments to Action 2022−2025, in August 2022. The DOE PFAS Strategic Roadmap (Figure 9-3) outlines DOE's overall approach, goals, objectives, and planned actions to assess and manage PFAS risk at DOE sites in an effort to protect human health and the environment.

DOE-Headquarters (DOE-HQ) established a PFAS Working Group (PWG) in March 2021. The DOE-HQ PWG is responsible for

- Exchanging and gathering information from DOE sites, including sampling strategies, remediation techniques, and success stories
- Working collaboratively with DOE sites to identify potential PFAS contamination issues
- Interfacing with HQ interagency working groups
- Educating DOE sites on PFAS
- Understanding PFAS operations and use at DOE sites
- Sharing lessons learned regarding PFAS

In October 2022, DOE established a PFAS Panel to provide input on critical DOE guidance and policy documents.

Figure 9-3 DOE's Approach to PFAS Rests on Four Pillars and Their Associated Goals

9.2.3 Savannah River Site

In response to the DOE directives, the Savannah River Site (SRS) established its own PWG in March 2022. The SRS PWG serves as a Site-level conduit to the DOE PFAS Coordinating Committee, which led the development of and will guide future updates to the DOE PFAS Roadmap. The SRS PWG researches the interpretation of aspects of PFAS issues. As appropriate, it may develop advisory or tactical recommendations to DOE-Savannah River (DOE-SR) management on specific PFAS issues or objectives. The SRS PWG recognizes that decision-making and communications with regulators and stakeholders rest with DOE-SR management and coordination with DOE-HQ.

As part of the DOE PFAS Strategic Roadmap commitments, SRS submitted the *SRS PFAS Implementation Plan* in December 2022. This plan documents the actions that will implement the goals, objectives, and actions described in the DOE PFAS Strategic Roadmap. The 2022 *SRS PFAS Implementation Plan* was reviewed during the summer of 2023, and SRS submitted Revision 1 to DOE-SR for review in October 2023. The revision included updates to sampling and monitoring conducted by SRS, Site activities to develop and update procurement guidance to restrict purchases of PFAS-containing products, and updated information on research projects associated with the effects of PFAS on Site surface water, groundwater, and biota.

9.3 ONGOING SRS PFAS ACTIVITIES

SRS is working with federal and state regulators to comply with rapidly changing regulations and directives associated with PFAS contaminants. SRS is actively engaged in responding to the emerging requirements for PFAS as discussed in the following sections.

9.3.1 PFAS-Containing Aqueous Film Forming Foam (AFFF) Discontinuance and Disposal

In September 2020, SRS evaluated whether existing AFFF used by the SRS Fire Department contained PFAS. The following was identified:

- SRS had a total of 500 gallons of fluorinated AFFF: 250 gallons on its fire trucks for immediate use and 250 gallons for future use.
- E Area had approximately 200 gallons of fluorinated AFFF in inventory.

Waste determination confirmed that the AFFF products were nonhazardous, but it was likely that they contained PFAS constituents. At that time, all fluorinated AFFF at SRS was replaced with Firebull F3 Fluorine Free Foam (manufactured by EnforcerOne, LLC).

Two Lined 25-Cubic-Yard Roll-off Containers Hold a Mixture of Liquid AFFF and Portland Cement, Which Hardens Into Solid Concrete Blocks.

After evaluating the available options, SRS decided that solidifying and stabilizing the AFFF was the most environmentally protective option to prevent the release of PFAS into the environment. The goal in solidifying and stabilizing the AFFF was to form a uniform, solid block of treated waste with high structural integrity limiting the mobility of the PFAS constituents. To ensure that the liquid AFFF was sufficiently mixed and formed a uniform matrix, SRS employed a method that the hazardous waste industry routinely uses for stabilization. SRS added a layer of Portland Cement and absorbent to the lined 25-cubic-yard roll-off container and poured a portion of the liquid AFFF into the container. The liquid and solid material was thoroughly mixed using a backhoe until it was of a uniform consistency. Additional liquid and cement was added and mixed until the roll-off container was approximately three-quarters full. Another layer of cement was added to the top of the mixture, and the entire batch was allowed to set. SRS used the same process to treat the remaining liquid AFFF in the second roll-off container. Approximately 12,000 pounds of concrete was used. The contents of the roll-offs were inspected the next day and were found to be solid concrete blocks. Subsequently, SRS installed covers on the roll-offs and performs routine inspections. In 2023, SRS requested approval from DOE-HQ to dispose of the roll-off containers. It is currently awaiting authorization before final disposition of the containers.

9.3.2 D-Area Groundwater

As information about the environmental presence of PFAS began to arise, SRS reviewed its historical uses of PFAS, especially PFOS and PFOA. Research showed that AFFF was used at D Area in the fire-training areas and in response to a fire-suppression event at a D-Area gas station.

SRS shared this information with the regulators as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Federal Facility Agreement (FFA) Core Team (DOE, the EPA, and South Carolina Department of Health and Environmental Control [SCDHEC]) scoping process, and the sampling data has been included in recent D-Area Groundwater Monitoring Reports supplied to the regulators and the public. SRS began sampling for PFAS in D-Area groundwater in 2020; sampling results identified PFAS-contaminated groundwater. Chapter 7, *Groundwater Management Program,* includes this data.

Current work focuses on obtaining additional data to adequately assess the nature and extent of the plume to support future decision-making. The current schedule for D-Area groundwater includes a record of decision by March 2028. SRS is committed to understanding the nature and extent of PFAS contamination at the Site.

When new information regarding historical use of PFAS is documented or sampling identifies PFAS contaminants, SRS will assess Site-specific uses and locations. CERCLA investigations, including sampling, will be developed with input by the FFA Core Team. Public notice of all actions will follow the existing CERCLA process, and SRS will share data within the *SRS Environmental Report*.

9.3.3 Savannah River National Laboratory (SRNL) Technology Development Grant

The DOE-Environmental Management Technology Development Office funded a project for Savannah River National Laboratory's (SRNL's) Environmental and Legacy Management Directorate to support the DOE PFAS Strategic Roadmap, which was released in August 2022. This project will provide data that will contribute to understanding the fate and transport of PFAS compounds in soil and groundwater. It will also demonstrate both the biotic and abiotic (or combined) approaches for treating PFAS. The initiative will provide data on toxicity during exposure to PFAS by performing studies on human and other mammalian cell lines. Planning for this multiphase project began in 2023 and will continue through 2024.

9.3.4 University of Georgia's Savannah River Ecology Laboratory (SREL) Ongoing Research

SREL initiated a characterization study of PFAS at SRS. The overarching goal of the study is to characterize the spatial distribution of PFAS, as well as learn more about the extent to which these compounds are biologically available.

Surface water, sediment, and mosquitofish samples were collected from aquatic systems on SRS, including the identified PFAS-contaminated streams in the D-Area fire training area; historical stream sites monitored by the SRS Integrator Operable Unit program; non-stream sites, such as Par Pond and L Lake; and the H-02 constructed wetland as a reference site. Samples were processed at SREL and measured for PFAS concentrations at the University of Florida in 2023. Data analyses were completed for water and sediment samples. Mosquitofish analyses need to be repeated due to issues with analytical instrumentation.

Generally, PFAS concentrations in surface water samples collected from SRS were relatively low compared to the surface water concentrations throughout South Carolina that SCDHEC collected. There appears to be a positive correlation between PFAS concentrations in surface water and potential PFAS sources on the Site.

Findings from this study will provide an initial snapshot of PFAS on the Site regarding their distribution, levels, bioaccumulation potential, and toxicity. Ultimately, the work may provide baseline levels of PFAS on the SRS landscape, identify potential remediation efforts for PFAS on the Site, and reduce uncertainties in risk assessment regarding these long-lasting contaminants at SRS.