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

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

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

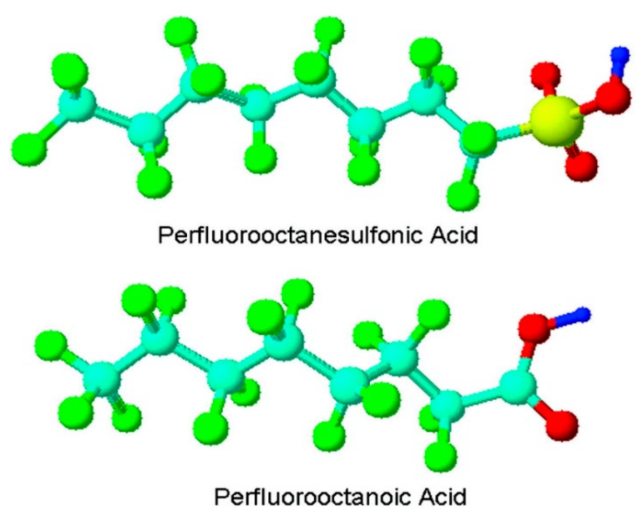
2022 Highlights

- In response to the DOE directives, SRS established its own PFAS Working Group (PWG) in March 2022.
- As part of the DOE Roadmap commitments, SRS submitted the draft *SRS PFAS Implementation Plan* in December 2022.
- In 2022, SRS sampled 65 wells and 10 surface water stations in D Area for PFAS constituents as part of CERCLA remedial investigation efforts.

9.1 INTRODUCTION

Increasing national attention to 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 broad group of man-made chemicals with numerous different properties and applications.



Chemical Structure of PFOS (top) and PFOA (bottom)

They include 3,000 to 5,000 individual chemicals. The most-studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).

Chemicals within the group are categorized by their chemical and physical properties, including

- Repelling oil (oleophobic), water (hydrophobic), stain, and soil
- Providing chemical and thermal stability
- Reducing friction

Because of their wide range of properties, PFAS use is ubiquitous and pervasive from both a consumer product and industrial use, which includes

- Protectants to enhance water, grease, and soil repellency for paper and cardboard packaging products, carpets, leather products, and textiles
- Processing aids in the manufacture of fluoropolymers, such as nonstick coatings on cookware and membranes for clothing that are both waterproof and breathable; electrical wire casing; fire- and chemical-resistant tubing; and plumbing thread seal tape
- Industrial surfactants, emulsifiers, wetting agents, additives, and coatings. PFAS have been used in fire-fighting foams because they are effective in extinguishing hydrocarbon-fueled fires.

PFAS were invented in the 1930s and originally used primarily for nonstick and waterproof coatings. Their development and production skyrocketed in the 1960s in response to a deadly fire aboard the USS Forrestal, an aircraft carrier, in 1967. The fire resulted from the accidental launch of a rocket into armed planes and loaded fuel tanks. This blaze nearly destroyed the ship and killed more than 130 people. In response, scientists and manufacturers developed PFAS-containing aqueous film-forming foam (AFFF), a mixture that rapidly extinguishes fire. The PFAS allow the mixture to spread, making it highly effective against petroleum fires and other flammable-liquid fires when mixed with water. PFAS-containing AFFF was subsequently installed on military and civilian ships, on airplanes, and in airports.

PFOS was last manufactured in the United States in 2002, according to Chemical Data Reporting, and the U.S. Environmental Protection Agency's (EPA's) PFOA Stewardship Program phased out the country's manufacturing and importing of PFOA.

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, 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.

Figure 9-1 shows exposure pathways, which include

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

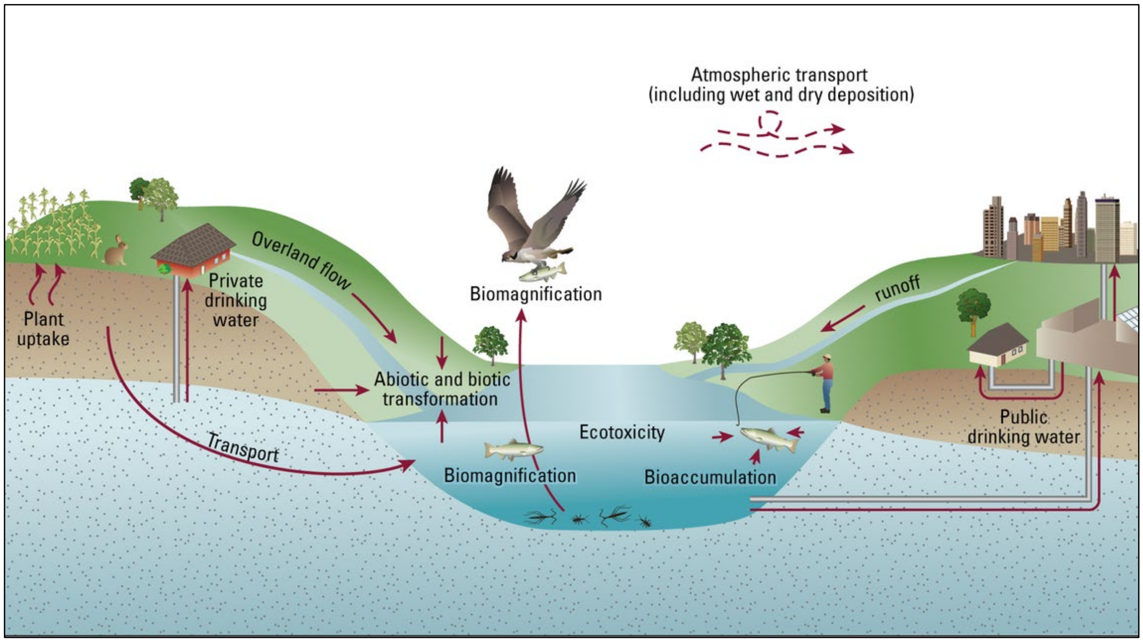


Figure 9-1 PFAS Exposure Pathways
(Source: usgs.gov/programs/environmental-health-program/science/ pfas-transport-exposure-and-effects

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 Control and Prevention show that most people in the United States have been exposed to PFAS.

Terminology is one of the confusing points when discussing PFAS both within the scientific community and 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 at this time only a small portion of the thousands of PFAS have been linked to cancer.

Current peer-reviewed scientific studies have shown that exposure to certain levels of PFAS 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 Environmental Protection Agency

The EPA's PFAS Strategic Roadmap is the driver for all the regulatory actions. The agency developed the 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 upon 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.

2022 highlights of the EPA's regulatory initiatives include

- Adding nine PFAS to the Toxic Release Inventory (TRI) list to be reported starting in reporting year 2023 (forms due July 1, 2024)
- Publishing a Proposed Rule to eliminate the *de minimis* exemption for reporting of PFAS under TRI (*Federal Register,* December 5, 2022)

- Initiating nationwide monitoring for PFAS in drinking water under the fifth Unregulated Contaminant Monitoring Rule. SRS is scheduled for groundwater monitoring in 2025.
- Publishing a Proposed Rule to designate certain PFAS as Comprehensive Environmental Response Compensation and Liability Act (CERCLA) hazardous substances requiring reporting of PFOA and PFAS releases (*Federal Register*, September 2, 2022)

9.2.2 U.S. Department of Energy

In response to the EPA's roadmap, DOE issued its own PFAS Strategic Roadmap, *DOE Commitments to Action 2022-2025,* in August 2022. The Roadmap (Figure 9-2) outlines DOE's overall approach, goals, objectives, and planned actions to assess and manage PFAS risk at DOE sites to help protect human health and the environment.

In October 2022, DOE-Headquarters (DOE-HQ) established a PFAS Panel to provide input on critical DOE-HQ guidance and policy documents.

Figure 9-2 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, SRS established its own the PFAS Working Group (PWG) in March 2022. The PWG serves as a Site-level conduit to the DOE PFAS Coordinating Committee. The PWG will research interpretation on aspects of PFAS issues. The PWG may develop advisory or tactical recommendations to DOE-Savannah River (DOE-SR) management on specific PFAS issues or objectives. The PWG recognizes that decision-making and communications with regulators and stakeholders rests with the DOE-SR management and coordination with DOE-HQ.

As part of the DOE Roadmap commitments, SRS submitted the draft *SRS PFAS Implementation Plan* in December 2022. This plan documents the actions that SRS will take to implement the goals, objectives, and actions described in DOE's strategic roadmap.

9.3 A PFAS CASE STUDY: 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, the most commonly identified PFAS contaminants. 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 CERCLA Federal Facility Agreement Core Team (U.S. DOE, the EPA, and 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. The groundwater data has been included in the Chapter 7 of the *Annual Site Environmental Report*.

In 2022, SRS sampled 65 wells and 10 surface water stations in D Area for PFAS constituents as part of CERCLA remedial investigation efforts (Figure 9-3). Current work is focusing on obtaining a complete data set to adequately assess the nature and extent of the plume in support of future decision making as part of the feasibility study. 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 Core Team. Public notice of all actions will follow the existing CERCLA process and data will be shared within the *Annual Site Environmental Report*. SRS is working closely with federal and state regulators to comply with rapidly changing regulations and directives associated with PFAS contaminants.

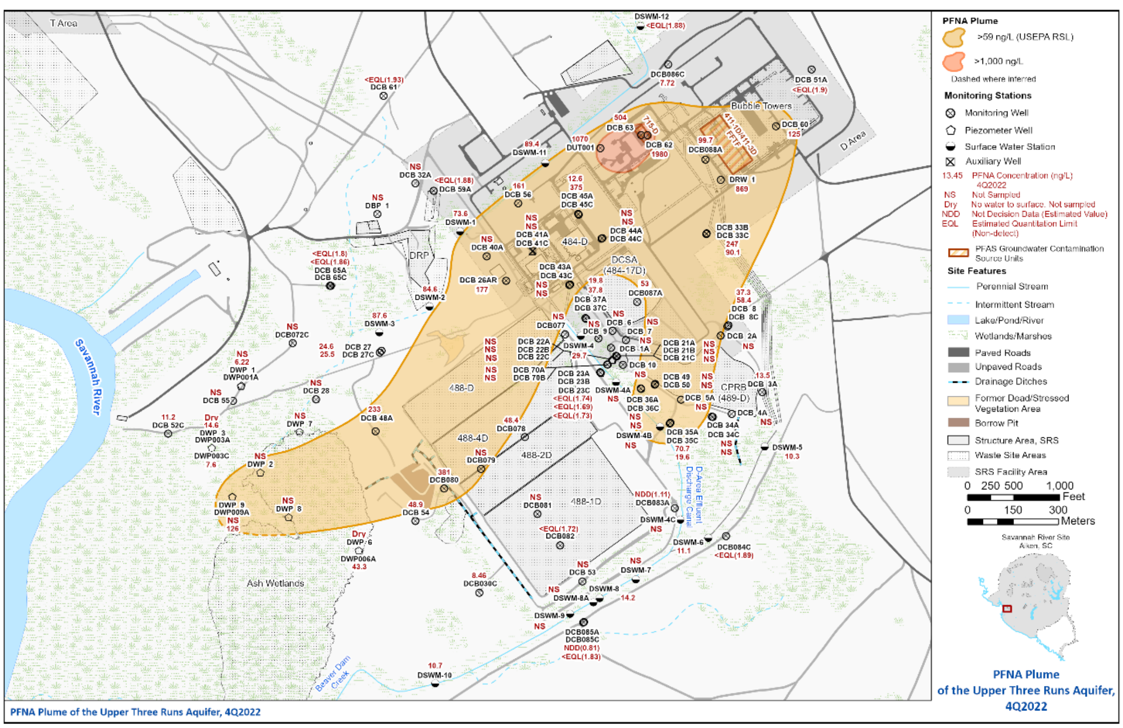


Figure 9-3 D-Area Wells and Surface Water Stations Sampled for PFAS Constituents