What is Per- and Poly-Fluoroalkyl Substances (PFAS) and How Do They Impact Drinking Water?

Per- and Poly-Fluoroalkyl Substances (PFAS) are a large family of organic compounds, including more than 3,000 manufactured fluorinated organic chemicals used since the 1940s. PFAS have unique surfactant properties that make them repel water and oil. Because of these properties, PFAS have been used extensively in surface coatings and protectant formulations of consumer products, including paper and cardboard packaging products, carpets, leather products and clothing, construction materials, nonstick coatings, and aqueous firefighting foams typically used at airports, chemical facilities, and training facilities. Uncontrolled releases of these materials to land or surface water may result in PFAS in groundwater or surface water that is used as a drinking water source.

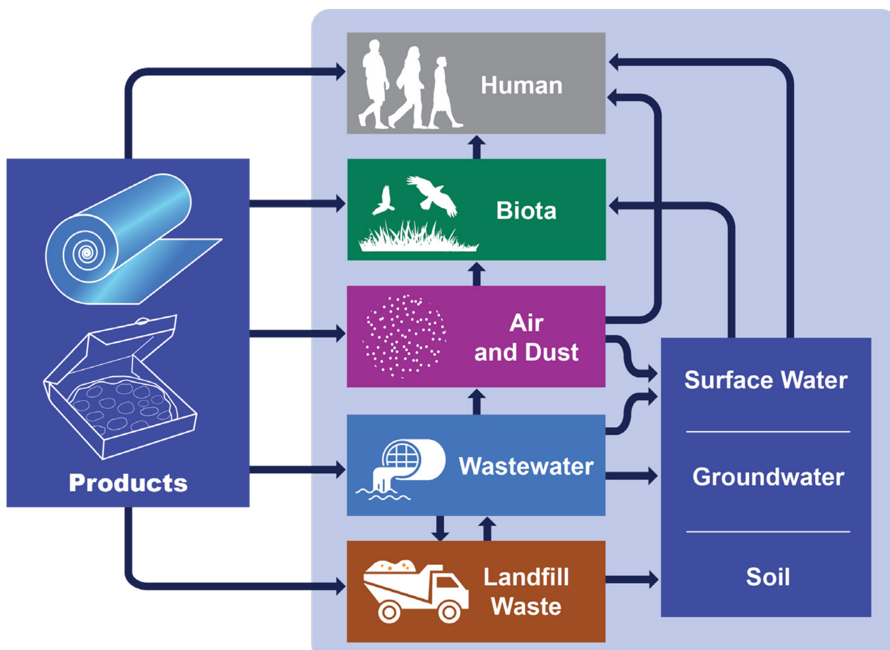
What Makes PFAS a Concern?

PFAS are resistant to degradation, chemically and biologically persistent, highly soluble, and mobile in the environment. This leads to environmental accumulation of these substances in groundwater, drinking water sources, and wastewater treatment plant (WWTP) effluent, which can lead to exposure in humans and biota. Much of the current human health impact information available is focused on perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), which are readily absorbed into the human body and not effectively metabolized. However, there are hundreds to thousands of other PFAS compounds with unknown health effects.

Half-lives in humans have been reported in the range of 2 to 5 years and PFOA has been found in almost all human blood samples collected worldwide. Toxicology studies conducted in multiple species, including monkeys, rats, and mice, have reported health effects, including high cholesterol, pregnancy-induced hypertension, liver and kidney toxicity, immune effects, and potential cancers (liver, testicular, and pancreatic). PFOS has been shown to bioaccumulate and biomagnify in fish and fish-eating birds.

Recently, PFOS has also been identified in milk from dairy cows grazing on grasses grown in biosolids-amended soils.

PFAS Life Cycle Diagram



Sources of PFAS

Uncontrolled releases of PFAS to the environment, where these compounds may ultimately end up in a drinking water source, generally result from four sources: fire training/fire response sites, industrial sites, landfills, and WWTPs or WWTP biosolids.

PFAS are used extensively in the aqueous film-forming foams (AFFF) used for decades by the U.S. military and civilian airports for flammable vapor fire suppression. Emergency response operations, equipment testing, accidental releases, and poor disposal practices of AFFF may result in PFAS being released to drinking water supplies. Industrial processes that use or manufacture PFAS may release them to the environment through wastewater discharges, poor disposal practices, accidental releases, and air emissions. Consumer goods landfilled since the 1950s are potential sources of PFAS which may enter the environment through landfill leachate. WWTPs receive PFAS-contaminated material and may release PFAS to the environment primarily through effluent discharge and the disposal of biosolids. Land application of biosolids may introduce PFAS to surface water through runoff and migrate to drinking water supplies.

Conventional Technologies

Coagulation/flocculation is used to remove particulates and dissolved organic carbon, but often sedimentation and filtration is marginally effective (<30% removal). Greater removal is observed (30 to 50%) with dissolved air flotation.

Adsorption (ion exchange [IX] and activated carbon as granular-activated carbon [GAC] or powdered activated carbon [PAC]) and reverse osmosis (RO) membrane filtration have been demonstrated for PFAS removal on the bench-scale. PAC or seasonal GAC caps may be used on gravity filters for taste and odor (T&O) mitigation for surface water sources. However, the type and configuration of carbon contact used for T&O mitigation may not be adequate for PFAS removal.

IX Resins specifically for PFAS removal are available, but some are single-use media due to difficulties achieving effective regeneration or complicated management of the regeneration process liquid wastes, which may require incineration or landfill disposal of spent resins. Other IX resins are being promoted as effective for onsite regeneration using proprietary regeneration processes.

Given their ability to remove dissolved contaminants at a molecular size level, RO, and potentially some nanofiltration, membranes can remove PFAS from drinking water. Typically, 75 to >90% of the water supplied into a membrane RO process is recoverable as treated water. The remaining <10 to 30% is reject containing approximately 4 to >8 times the initial PFAS concentration, depending on recovery rate.

Promising Technologies in Development

There are a number of technologies showing promise for PFAS treatment in development, including alternative adsorbents, specialty coagulation/precipitation, and advanced oxidation/reduction. Jacobs has experience in evaluating many of these technologies on drinking water and groundwater in both laboratory and field settings.

How Jacobs Can Help

Jacobs Engineering Group Inc. (Jacobs) can assist water utilities through planning, assessment, technology evaluation, treatability testing, design, construction management, and turn-key design-build solutions for treatment of PFAS in groundwater and surface water supplies. Our extensive experience allows for a high degree of confidence in successful execution of plant upgrades and expansion to address PFAS, utilizing Industry-leading models and design tools.

Master Planning, Distribution Modeling, and Alternative Water Supply Evaluations

To understand the extent of the problem, we identify type, amount, and locations of PFAS through interviews with personnel, monitoring, site investigation, characterization, and hydrogeology.

Communication Strategy

Jacobs can help develop an effective public communication strategy and offer utility managers guidance and support, including development of fact sheets, facilitating public meetings, and web-based engagement tools, such as our PFAS Dashboard, prepared for the U.S. Navy.

Mitigation Strategy and Solutions

We plan and develop cost-effective, regulatory-compliant mitigation strategies, which include:

Master planning

- Hydrogeological and distribution system modeling
- Alternative water supply and conveyance evaluations
- Upgrades to existing water treatment facilities
- Consideration of latest technologies for treatment of PFAS

Funding Support

Jacobs helps clients identify grant programs in a number of ways with access to federal, state, and foundation grants that may be relevant for your projects. We also have a Government Relations team that stays connected to changes to Federal grant and loan programs at the Federal level. Lastly, we have helped client apply for low-interest loans through EPA's WIFIA loan program. This is an interesting program as it allows public/private partnerships to apply.

Additionally, Jacobs delivers front-end environmental planning, compliance, and liabilities management services. Our strategic environmental solutions for capital project clients are delivered throughout the project lifetime, from planning and inception, through studies and permitting, construction, operation and eventually closure, reclamation, and revitalization.

Jacobs' PFAS expertise has already been used to:

Sample more than 10,000 groundwater and soil samples for PFAS

- Design groundwater treatment systems
- Manage large-scale pilot programs for major utilities
- Evaluate advanced treatment technologies
- Lead the PFAS treatment section for the forthcoming Interstate Technology & Regulatory Council PFAS Guidance Document and give PFAS training on these topics across the United States

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