Winning the PFAS Battle – Which are the Best Solutions?

Treatment Alternatives for PFAS Mitigation

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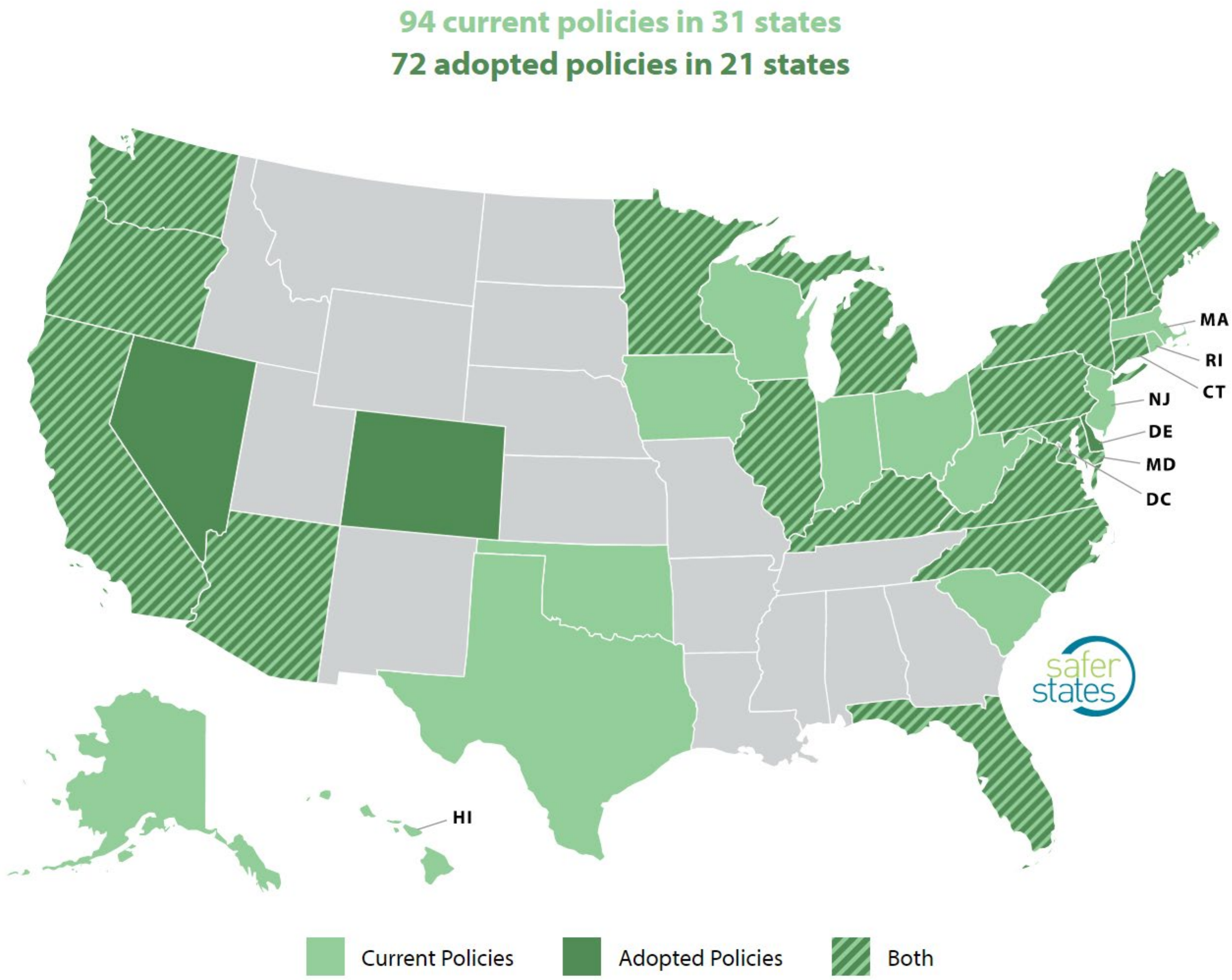
PFAS – A New Real-World Challenge: Over the last 70 years, the development and application of per- and poly-fluoroalkyl substances (or PFAS) has been seen as an important innovation in the invention of many new products, from cookware to firefighting foams to stain-resistant coatings to clothing. But as with many innovations, PFAS have had unintended consequences. These chemicals are now found in just about everything – including our groundwater. Widespread sampling due to the federal UCMR program and state requirements have found that high-concentration PFAS contamination has been found near firefighting training sites, and lower-level contamination has been found around industrial and municipal wastewater discharges and in landfill leachates. PFAS are mobile and do not degrade in groundwater, so the extent of groundwater contamination in the United States is still being uncovered.

Growing public concern has caused a wave of litigation in the U.S. chemical industry and inspired demands for the removal of these man-made "forever chemicals" from drinking water and the environment. While the EPA developed health advisory limits for Perfluorooctanoic acid (PFOA) and Perfluorooctane sulfonate (PFOS), states have been leading the regulation of PFAS (Figure 1), until federal drinking water standards are established. It is worth noting that although PFOA and PFOS are targeted in federal health advisory limits and many states' regulatory policies, numerous other PFAS have been detected in the environment and are under environmental, toxicological, and regulatory scrutiny. It is currently believed that there are possibly over 6,000 PFAS compounds in the environment that are the result of PFAS manufacturing and use.

Figure 1: PFAS Policies by State (as of 10/27/21)



Source: https://www.saferstates.com/toxic-chemicals/pfas/

PFAS Treatment Options – Selecting the Technology to Remove PFAS

In 2016, the Water Research Foundation funded a seminal study evaluating various treatment technologies for PFAS removal from drinking water. Granular Activated Carbon (GAC), Anion Exchange Resin (IX), High Pressure Membrane Filtration (reverse osmosis and nanofiltration) proved to be effective at PFAS removal (Figure 2). Due to high capital costs and brine generation attributed to reverse osmosis and nanofiltration, utilities are currently favoring GAC, IX, and/or blending. Although blending is not considered treatment, it can be effective at reducing contaminant levels to below regulatory levels.

As in every challenge to the water industry, the best solutions are dependent on several factors, and the smartest approach is to design treatment solutions that run efficiently, are operator-friendly, and are financially cost-effective. In our experience, the best approach involves collaboration with the utility every step of the way – evaluating treatment feasibility, effective water resource planning, treatment life-cycle cost estimation, construction approaches to meet tight schedules, and regulatory permitting efforts to assure public health.

Select the Best Treatment:

Granular Activated Carbon (GAC): GAC is currently the most accepted treatment technology for PFAS removal. There are various GAC products available that should be evaluated to determine which is best for the ground water quality you are treating. GAC requires a significant empty bed contact time (EBCT) which can result in large, or many, GAC vessels and significant cost to replace spent media. GAC filtration technology requires relatively little operations effort as the filters are placed in-line from the groundwater well to the distribution system or storage tank. GAC filter bed conditioning is recommended (via filter bed backwashing) to reduce preferential flow in the filter bed and extend media life. Care should be given to where chlorine is applied as GAC will reduce added chlorine and the GAC bed may be impacted. Any disinfection chemicals should be added after GAC filtration.

Ion Exchange (IX): Single use anion exchange resin is an effective, yet less common, treatment technology for PFAS removal. The number of facilities utilizing IX is increasing, however, as regulators and utilities are gaining confidence in the technology. IX has the advantage of requiring a much shorter EBCT than GAC so smaller, or fewer, vessels are required as compared to GAC. This is especially important for higher-flow centralized systems that treat more than one well or sites that are limited in footprint or require a lower-profile treatment system. IX has also shown the ability to remove smaller chain PFAS with greater efficiency than GAC so consideration of local current and future regulatory requirements should be considered. Despite these advantages that IX has over GAC, life-cycle costs are typically comparable as IX resin is significantly more expensive than GAC.

Life-cycle cost considerations:

When comparing life cycle costs between GAC and IX treatment systems, water quality is important. Constituents that naturally occur in groundwater can significantly shorten the life of either a GAC or IX filter bed, leading to more frequent replacement of the filter media. Once either the GAC or IX process is chosen, care should be taken in choosing from GAC or IX media products that are currently available in the marketplace. GAC carbons manufactured from different starting material or that contain manipulated pore sizes can have significantly different bed lives for a particular groundwater. Ion exchange media with various structures and resin types are available that should be considered for a particular application. As life-cycle costs for PFAS treatment systems are heavily skewed to Operations and Maintenance (O&M) costs due to spent media replacement, choosing the right adsorptive media can be critical to project success (Figure 3).

Getting Groundwater Wells Up and Running Again:

Utilities that have found PFAS in groundwaters have often shut down the wells to plan, design, and construct treatment facilities. In the meantime, some are forced to purchase more expensive imported water, thereby increasing project costs. This has resulted in very fast-paced projects where treatment evaluation, design and construction have been completed in under a year. Preparing for an accelerated schedule by pre-purchasing equipment, such as treatment vessels and media, or considering alternative delivery methods, such as design-build, can significantly shorten the length of the project and save the utility money.

Figure 2: PFAS Treatment Alternatives (WRF 2016)

Figure 3: Comparing GAC and IX Pros and Cons

Treatment Alternative	Pros	Cons
 GAC	✓ Proven technology ✓ Widely used for PFAS removal ✓ Good for long-chain PFAS	× Requires 10 min EBCT × Less effective for short-chain PFAS × TOC can limit bed life
 IX	✓ Smaller footprint; 2 min EBCT ✓ IX offers longer bed life than GAC ✓ Good for higher PFAS concentrations	× New and relatively untested for PFAS × Other anions can limit bed life × IX resin is 4 to 5 times more expensive than GAC

CASE STUDIES FROM THE FIELD

First Pilot Study: Preliminary and Final Design for Well 59, Eastern Municipal Water District, Perris, California

In 2016, when the Eastern Municipal Water District's (EMWD) Well 59 was found to have exceeded the health advisory level for PFAS, it was taken out of service. At the time, little was known about treatment options and efficacy.

The team launched a pilot study, and their efforts helped foster state-of-the-art thinking; while there were studies being performed on the university level, EMWD and its consultants participated in one of the first bench-scale studies to simulate full-scale drinking operations of this technology on the West Coast.

The agency and engineering team worked together to provide regulators with critical information on the issues and potential technologies, ensuring confidence in the design and permitting process. After evaluation, a GAC-based PFAS treatment system was chosen. Regulatory issues were pro-actively addressed by having discussions with state regulatory staff, fostering dialogue with EMWD and conducting weekly planning meetings with stakeholders to restore well production as soon as possible.

This first-of-its-kind partnership took a collaborative approach to performing testing, interacting with regulatory staff and planning stakeholder meetings before identifying the right solution to bring Well 59 back in service.

First-In-Class Case Study: PFAS Groundwater Treatment Project, Santa Clarita Valley Water Agency, California

Almost a third of the water used in the Santa Clarita Valley Water Agency (SCVWA) area comes from ground water sources, and 28 of the agency's 44 wells were impacted by PFAS. The agency needed to formulate a response plan to remove PFAS and get the wells back in service quickly to provide safe, high-quality water to residents.

The Agency's consultants conducted bench testing of treatment options and provided design and engineering services to construct the single-use ion exchange system that was identified as the right technology. To get the wells back in service quickly, the consultant developed pre-purchase specifications for the required treatment equipment. These wells began operating in November 2020.

This ion exchange technology is one of the first permitted in California for PFAS removal. "Nothing of this scope and speed has ever been seen in the water industry," said Kathie Martin, Santa Clarita Valley Water Agency, noting the start-to-finish timeline of only 10 months from design to the end of construction of a ion-exchange-based PFAS treatment system. This is considered lightning fast in the industry, particularly during COVID-19.

Figure 4: SCVWA N Wells Operating Ion Exchange PFAS treatment system

Washington State's Largest PFAS Treatment: Ponders Wells Treatment Plant Replacement, Lakewood Water District, Lakewood, Washington

The Ponders wellfield provides over 10% of Lakewood Water District's drinking water supply. The two wells are located down-gradient from McChord Field, where PFAS-containing fire-fighting foam was used. In 2018, the District asked Kennedy Jenks to evaluate treatment alternatives for the rising concentrations of PFAS, including PFOS and PFOA in the groundwater.

Due to near-identical water quality, the data from the Eastern Municipal Water District's Well 59 project was used to select the appropriate GAC media. By drawing on innovative solutions, the engineering firm and the District were able to design the system in four months and complete construction in 10 months. Since going online in January 2020, no target contaminants have been detected in the treated water. This site is the largest PFAS treatment system for drinking water in the state of Washington.

Figure 5: Lakewood Ponders Wells Operating GAC PFAS Treatment System

Conclusion: Winning the PFAS Battle Through State-of-the-Art Technologies and Client-Focused Solutions

Across the nation, communities are determining how to address PFAS contamination in their water supplies. Proven and emerging technologies will help utilities develop and implement cost-effective strategies as regulations and public sentiment require. Creative and customized solutions, along with fast-tracked construction techniques are now helping water utilities safely deliver vital clean water resources to their communities with confidence.

About the Authors: Dr. Jean Debroux is Director of Technology & Innovation at Kennedy Jenks. Jean's expertise is a critical success factor in numerous Kennedy Jenks' client projects where he is utilized as a project manager, water quality expert, research scientist, and as a design engineer. Dr. Stephen Timko is a Scientist and Engineer in the Applied Research Group at Kennedy Jenks; along with Jean, he is currently leading PFAS initiatives for Kennedy Jenks, helping clients plan, design, and stay current on PFAS treatment technologies and systems to protect public health and comply with state regulations.

Kennedy Jenks has delivered clients more than 20 PFAS planning, treatment feasibility or design projects within the past two years. The national firm has been finding innovative solutions to address water contamination of all types for more than a century, responding quickly to new challenges. In recent years, KJ has overseen numerous applied research, planning, design, and construction management projects in multiple states.