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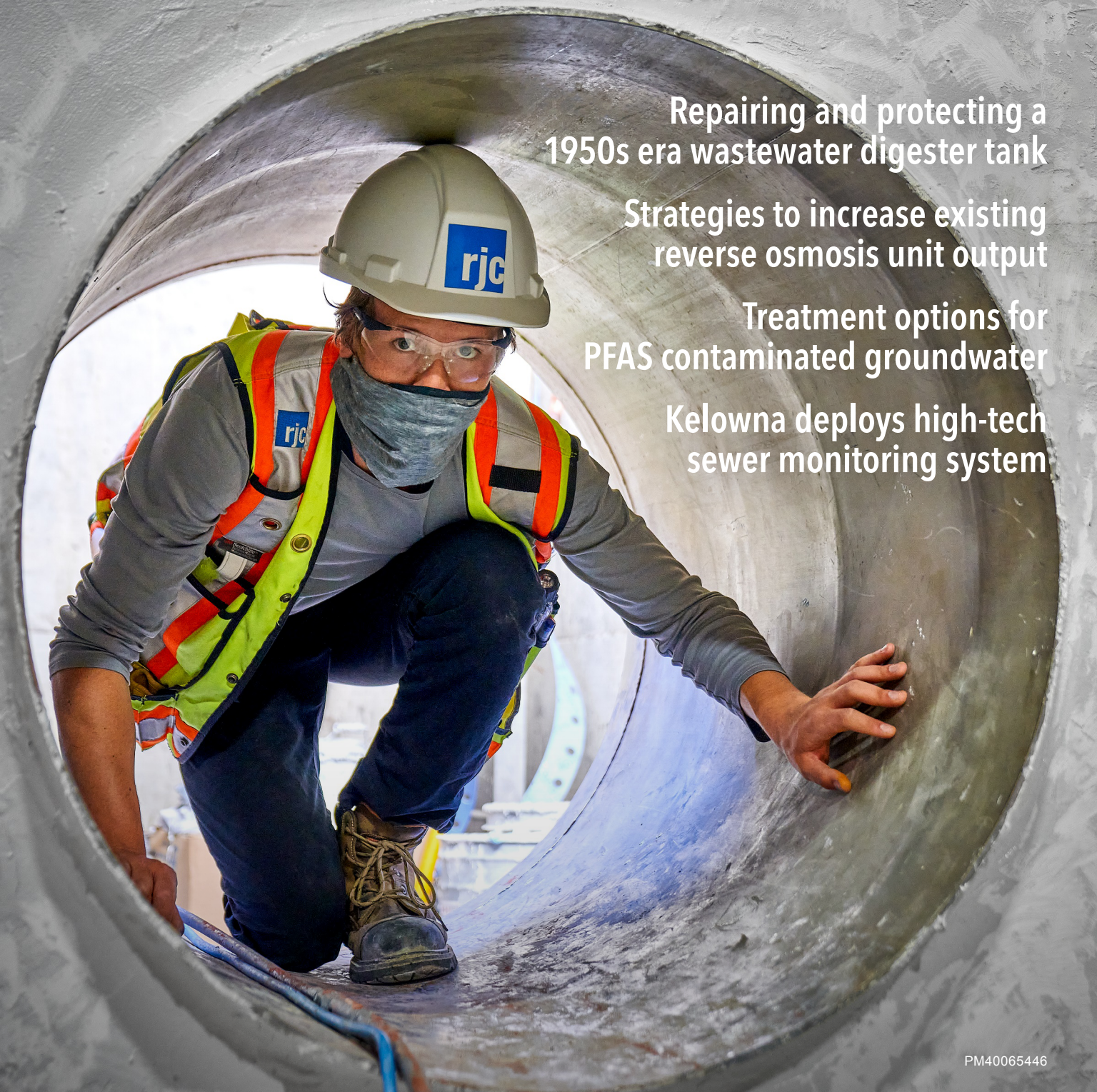

Repairing and protecting a 1950s era wastewater digester tank

Strategies to increase existing reverse osmosis unit output

Treatment options for PFAS contaminated groundwater

Kelowna deploys high-tech sewer monitoring system

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TREATMENT OPTIONS FOR PFAS CONTAMINATED GROUNDWATER

By **Ryan Moore**

Per- and polyfluoroalkyl substances (PFAS) are a class of chemical compounds that have been used in the manufacturing of a wide variety of consumer products since the 1940s. These compounds have recently come under scrutiny for their persistence, toxicity and the potential risk to human health and the environment.

Studies have linked exposure to these "forever chemicals" to several cancers, developmental problems, thyroid, kidney and liver diseases, and immune system malfunctions. Due to growing public awareness and an evolving political climate, widespread changes to government regulations and enforcement are imminent.

The following are a few common everyday items that may contain PFAS:

- Carpets and upholstery
- Dental floss
- Makeup
- Water-resistant clothing
- Child car seats
- Non-stick cookware
- Pizza boxes, carry-out food wrapping
- Microwave popcorn

Researchers are finding PFAS in a number of places. Bald eagle eggs were collected from the Great Lakes area and analyzed from 2000 to 2012. Numerous PFAS compounds were detected.

The study also noted that bald eagle eggs from breeding areas located within a few miles of a Great Lake shoreline or tributary had significantly higher total PFAS concentrations than those from breeding areas located further away.

Polar bears are the Arctic's top predator, and PFAS are known to bioaccumulate throughout the Arctic marine ecosystem. For years, biologists have been studying the accumulation of organic pollutants in polar bears from Eastern Greenland. More recent studies have focused on PFAS occurrence in different polar bear tissues, including brain tissue.

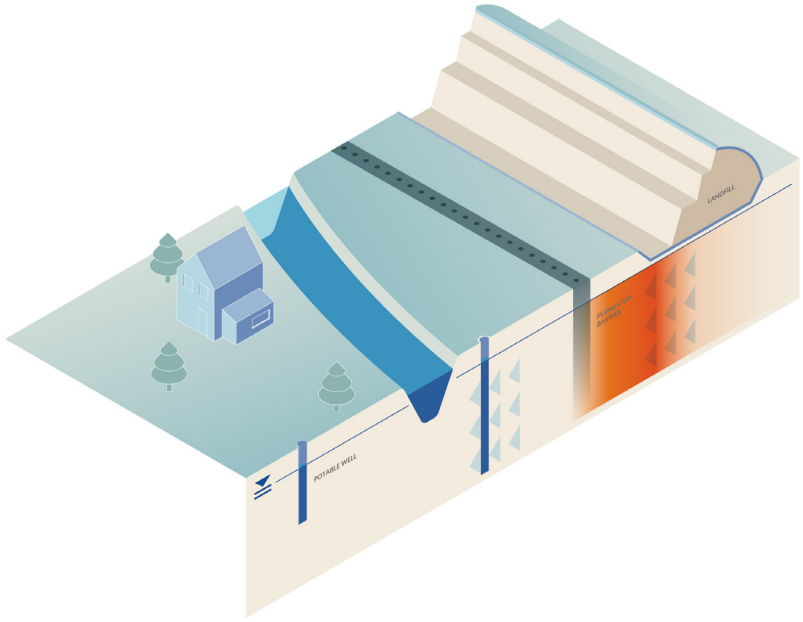

Figure depicting an in situ colloidal activated carbon permeable reactive barrier preventing migration of PFAS to sensitive receptors.

The study results showed PFAS occurrence in all brain regions, especially the longer-chain PFAS compounds that more easily lodge into the fatty brain-tissue cells.

In 2018, a dairy farmer in New Mexico received notice that his dairy cows may have been contaminated with PFAS after investigations at a nearby military installation revealed high concentrations of PFAS that had migrated to a wellfield supplying water to his farm and the town. USDA testing confirmed that the affected cows' milk contained PFAS levels approaching 100 times more than the EPA's health advisory.

PFAS IN OUR BLOOD

According to data from the U.S. Centers for Disease Control (CDC), PFAS is found in almost all Americans' blood, regardless of age, race or gender. According to the CDC, "human health effects from PFCs at low environmental doses or at bio-monitored levels from low environmental exposures are unknown."

This statement should not be taken as reassurance, however, as the average total PFAS in blood serum currently exceeds 5,000 parts per trillion (five parts per billion).

Trends over time indicate these levels are slowly decreasing as PFAS materials are gradually phased out of manufacturing. Nevertheless, there is much work to be done to identify and remove the sources contributing to PFAS in our blood.

PFAS IN GROUNDWATER

PFAS did not originate in groundwater. They are manmade chemicals contaminating it after nearly 80 years of uncontrolled spills, PFAS-laden air and water discharges and dumping. As PFAS

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compounds were not regulated, most of these activities were not illegal.

PFAS concentrations in groundwater are mostly below the current health advisories. However, many communities' and single-well owner water supplies are currently being threatened by these groundwater compounds at much higher levels.

Most remain unaware, since these wells have not yet been tested for PFAS.

APPROACHES FOR TREATING PFAS CONTAMINATED GROUNDWATER

There are two general types of approaches currently employed to treat PFAS-contaminated groundwater: ex situ and in situ. Ex situ treatments mostly involve mechanical groundwater extraction and filtration using granular activated carbon (GAC).

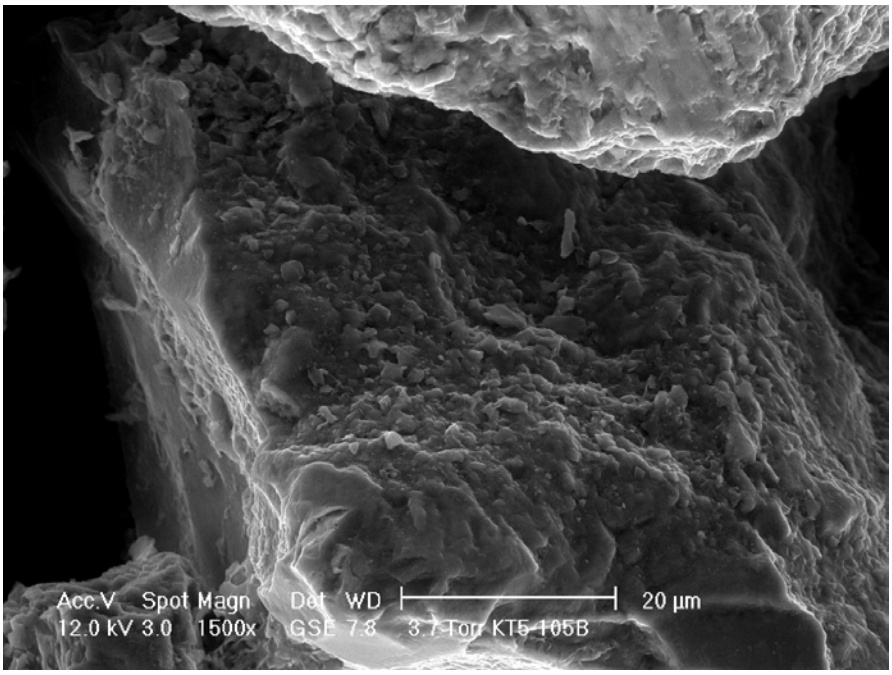
Pump and treat (P&T) systems have been reliably used to prevent migration of organic contaminant plumes in groundwater for decades. If properly constructed, a line of extraction wells can form an impassive flow boundary that PFAS or other contaminants cannot cross.

Like all mechanical systems, P&T systems must be maintained to ensure effective operation. Part of the maintenance required for them includes routine sampling of treated water to demonstrate PFAS removal effectiveness, and changing out of the spent carbon.

As governments designate certain PFAS compounds as hazardous substances, spent carbon materials will have to be managed as hazardous waste, resulting in significant cost increases to maintain these systems.

More recently, groundwater scientists have adopted an in situ PFAS treatment method. This approach uses a colloidal form of activated carbon applied directly into the groundwater. The colloidal activated carbon (CAC) treatment works by intercepting contaminants that move naturally through established groundwater pathways.

To accomplish this, CAC is injected along a line of delivery points into the affected aquifer zone to form a permeable reactive barrier (PRB). As groundwater migrates across the PRB, PFAS sorbs onto the carbon, resulting in clean water discharge from the barrier's down-gradient edge. Thereby, the potential exposure to these chemicals is eliminated, and so is the risk.



Micro-scale image showing CAC coating individual sand grains.

Material scientists developed CAC to overcome evenly dispersing a solid injected material (i.e., activated carbon) through aquifer soils. This required carbon particles to be ground to 1 to 2 microns, equivalent in size to a red blood cell and small enough to fit through soil pores.

However, due to hydrostatic forces that result in particle agglomeration (i.e., clumping), merely shrinking their particle size will not allow carbon to pass through soil pores.

This requires forming the carbon as a colloidal suspension, made possible by the use of a proprietary, drinking-water safe, anti-clumping treatment that cloaks the surface charge of the particles.

The result is that as CAC is injected, it moves through the soil pores but also coats them with a thin carbon layer that encapsulates the individual soil grains, in effect painting them with carbon.

In situ CAC treatments have been used to capture and treat groundwater contaminants since 2014 and applied at numerous PFAS-contaminated groundwater sites. More than one hundred PFAS projects are currently in the implementation or planning stages.

The longest-running application has reduced PFAS for five years, with the treatment expected to be maintained for 50 years, based on independent, peer-reviewed modeling estimates.

In a cost-comparison analysis, this particular treatment was 17 times less expensive than implementing an ex situ P&T approach.

CONCLUSIONS

While PFAS exposures in daily life may be managed over time through conscious purchasing decisions, PFAS in groundwater will remain an invisible threat to millions for many years to come. However, there are reliable ex situ and in situ methods to safely address this threat. ■

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