Losing Wells to Arsenic?

Demonstration project hopes to show how to reclaim them cost effectively.

Written by Mary Elizabeth Mach
with assistance by Jon Hetzel

Several municipalities in central Oklahoma depend on groundwater from the Garber-Wellington Aquifer for their public water supply. Unfortunately, due to arsenic contaminant levels above Environmental Protection Agency mandates, city wells are being shut down. Norman is one city that is piloting a system that could provide an arsenic-removal solution and bring its wells back into use.

The Garber-Wellington Aquifer has historically produced yields of 100 to 500 gallons per minute per wellhead (USGS, 2005) of high-quality water. However, the conditions that frequently make groundwater high in quality and cost effective as a supply source have their caveats. Groundwater is often high in dissolved solids and may contain high concentrations of metals such as iron, magnesium, selenium, and arsenic. The Garber-Wellington Aquifer has elevated concentrations of arsenic.

Arsenic is an element that naturally occurs, and it is often introduced through weathering minerals and human activities. Though tasteless, odorless, and colorless, this element can be very toxic. Its presence in groundwater is particularly hazardous. Much of the western United States, particularly the Southwest, report elevated levels of arsenic in groundwater. Because exposure to or ingestion of arsenic in high concentrations has been known to cause cancer and organ failure in humans and animals, arsenic is a regulated contaminant by the United States Environmental Protection Agency.

The intricate valving and piping for the arsenic removal vessels is necessary to accomplish all functions of the system such as normal flow-through, backwashing, and draining.

In 2006, the EPA lowered the maximum contaminant level for arsenic in drinking water from 50 micrograms per liter (μg/L) to 10 μg/L. Consequently, all non-compliant wells utilizing the Garber-Wellington were removed from service, with cities shutting down what were otherwise high-quality wells that had been in production for decades. Norman, Okla. shut down 11 of its wells, which reduced the average well production from nearly 5 million gallons per day to just over 2 mgd. This has resulted in lost revenue for the city as well. In order to return these non-compliant wells back to service while providing safe drinking water and bolstering the city's revenue stream, arsenic must be removed from the contaminated groundwater.

Various methods of removing arsenic from well-head treated water have been documented. One practice increasing in popularity is an iron-oxide based media that adsorbs arsenic on its surface, such as Bayoxide® E33. This arsenic-removal approach has been proven to be an efficient treatment process in several regions of the United States, though its use on the Garber-Wellington Aquifer in Oklahoma has not previously been tested.

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Norman officials took the initiative to pilot a turn-key packaged wellhead arsenic removal system on its Well No. 31—one of a handful of wells that tested between 40 μg/L and 70 μg/L for arsenic contamination. Acting as project manager and design engineer, Garver Engineers is working with the city and Severn Trent Services to ensure the debut of the SORB 33®

The three arsenic removal vessels at the Norman site. Three vessels are required to provide series flow and redundancy to the system

Arsenic Removal System in Oklahoma is a success.

The full-scale system applies a pump-and-treat process that sends pressurized water through a stationary filter vessel containing a ferric oxide media. As water is forced through the fixed bed of Bayoxide® E33, arsenic is attracted to the media and adsorbed onto its surface sites, thus removing it from solution. The arsenic concentration in the effluent is reduced to within compliant levels, allowing it to be put into the distribution system. Once the media has been exhausted, it is vacuumed out of the vessels and replaced. Depending on the site, media may last from six months to two years, and because it has passed the Toxicity Characteristic Leaching Procedure (TCLP) set by the EPA, it can be disposed of in nonhazardous landfills.

In Norman, three vessels designed to treat 230 gpm were installed. Three vessels are also necessary to provide redundancy in the system, as well as to extend the life of the media. To enable the media to treat up to 40 percent more water before being replaced, Norman uses a lead-lag configuration in conjunction with a parallel flow pattern. The lead filter operates until it reaches a set level (close to the MCL) and is then valved to a lag filter containing virgin media for polishing and further arsenic removal. Once the lead vessel's media is changed out, the lag filter takes the lead and a new filter becomes the lag. Utilizing this configuration allows additional media adsorptive capacity.

The flow configuration is not the only variable that affects the media's adsorptive capacity. The groundwater pH may possibly be one of the most important. Coming out of the ground, water from Well No. 31 has a pH above 9.0. However water must be close to a pH of 7.0 for the media to be effective. To remedy this issue, the system in Norman was installed with a carbon dioxide injection system, which has effectively lowered the pH to between 7.0 and 7.5. If there is a failure with the CO_2 system, the treatment system has been programmed to shut down, preventing high concentrations of arsenic from entering the distribution system.

Arsenic has a high affinity for iron-based minerals and can adsorb quickly to surface sites. This makes granular iron-oxide an excellent application for arsenic removal. However, other elements common to groundwater also have a high affinity for iron-based minerals. This creates competition amongst ions for adsorption sites on the media, resulting in less arsenic being adsorbed per volume of treated water.

Bayoxide® E33 is specifically designed to adsorb arsenic while reducing competition with other ions, thus improving the arsenic adsorbing potential of this media. Additionally, iron-oxide media can adsorb large amounts of arsenic while maintaining a shallow breakthrough curve. This is advantageous because effluent arsenic concentrations will gradually rise, making it easy to monitor and plan for media replacement or adjustments with the flow configuration. Furthermore, installing the system on an existing well site that utilizes an infrastructure already in place reduces capital costs for installation. All of these factors point to a system that optimizes materials and reduces operation and maintenance costs while producing safe water and a consistent revenue stream for a municipality.

And money talks. As a full-scale project, Norman will be able to perform an accurate cost analysis on the year-long demonstration project. This will then be compared to other options for meeting demand such as buying finished water, buying additional water rights, increasing capacity at the water treatment plant, or drilling new wells. At the year's end, the city will be able to make an informed decision as to whether the adsorption technology is a cost-effective option to be implemented for other non-compliant wells in an effort to meet its ever increasing water demands.

Mary Elizabeth Mach is a Project Engineer with Garver Engineers (Norman, OK).

This article was originally published in APWA Reporter, February 2009.

1016 24th Avenue NW
Norman, Oklahoma 73069
(405) 329-2555

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