By Pat McCool, KRWA Consultant

City of Kirwin Selects POU Systems as Less Expensive Alternative for Nitrate Removal

Many Kansas public water supplies using groundwater are facing the challenge of increasing nitrate in the groundwater. There are several alternatives available to address the nitrate in the drinking water. The city of Kirwin, located in Phillips County in north-central Kansas, recently chose to install nitrate removal systems at each customer's kitchen sink to reduce nitrate to acceptable levels. This choice was made in order to save substantial money as compared to constructing a new water treatment plant.

Nitrate in groundwater

Some possible, likely sources of high nitrate in groundwater include the use of fertilizer on farm ground, the past improper disposal and spillage of fertilizers at farm supply services having fertilizer sales, heavy use of lawn fertilizers, and septic tank lateral field seepage. The nitrate from these sources can seep down slowly through the soil and subsurface over many years, decades in fact, and contaminate the groundwater. Also, the nitrate can enter the groundwater in a relatively short period of time from improperly constructed water wells, improperly constructed monitoring wells, and abandoned wells that are not properly sealed.

This historical marker in downtown Kirwin notes the location of Station 13 on an early trail line leading from Kansas City to Denver.

In many cases the groundwater aquifer is contaminated with nitrate in the upper levels while most of the aquifer at the middle depths and lower depths have very low nitrate. In the past, most wells were designed and constructed in a way

that the pumping of the well could result in a significant amount of high nitrate water from the upper levels being drawn down to the well screen. And that water was supplied to customers.

Nitrate in drinking water

In 1975 the Environmental Protection Agency set the maximum contaminant level (MCL) for nitrate in drinking water at 10 mg/l measured as nitrogen. High nitrate intake from food and water can cause methemoglobinemia or blue-baby syndrome in infants six months of age and younger. Nitrate in drinking water does not affect children in the womb, children older than six months, and adults. Many Kansas public water supplies have had nitrate in the range of 10 to 20 mg/l or higher for many years and there have been no known cases of methemoglobinemia as a result.

The most selected way in Kansas of lowering nitrate in the drinking water is the construction of a water treatment plant. Presently ten or more water treatment plants to reduce nitrate contamination have been constructed in Kansas. There are at least four additional plants in the design or construction phase and at least four other water suppliers considering the construction of such treatment plants.

There are several other alternatives than constructing a water treatment plant that should be evaluated when determining how to lower nitrate in the drinking water. All or most of the alternatives are possible, so careful evaluation is needed in determining the most economical and preferred alternative(s).

Alternative 1 – New well water source

Constructing a new well is a good alternative. The difficulty in this alternative is selecting a suitable location that does not have high nitrate water or selecting the location near the existing well that has high nitrate.

Depending on distance, a new well location might involve considerable cost due to the need to install water transmission pipeline. Also, the water rights situation may have a significant bearing on the matter.

However, it might be possible to construct a new well with low nitrate at or near the existing high-nitrate well. This might be possible by eliminating the path or conduit from the contamination source or from the water at the top of the aquifer to the existing or new well's screen and pump. Remember, it is possible that the high-nitrate water at the top of an aquifer is getting into the water well through the gravel pack of another well or another improperly constructed well or monitoring well.

If a water supplier is looking for a new well location or considering construction of a well to avoid the high-nitrate water at the top of an aquifer, it is highly recommended that a licensed, consulting geologist experienced in water well construction and contamination be hired to evaluate the situation and give recommendation on how best to construct a well to avoid nitrate contamination.

In either case, the high-nitrate well that is no longer used for general water supply purposes can still be used for emergency purposes. The Kansas Department of Health and Environment should be consulted on using the high nitrate well only for emergency purposes. Also, you should contact the Division of Water Resources on water rights for new and standby purposes.

If a water supplier is looking for a new well location or

Comparing Costs of POUs to Treatment Plant Alternative

There are no direct estimates on how much a nitrate removal treatment plant would have cost the city of Kirwin. But a comparison to how much other water suppliers have paid for such a treatment plant can be made.

The table below shows the cost of two Kansas, nitrate removal treatment plants: one serving a smaller system and one serving a larger system than Kirwin. This comparison shows that the treatment plants for these small systems are quite high at approximately $6,000 per meter. This is almost 6.5 times the cost of the POU systems in Kirwin.

The table also shows that the treatment plant alternative was subsidized with grants to make the plants "affordable" for these small systems' customers. Future treatment plant construction for other systems may not receive the 69-78 percent grants as the systems shown in the table benefited from – thus affecting "affordability".

The last column in the table shows that the local water supply customers in the other two systems had to pay approximately twice as much for the treatment plant alternative than for the POU systems of Kirwin. And remember, that is paying two times as much after a large amount of grant money was obtained.

Cost Comparisons of Nitrate Removal for Very Small Systems by Type of System and Number of Meters

System	Number of Meters	Method of Nitrate Reduction	Total Project Cost	Federal Grant or Loan Forgiveness	% Federal Grant or Loan Forgiveness	Cost to System	Total Cost Per Meter	Cost to Federal Taxpayer per Meter	Cost to System Per Meter
City of Kirwin	126	POU system	$116,000	$30,000	26%	$86,000	$921	$236	$683
Larger System	160	Nitrate Removal Plant	$900,000	$620,000	69%	$280,000	$5,625	$3,875	$1,750
Smaller System	70	Nitrate Removal Plant	$450,000	$350,000	78%	$100,000	$6,429	$5,000	$1,429

considering construction of a well to avoid the high-nitrate water at the top of an aquifer, it is highly recommended that a licensed, consulting geologist experienced in water well construction and contamination be hired to evaluate the situation and give recommendation on how best to construct a well to avoid nitrate contamination.

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Alternative 2 – Blending water

The water from a high nitrate well can be blended with water from another existing well, a new well, or another approved water supply source such as distribution system water from another city or RWD to reduce nitrate in the water. This alternative can be very attractive from a cost basis as compared to a treatment plant or a new, distant-well location. This alternative can also provide increased reliability if an adjacent water supply source is selected for blending. For example, if one water supply loses power, then water might still be obtained from the other water supplier.

Alternative 3 – Point-of-use devices

A point-of-use (POU) device is a treatment device that is installed at customer's residence or business. A POU device can be a home, water softening unit or, as most generally used, a device installed under the sink or at the end of the faucet. The POU device for nitrate removal is under the sink and has an additional faucet to obtain treated water for drinking and cooking.

The attractiveness of this alternative is that it only treats water that is used for drinking and cooking; and that it is much less expensive than treating all the water that is used. There is no really good reason or no need to lower nitrate in water for bathing, stool flushing, washing clothes or dishes, watering lawns, or pets. People drink or cook with about 0.5 gallons per day average while the overall water usage averages about 100 gallons per day.

Many POU devices are multi-stage depending on what is to be removed from the water. The treatment stage for nitrate removal is either reverse osmosis or ion exchange. In POU devices it is usually reverse osmosis.

City of Kirwin choses POUs

Prior to 2003, the city of Kirwin was served by city wells #5 and #6 located in town. These wells were high in nitrate in the range of 12 to 16 mg/l. The city decided to construct two new wells approximately four miles northeast of town. The new wells #7 and #8 were constructed in late 2002.

Monitoring data show that wells #7 and #8 were in compliance with the MCL for nitrate in 2003 – 2005. These wells began to increase in nitrate and were out of compliance with nitrate in the years 2006 – 2010. The city decided and began to install at the city's expense a POU device at each home and business in 2010.

The installations were at the kitchen sinks for all residences and restaurants. A separate faucet was installed to

provide the low nitrate water to be used for drinking and cooking. City ordinance allows "access to the city, its employees, agents, and contractors for the purpose of installing, servicing and testing" the treatment systems at each customer's residence of business.

City chooses technology

The city's contractor installed a Culligan® Aqua-Cleer® RO30 advanced drinking water system at each residence and business. Each individual treatment system in Kirwin consists of a sediment filtration cartridge, a carbon filtration cartridge, a reverse osmosis (RO) cartridge, and post-filtration granulated activated (GAC) block. Each installation also has a faucet with a light showing that the unit is working properly and when the reverse osmosis cartridge needs to be replaced. Each residence installation has a 3-gallon storage tank and a performance indicator device (PID) to track gallon usage.

This separate faucet provides treated water. The green light indicates that the system is working properly. The monitoring system would show a red light instead if the system needs to be checked. Each home has one such faucet that provides the treated drinking water.

The sediment filtration cartridge will remove sand, fine sand, precipitated iron and manganese, and dirt. The carbon filtration cartridge, the RO cartridge, and the GAC block are designed and constructed to treat water with up to 27 mg/l of nitrate in the influent. These systems also reduce arsenic, copper, lead, radium 226/228, selenium, and Giardia Lamblia and Cryptosporidium.

The system operates only for water supplies with a pressure of 40 psig or greater. A photo with this article shows the system installed at the city library. The POU devices installed in Kirwin are much more than just a "device". Each is a complete system that includes much more.

This is Kirwin City Library and City Hall building. The building was erected in 1916 and was originally used as a fire station.

Treatment costs

The city received a 20-year loan from the Kansas Public Water Supply Loan Fund that is administered by KDHE with some loan forgiveness. The loan covered the installation of the POU systems and also repairs and upgrading the city's elevated water storage tank. The total cost of the POU systems, including installation, was approximately $116,000.

The city increased water rates in order to make the payments on the loan. It is estimated that the average water rate increase for only the POU systems, and not the city's elevated storage tank, was approximately $5.00 per month. The city is presently considering an additional $3.50 per month increase in the base water rates to cover the ongoing maintenance costs of these systems. It is estimated that these maintenance costs are in the range of $2.50 to $3.50 per month per residence.

City satisfaction

The city council and staff report that they and the citizens of Kirwin are generally quite satisfied with the POU treatment systems. The semi-annual debt payments on the loan and the ongoing maintenance costs of the POU treatment systems are a burden on the city customers. But they know that those costs are low when compared to the alternative of constructing a treatment plant and the debt payments and maintenance costs that would be associated with a plant.

One of the challenges with the POUs is making sure that the treatment systems do not freeze when a homeowner may leave for several weeks or months. The city staff is always vigilant in ensuring against such as freezing can severely damage the system resulting in the significant cost of a new system.

The city has been required to conduct very extensive sampling of the systems for nitrate levels. The sampling results have shown very consistent, very low nitrate in the water.

The city is concerned with possible increases in maintenance costs and is looking for ways to reduce such.

The residential POU systems are like this one at the Kirwin Library but with a smaller tank.

The city superintendent is quite capable in performing many of the maintenance procedures now provided by the city contractor. There may be progress in this matter in the future as more data indicate that the systems are working very well.

My observations and comments

The cost of constructing a nitrate removal plant is very high, especially for small systems. There are other, more economical alternatives that should be seriously pursued by our elected officials, consulting engineers, state officials, and federal funding agencies. It should be noted that the cities of Liebenthal and Glade have also installed a POU system at each residence to meet drinking water standards.

The construction of a well in a new or existing location is a viable alternative. To locate a well in an area known or suspected of having high nitrate, a geohydrologic investigation can show how to avoid nitrate that may be only in the upper levels of the aquifer and getting into existing wells.

As shown by the city of Kirwin, the use of POU systems gives a low nitrate, high quality drinking water at a much less cost. The individual reverse osmosis systems in Kirwin also soften the well water that has total hardness in the range of 270 to 400 mg/l.

The extra money given out in grants to make projects "affordable" could be used by Kansas cities and RWDs to solve other water supply problems that are important.

When city and RWD systems are significantly larger, the total cost of a water treatment plant per meter decreases and becomes competitive with all alternatives. All alternatives should still be evaluated. But for small systems, water treatment plant construction is an expensive selection.

Get more information

I encourage elected officials, managers, administrators and operators of public water systems that are having to address water quality standards to attend various training sessions on the topic. I particularly encourage people to attend the annual KRWA Conference & Exhibition in Wichita. There is no other meeting that provides as many technical presentations and displays of products and services as does the KRWA conference. Special sessions are being planned that will further discuss the issues that are mentioned in this article. I hope everyone will check out the sessions for the 2015 conference. There will be presentations on nitrate in groundwater and alternatives in addressing that issue.

KRWA staff are also available to attend city council or RWD board meetings or work sessions to discuss water quality issues and the options that the public water supplies may have.

Pat McCool has worked as a consultant to KRWA since January 2004. He previously worked for KDHE for 30 years. Pat has a bachelor degree in Chemical Engineering and a masters degree in Environmental Engineering from the University of Kansas.