By Pat McCool, KRWA Consultant

Addressing High Nitrate in a Better Way

This photo shows football field in Cunningham. Note the city's wellhouses to the back of the field and their close proximity to the football field.

The March 2013 issue of *The Kansas Lifeline* had an article on how the city of Cunningham was addressing nitrate in drinking water. That article can be found on KRWA's Web site at http://krwa.net/portals/krwa/lifeline/1303/28.pdf. This article further discusses this situation.

The city of Cunningham is located 55 miles west of Wichita on US Hwy 400. The city has a population of 450 and is served by two water supply wells constructed in 1936 and located in the city park. In 2012 the city started a project to reduce the nitrate level in the drinking water and to add another well to allow for better well field management.

At that time, the city and consulting geologist Ned Marks of Terrane Resources, Stafford, Kan., began a subsurface investigation of the geology and water quality in the area of the existing wells. The subsurface investigation required the installation of monitoring wells that targeted different water levels within the aquifer.

Monitoring wells specific to different water producing zones are required to better define the actual water quality in the different water zones and the influence of pumping water on the water quality. The process and its results are known to some as “fingerprinting” the aquifer.

The city also increased the frequency of monitoring of nitrate levels in the water, and began a program to reduce the nitrate level. It was believed that nitrate was primarily coming from the nearby, previously fertilized football field.

The city’s goal is to provide drinking water with low nitrate level and to avoid the construction of a nitrate removal water treatment plant with a $2 million capital cost and high, yearly operating cost.

Nitrate levels

The maximum contaminant level for nitrate-nitrogen in drinking water is 10 mg/l.

Historically, the city’s wells had nitrate levels in the range of 4.5 to 7 mg/l in the 1960’s thru the early 1970’s. Table 1 shows a consistent difference in nitrate levels between the two wells in 2016 and since 2001. The nitrate monitoring data indicates a reduction in nitrate has been occurring since 2013. This is believed to be due to

2016 Nitrate Analyses (mg/l)		
Date	Well 1	Well 2
January 15	8.8	7.6
February 1	9.2	7.8
February 16	8.1	6.3
March 1	8.8	7.0
April 5	8.9	6.9
May 2	8.4	6.5
June 7	8.5	6.5
July 6	7.8	5.8
August 8	8.5	6.3
September 14	7.8	5.6

Nitrate Analyses since 2001		
Year(s)	Well 1	Well 2
2001 - 2008	7.5 - 8.6	5.0 - 7.0
2009 - 2012	9.3 - 9.6	7.3 - 7.9
2013	9.0 - 10.0	6.7 - 7.9
2014	8.2 - 9.6	6.3 - 7.8
2015	8.0 - 9.3	5.9 - 7.1
2016	7.2 - 9.2	5.8 - 7.8

Table 1

September '16 Pump Test 6 Hours at 150 GPM Pumping from Lower Aquifer		Monitoring Well MW 4-12 Upper Aquifer		Monitoring Well MW 3-12 Lower Aquifer	
Time	Nitrate (mg/l)	Time	Nitrate (mg/l)	Time	Nitrate (mg/l)
30 seconds	4.3	before test	6.1	before test	3.6
1 Hour	5.0	1.5 Hour	6.0	1.5 Hour	3.7
2 Hour	5.4				
3 Hour	5.5	3 Hour	6.1	3 Hour	3.7
4 Hour	5.6				
5 Hour	5.7	5 Hour	6.1	4.5 Hour	3.6
6 Hour	5.7	6 Hour	6.0	6 Hour	3.6

Table 2

locations of the wells, to possible difference in subsurface geology, well construction and to the location of potential upgradient nitrate sources.

Elimination of nitrate

The football field north end zone is within 100 feet of both city wells. The football field was seeded and last fertilized in 2010. It should be noted that after the last fertilizer application on the football field there would be a considerable delay between the application and the nitrate entering the water at the top of the aquifer. This might explain the high nitrate level in 2013 and possibly the subsequent nitrate reduction.

The city has eliminated fertilizer application to the football field. Also, the clippings from mowing the field and surrounding area are caught and disposed offsite. Clippings do contain nitrates. These two practices are believed to reduce of the nitrate entering the groundwater and, subsequently, the two city wells. Nutrient management is a key component to the success of this project.

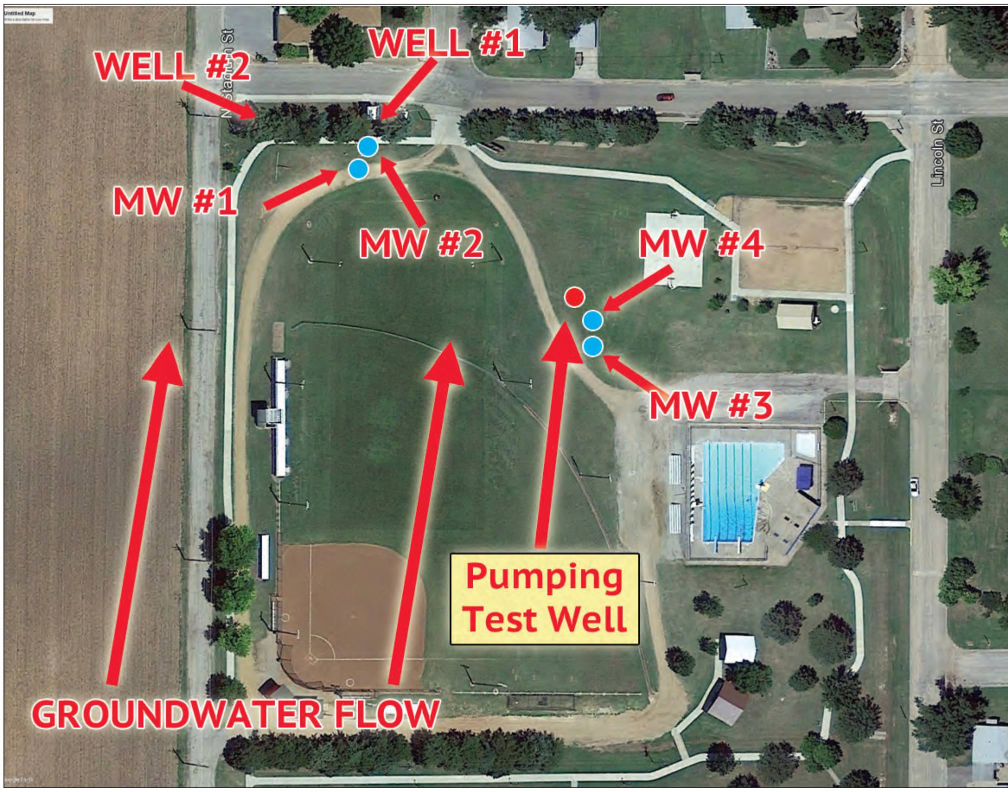
Also, under consideration is installing an interception well in the future in a high nitrate area between the city wells and the football field to irrigate the football field instead using of the city wells. Interception wells would only pump water from the top of the aquifer where the highest nitrate level is located; thus the highest nitrate water is eliminated from being drawn to the city wells and also provides some nitrogen to the area grass. The interception well will not be necessary as long as the city wells have acceptable nitrate level.

Test pumping of new city well

In August and September 2016 the city conducted pumping tests of a temporary, constructed well very near the site of a possible new city well. During the pumping tests, water quality samples were taken from the pumping well, nearby monitoring wells and the city wells.

The pumping test well was located in the city park near the football field and near the two city wells. (See Graphic 1.) The pumping information and the water quality data will be used by the city and Ned Marks to determine if a

Graphic 1



Geologist Ned Marks of Terrane Resources, Stafford, Kan., records water level measurement from nearby piezometer hole during pumping test.

new well will be constructed in a "high nitrate" area. This area is desirable in that the city owns the land and blending with city Well No.1, which is higher in nitrate, is possible. The pumping tests were from the lower aquifer; the data is found in Table 2.

The subsurface investigation and water quality samples from 2012 showed there are three separate water producing zones in the main part of the aquifer that are separated by significant clay layers. The two city wells are constructed in such a manner that they commingle the two upper water producing zones of the aquifer.

It is believed that the lower, water producing zone in the aquifer will provide sufficient water for a new well and also is significantly lower in nitrate. The new well can either be used separately or blended with a present city well.

The September test indicates that a new well constructed in the lower aquifer can be adequately sized to alone provide enough water for the city during part of the year. But, as the city continues to grow, an additional low nitrate well will be needed so the city can better manage the wellfield and rehabilitate any existing well while still having two wells.

Nitrate transport in groundwater

Nitrate can enter the groundwater from man's practices on the ground surface or just below the ground surface. Nitrate can be transported to the upper level of the groundwater by the percolation of water containing the nitrate downward through the soil, through the subsurface formations, to the top of the groundwater.

A nitrate investigation at another city groundwater supply showed that the upper part of the aquifer had a 24 mg/l nitrate level, that the middle part had a 6.5 mg/l, and the lower part 1.4 mg/l. Obviously, avoiding the upper part of the aquifer may be all that is necessary to obtain low nitrate level drinking water.

Nitrate movement in groundwater by diffusion only is very slow in the order of ten feet in nine to ten years. It is the pumping of wells that causes the significant nitrate movement downwards from the upper part of the

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aquifer. Nitrate movement typically occurs horizontally due to the natural flow of groundwater.

Once the nitrate reaches the top of the groundwater, the nitrate movement is very slow downward to lower levels unless there is a conduit or pathway and there is a pumping well drawing down the high-nitrate water at the top of the aquifer toward the well screen.

Contaminant pathways have been addressed since at least 1947, for example, " ... A deep well is no safer than a shallow one, unless the upper part of the deep well is properly constructed to seal out all shallow water and surface drainage. ..." [1]

Such conduits or pathways include an existing, improperly constructed well nearby; an abandoned well not plugged properly; or the pumping well itself if it is not adequately sealed. Plugging the inside of a well only may still leave a contaminant pathway on the outside of the casing.

For example, often inadequately grouted annular spaces in the well bore, between the outside of the well casing and the surrounding formations are a contamination pathway. At other sites the downward transport of upper water and contaminants from a shallow aquifer has been documented to contaminate a well pumping from a deeper aquifer or even when the well is at rest or out of service.

Reduction of nitrate

There are two possible ways of reducing the nitrate level in water being pumped from a well. The first way is reducing the nitrate entering the top water of the top aquifer by managing or eliminating nitrate applied to the ground surface and just below the ground surface. This method is used in Cunningham by eliminating fertilizer use on the nearby football field and managing the grass clippings.

The second method is reducing or eliminating the amount of water being pumped from the top of an aquifer where the high nitrate is located. This method has to do with well construction; interception wells; well pumping practices; and nearby wells, abandoned wells, and other conduits allowing a significant amount of the high nitrate water at the top of the aquifer to enter the water being pumped from the well. This method will be used in Cunningham in the design and construction of the new city well.

There are many who say that nitrate removal plants must be built to protect the public from harm and nitrate. Do not assume for sure that their way is the only way or the best way.

Water well and nitrate investigation

Any city or rural water district that has nitrate approaching or exceeding the 10 mg/l maximum contaminant level should consider a geohydrologic, subsurface investigation. Such investigation involves several phases that determine what is and what might be possible. The decision to continue to the next phase is contingent on the information obtained and judgment based on prior phases.

The first phase as Groundwater Consultant Ned Marks says would be a forensic geoscience investigation. This process includes reviewing present information on the construction of area wells, on water quality, on possible contamination sources, and on subsurface geology.

A possible second phase might include the construction of test holes to better determine subsurface geology, number and position of all aquifers, and water quality. A possible third phase would include test pumping to determine well yield and well construction.

Then a final phase would include the construction of a new water well, reconstruction and decommissioning contaminant pathways, plugging of wells, eliminating contamination sources, and blending of water.

There can be significant cost savings in addressing the nitrate issue through such an investigation as compared to the cost of constructing a nitrate removal water treatment plant that has very high capital cost and high, yearly operating cost. There are many who say that nitrate removal plants must be built to protect the public from harm and nitrate. Do not assume for sure that their way is the only way or the best way.

The Kansas Rural Water Association has staff who have decades of experience working with municipal and rural water systems. That experience ranges from water chemistry to pigging pipelines. The Association staff are available to discuss any water or wastewater utility issue with anyone. You can email me directly at pat@krwa.net or contact the KRWA office at 785-336-3760. In the meantime, check the KRWA Web site at www.krwa.net for news and information, KRWA's training calendar and many other resources for water and wastewater operators, managers and governing body members.

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.

1 *Water-Well Supplies, Eng. Bull. No. 22*, 1947,Univ. of Kansas, published by Kansas State Board of Health, Sanitation Division