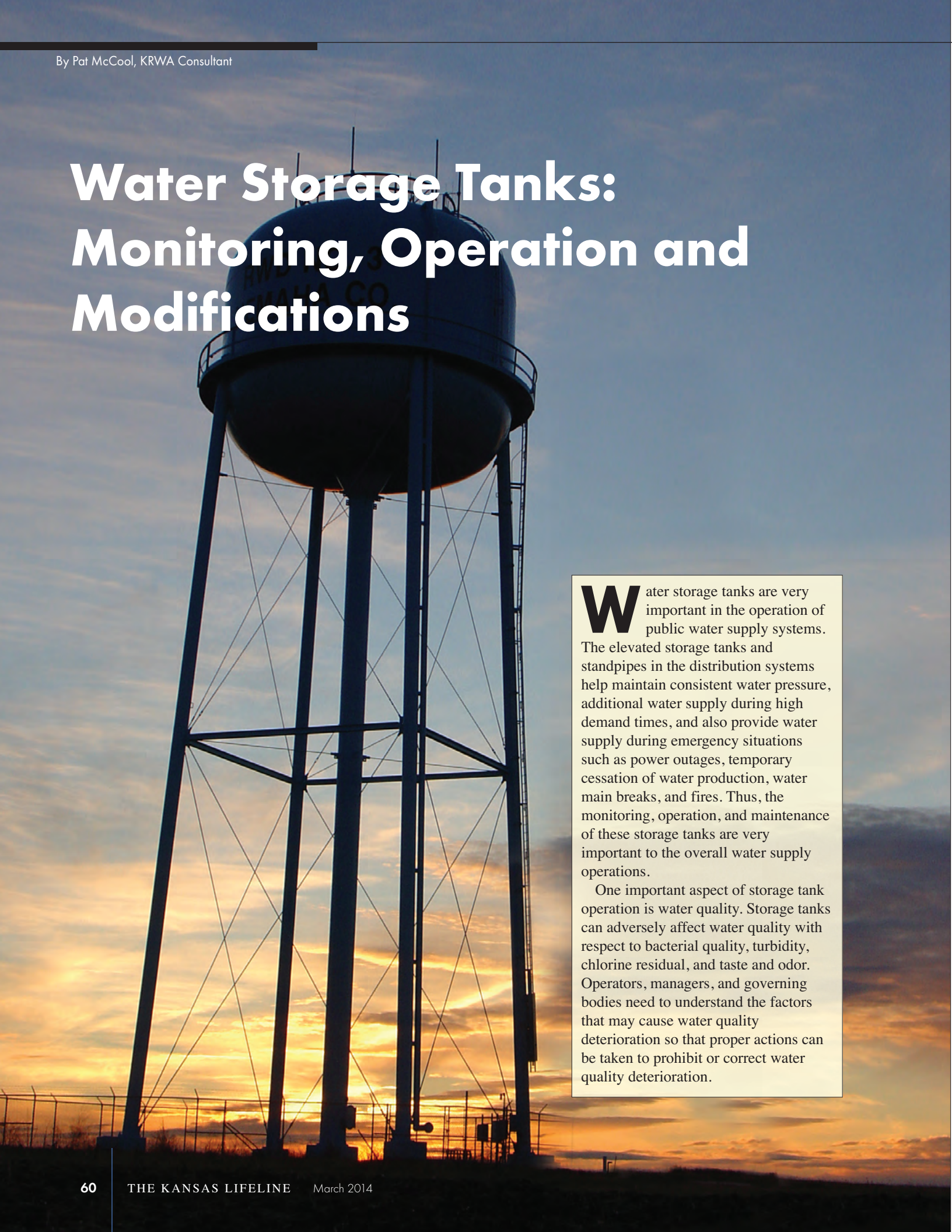
By Pat McCool, KRWA Consultant

Water Storage Tanks: Monitoring, Operation and Modifications



Water storage tanks are very important in the operation of public water supply systems. The elevated storage tanks and standpipes in the distribution systems help maintain consistent water pressure, additional water supply during high demand times, and also provide water supply during emergency situations such as power outages, temporary cessation of water production, water main breaks, and fires. Thus, the monitoring, operation, and maintenance of these storage tanks are very important to the overall water supply operations.

One important aspect of storage tank operation is water quality. Storage tanks can adversely affect water quality with respect to bacterial quality, turbidity, chlorine residual, and taste and odor. Operators, managers, and governing bodies need to understand the factors that may cause water quality deterioration so that proper actions can be taken to prohibit or correct water quality deterioration.

Long detention times

The design of the storage tank is very important variable in determining what water quality problems will or will not develop. Unfortunately, most tanks of concern are already constructed. The challenge in getting the design correct has to due with designing for future water demand, for instance in twenty years, and the optimisms of growth by engineers and governing bodies. That view of growth can have a major effect on the size and location of the tank; incorrect sizing and/or location can exacerbate and cause water quality problems.

The design of a tank has a major affect on the theoretical detention time of the water in the tank. In the simplest of terms, the detention time is the volume of water stored in the tank divided by the amount of water entering and leaving the tank in a day. For instance, if the tank holds 100,000 gallons and the fill-and-draw of the tank is 20,000 gallons per day, then the theoretical detention time would be 100,000 divided by 20,000 or five days. The detention time is also sometimes referred to as (water) "turnover" time or "age" of the water.

Unfortunately, because in most tanks the water enters and exits at the bottom of the tank, the water detention time is a much shorter time in the lower portion of the tank than the water in the top portion of the tank. Thus in the above example, the water at the bottom of the tank may be only six hours detention time where the water at the top of the tank may be twenty days or more. This phenomenon is also called stratification; that is, the water with respect to its location in the tank has varying detention time.

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Loss of chlorine residual

The most common water quality problem in storage tanks in Kansas is the loss of combined chlorine residual. The loss of residual is a major concern due to regulatory requirements, drinking water safety, increasing bacterial levels, and possible taste and odor.

For information on monitoring and operation of storage tank to combat residual loss, see the article, pages 54-56 in the November 2012 issue of *The Kansas Lifeline*. The article is also available at the KRWA Web site or by calling the KRWA office.

Sediment buildup

It is not uncommon that over a period of years that a sediment buildup may develop in the bottom of some water storage tanks. There are many factors that determine if, how much, or over what period of time this sediment may occur. The source water quality is a major factor with the concentration of iron, manganese, hardness, and water stability being important. Most sediments include iron and iron bacteria that will give the sediment a red/orange/tan color. Sediment is best addressed by inspection and cleaning if necessary. The November 2010 issue of *The Kansas Lifeline*, pages 30-34 has a good article on sediment on how to address this issue if it exists or is suspected to be a problem.

Common sense and required protection

Overflow pipes and storage tank vents should be screened to prohibit birds, animals, insects, rain, and dust from getting into the water/tank. *The Kansas Lifeline* has had three good articles on such which can be found on pages 38-41 of the November 2011 issue, and page 67 and pages 82-83 of the July 2012 issue.

Tank modifications

Many water supplies in Kansas have considered and some have implemented modifications to storage tanks in order to maintain/achieve better water quality, specifically, maintaining chlorine residual is the major consideration. Before modifications are installed, different operational practices should be implemented and monitored to determine if the residual loss problem can be eliminated or mitigated by change in operations rather than capital expenditures. Such changes may include varying the amount of water stored in the tank, the gallons of water in one fill-and-draw cycle, or time of day when the tank is filled. The issue really is detention time and incoming chlorine residual level.

Probably the best way by far to monitor the residual at the tank is to install a continuous chlorine analyzer and recorder on the water entering and leaving the tank. The monitor will provide valuable information on the extent of the problem and the benefits that may result in a change in tank operation or the installation of a modification. Such a monitor need only be used possibly during the time when conditions favor low chlorine residual, that is, late summer and early fall.

What is important for operators, managers, and especially governing bodies to know and remember is that what works or may work at one storage tank in another system will not necessarily work in another system or situation.

Two major modifications that are typically considered are: 1) installing piping modification in the tank that allows all incoming water to enter the tank at the top only and all exiting water to leave the tank at the bottom; or, 2) installing a mixer in the tank to "reduce" or "eliminate" stratification of the water.

What is important for operators, managers, and especially governing bodies to know and remember is that what works or may work at one storage tank in another system will not necessarily work in another system or situation. This is especially the case with the aforementioned modifications. Thus, installing a modification may result in a loss of money without necessarily the elimination of chlorine residual loss. Buyer Beware! – in spades.

When one discusses the aforementioned modifications, the language usual involves something like "mixing the good residual water with the low/no-residual water" with the implication that the overall residual is good, that is, more than desired. But the language could just as easily been

Recently, the city clerk in a small town in north-central Kansas asked KRWA staff member Greg Metz what his thoughts were on the topic of tank mixers. In this case, it was suggested to the city by the sales representative of a tank service company that installing the mixer "would help reduce the growth of mold on the exterior of the tank".

KRWA had not heard of such a promotion before so KRWA staff asked more questions. KRWA suggested that a wide range of factors might contribute to the growth of mold on the exterior of a storage tank and those mainly are the humidity, temperature, location, etc. But never before had anyone at KRWA heard of a mixer being a factor in reducing mold growth on the undersides of a tank.

KRWA contacted Dan Clair at KDHE in Topeka to learn of the State's experience with mold/mildew control in relation to internal mixing systems for potable water storage applications. Dan noted that control of mold/mildew on the outside of storage structures in potable water applications is unproven.

Dan Clair offered the following comments: "Simply stated, one gets what they get or does not get, so to speak, by virtue of the presence of an internal mixing system and site-specific circumstances. And that is as good as it gets. Since there is no way to quantify and more importantly guarantee what can be verifiable achieved, it would be fair to expect that such a method of control should not be marketed nor included in service contracts, as in a line item cost for example.

"In discussing the topic with mixing system vendors currently active in Kansas, it was requested that in the course of working with their partners they ensure that all staff, i.e., technical, marketing, sales, etc., understand these points and do not market such a method of control to public water supplies systems, at least those in Kansas.

"The system can best look after itself by keeping the following in mind. First enlist the services of a consultant who is both knowledgeable in this area and licensed by the Kansas Board of Technical Professions (KBTP) to practice in Kansas. Second ensure that the consultant follows State regulations by providing plans, specifications, a copy of the mixing system vendor's design, and a public water supply permit application to KDHE for review and approval prior to the start of construction. Lastly, ensure that the requirements for providing a copy of the vendor's mixing system design to the consultant and KDHE, and conducting a post-construction demonstration of performance, again industry standard is convergence of temperature and residual testing, are both explicitly stated in the specifications. Vendors who are truly interested in meeting the needs of the water supply system will be more than accommodating."

Dan Clair, MS, PE is with the Public Water Supply Section of KDHE's Bureau of Water and can be reached at 785-296-5516 or dclair@kdheks.gov.

In the case of the city mentioned above, it was successful in removing the proposed tank mixer from their service contract at a cost reduction of $18,000.

"mixing the low/no-residual water with the good residual water" with the implication that the overall residual is bad, that is, less than desired. Think about it.

Fill-in-the-top, drain at the bottom

Installing piping to fill a water storage tank at the top will reduce stratification. But, depending on the amount of water in the tank and the water detention in the tank, the water may still loose residual but perhaps not as quickly in the summer when residual-loss is likely.

However, if a tank is not "over-sized" for residual maintenance and the turnover is short, say one or two days, then the fill-in-the-top may solve the chlorine residual loss problem. In some situations and tank locations, the fill-in-the-top will not work and the installation will remove one operational procedure that has benefit, mainly the ability to overflow low-residual water at the top of the tank.

Careful consideration of this modification should be given especially where tanks are very large with long detention times or at remote locations such as many standpipes in rural water districts are.

What about mixers?

In this modification the stated benefit is the mixing of the good, high residual water with the bad, low residuals water. But the real issue is: will the resultant water be water meeting KDHE requirements or expectations of the governing body or will the water not meet those requirements? Here, Buyer Beware! – in spades again!

It should be emphasized that the water leaving the tank should have a residual greater than the required KDHE minimum required residual so that the residual will be adequate in the distribution system.

There is some mixing that occurs in all tanks due to thermal currents caused by temperature

difference between the water next to the outside of the tank and the water in the center of the tank. The water next to the outside of the tank warms up in sunlight and higher air temperature; but this water also cools due to lower air temperature at nighttime. But thermal mixing in many cases is not enough to prevent chlorine residual loss and stratification in the tank. The pertinent question with respect to mixers is whether or not the mixer will prevent stratification significantly to reduce or eliminate chlorine residual loss so that the residual leaving the tank meets the goal of the governing body and KDHE.

For instance, if the system installs a mixer the size of a kitchen cake mixer, then stratification and residual loss will surely not be significantly reduced or meet the residual goal. If however a mixer is installed, for example, 70 percent the size of the tank, then yes the stratification problem will be solved and maybe the residual leaving the tank will meet what is desired if the detention time is short, say one or two days.

Unfortunately, mixers being proposed or installed in tanks are not the 70 percent size, nor are they the small cake mixer sizes. Thus, whether a particular size in between works is unknown. When governing body considers a mixer, the language like "elimination of stratification", "mixing the water", "improving water quality", or whatever are just words. The issue is what will the resultant residual leaving the tank be, and what guarantee is there that if the governing body spends money that there will be adequate residual leaving the tank? Will the resultant residual meet KDHE requirements and the governing body's requirements? In some cases, rechlorination should be considered in addition to mixing.

The problems discussed are real to many water systems in Kansas. These problems can be and are being addressed and hopefully mitigated or eliminated by a good monitoring program, good/possibly different operations, and periodic inspection and maintenance. But careful consideration must be given when approving modification to tanks because such modifications will not necessarily work in all situations and those situations may include the storage tank(s) in your water system.

Conference topics

I encourage readers to attend the 2014 Annual Conference & Exhibition at Century II Convention Center. The dates are March 25 – 27. The conference features numerous breakout sessions that address issues associated with water quality, and operations and maintenance, including storage tanks.

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.

For further reading . . .

Check out these prior articles from KRWA's magazine, *The Kansas Lifeline*, that review the topic of water quality as often is related to storage tanks. These articles may be found at this link for archived issues of the magazine: www:krwa.net/lifeline/pastissues.shtml

Henderson, Erika I. "The Inspector Found What?" *The Kansas Lifeline* (July 2012): 67.

Lamfers, Jeff. "Kansas Water System Contaminated Due to Birds Accessing Storage Tank". *The Kansas Lifeline* (July 2011): 38-41.

McCool, Pat. "Combined Chlorine: Maintaining Residual in Distribution Systems". *The Kansas Lifeline* (November 2012): 54-56.

Moore, Randall. "A Sustainable Approach to potable Water Quality Management" *The Kansas Lifeline* (November 2010): 30-34.

Zelch, Clyde H. "Pay Attention to Sanitary Issues Associated with Storage Tanks". *The Kansas Lifeline* (July 2012): 82-83.