By Daryn Martin, KRWA Technical Assistant

Have You Settled on a Settled Water Turbidity Goal Yet?

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The Safe Drinking Water Act (SDWA) was passed during the Nixon Administration in 1974. In the SDWA, Congress gave the US Environmental Protection Agency (EPA) direction and authority to create and enforce regulations on drinking water delivered to the taps of Americans. However, it was not until the 1986 SDWA Amendments that regulations specific to surface water plants were enacted. In 1989 the first Surface Water Treatment Rule (SWTR) was finalized. The SWTR regulations apply to all Public Water Supplies (PWS) that utilize surface water (i.e., streams or lakes) and all PWS that use groundwater under direct influence of a surface water (GWUDI) as a source. The SWTR required water plants to have certified operators (Kansas requirements began in 1974), contained treatment techniques (TT) for Giardia lamblia and viruses, contained disinfection residual requirements and combined filter effluent (CFE) turbidity requirements. In response to the new rules, surface water plants around the country began to install turbidimeters and disinfection (already common in Kansas, the last holdout started disinfecting in 1966). Things were good in those halcyon days, until 1993 when the largest outbreak of waterborne disease in US history struck Milwaukee, Wisconsin. Sewage contamination in Lake Michigan near the WTP intake caused high turbidity that included Cryptosporidium oocysts. The contamination made it through the plant to the customers' taps. The Milwaukee cryptosporidiosis outbreak tallied more than 400,000 cases and 104 deaths. For comparison, the largest waterborne disease outbreak in Kansas took place in Newton in 1942. A sewage line drained into an open water main during construction work, leading to more than 3,000 reported cases of dysentery in town. US military troop trains stopping in the city reported thousands more cases. This outbreak was the impetus to requiring all Kansas PWS to disinfect their water. After the Milwaukee outbreak, congress was called upon to tighten water treatment regulations to prevent similar outbreaks in the future.

The next version of the SWTR, called the Interim Enhanced Surface Water Treatment Rule (IESWTR) came about in 1998 and contained stricter CFE turbidity requirements, included individual filter effluent (IFE) requirements, required states to perform sanitary surveys (PWS inspections), created TT requirements for Cryptosporidium, required treatment plants to profile disinfection levels to create a benchmark and required a cover over all newly-constructed finished water reservoirs. Most IESWTR provisions only applied to utilities that served ≥ 10,000 customers. But the EPA did not want the small guys feeling left out, so in 2002 they finalized the Long Term 1 Enhanced Surface Water Treatment Rule (LT1) which required systems serving < 10,000 to follow the

IESWTR regulations. The most recent update to the rule is the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) finalized in 2006. LT2 requires utility-size-dependent source water monitoring for E. coli, Cryptosporidium and turbidity. Based on source monitoring numbers, WTPs were placed into a “bin classification” which may or may not require additional treatment for removal of Cryptosporidium. LT2 also required all finished water facilities be covered.

In Kansas, a majority (approximately 55 percent) of PWS are served by groundwater. There are only 72 surface water treatment plants (WTP), and almost all of those are found in the eastern third of the state. There are five (5) PWS that are served by GWUDI. That adds up to about eight percent of PWS in Kansas that are subject to SWTR. But, that eight percent of PWS serves approximately 2.3 million of the state’s 3.0 million citizens. These are common statistics in the United States; the largest water providers utilize surface water.

Those of you who treat surface water are familiar with many of the requirements that the Kansas Department of Health and Environment (KDHE) places on surface water plants. The monthly operating report (MOR) that is sent to Topeka each month is a summary of the SWTR requirements. But, the MOR only reports the final turbidity and disinfection results. It does not necessarily tell the entire story of the SWTR and the reasons for its requirements.

In surface water treatment, the main goals are: 1) The removal of pathogens; and, 2) Creating a safe product for customers. There are three main barriers to pathogens in the WTP. They are: 1) coagulation/flocculation/sedimentation; 2) filtration; and, 3) disinfection. Each barrier is vital to pathogen removal and safe drinking water with none more important than the others. Because there are no specific requirements for coagulation/flocculation/sedimentation, most operators do not have specific process control guidelines or goals for these processes. If these processes do not work correctly, many operators do not know it until an increase in IFE turbidity, and by then it’s far too late. Studies show a very high correlation between turbidity levels and waterborne disease outbreak. During the cryptosporidiosis outbreak in Las Vegas during 1993 – 94, when there were 78 laboratory confirmed cases, the maximum CFE turbidity was measured at 0.17 NTU. During the Milwaukee outbreak, CFE turbidity reached 2.7 NTU. Due to this data, EPA has established a “settled water” (top of filter, after sedimentation) goal of 1.0 NTU. If a plant’s standard procedures do not include measuring turbidity after these individual processes, I recommend doing so. This

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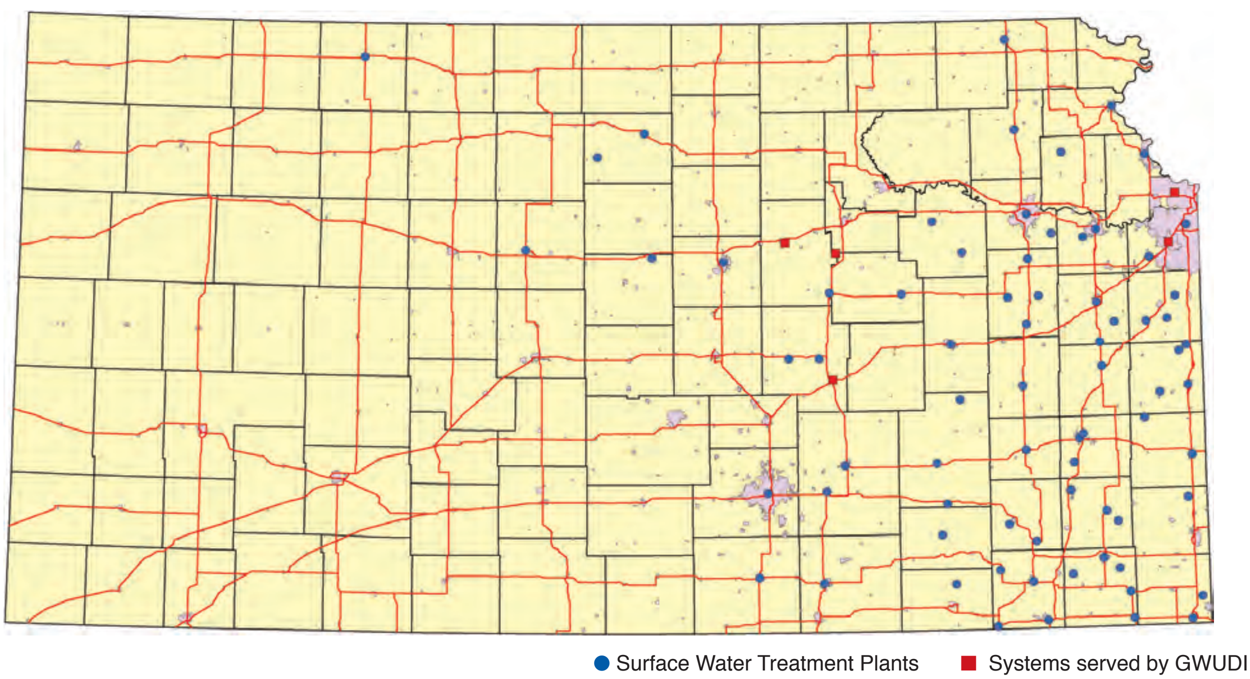
data will help operators make process control decisions more accurately and identify developing treatment problems before they become full-blown catastrophes.

The coagulation/flocculation/sedimentation process, as the name implies, is actually multiple processes. Many operators refer to coagulation and flocculation interchangeably, but they are in fact separate processes. Coagulation begins with the rapid mix where the chemical coagulants are introduced into the raw water. Coagulation is the process where the colloids, or small particles in the water, are chemically changed to promote flocculation. Colloids by nature are negatively charged and they repel each other as magnets will when the negative poles are pushed together. Coagulants are an inorganic chemical comprised of metal salts that destabilize the colloids so they are attracted to one another, creating floc particles and are often used in combination with polymers or flocculant aids. Polymers are generally synthetic mixtures with a high molecular weight used to create large, heavy floc particles. Many chemical companies create custom "blends" that include a primary coagulant mixed with a flocculant aid. Coagulants are added in or just prior to the rapid mix to ensure complete mixing. Fast in and fast out is the goal of the rapid mix, usually in 30 to 60 seconds. Proper dosing is critical to proper floc formation. Over or under feeding coagulants can impede performance. A plant jar testing procedure is necessary to find the proper dosages needed for different raw water conditions.

After coagulation, flocculation combines the colloids into floc. Good floc formation is important to multiple aspects of water treatment. Floc particles contain pathogens (Crypto and Giardia), taste and odor causing compounds, compounds that add to the total organic carbon (TOC) measurements and disinfection byproducts (DBP) precursors. Particles are slowly mixed, and they continue to combine into larger and larger floc particles. Large, heavy floc is easier to settle and will result in lower turbidity on the top of filter. Many floc basins have multiple mixers, each with a decreasing mixing velocity to avoid floc shearing. Shearing creates "pin-floc" which does not readily settle and will carry over onto the filter. Daily visual observations are a must when operating a WTP. An astute and experienced operator can tell how well the process is working on a given day just by walking along the top of the floc basin.

The last major process discussed in this article is sedimentation. Sedimentation is the gravity induced settling of the floc particles. Sed basins are designed for very long detention time of one or more hours to days in some instances. Upon leaving the floc basin, the water is slowed down usually by a weir and gravity will take over. This is where large, heavy floc is advantageous. Many sed basins are gently sloped down towards the head of the basin to allow easy sludge removal. This can be accomplished many different ways but the important thing is to keep the basins cleaned. Sludge blowdown or wastewater can



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be sent to the sewer plant or purpose-built handling facilities. The important thing to remember is if the waste is directed to a stream or ditch, the facility MUST have an NPDES wastewater permit from KDHE. In the last few years, many WTPs have been cited during an inspection because the water plant was discharging wastewater without a permit.

There are many plants in Kansas that have the rapid mix, floc and sed basins combined into a solids contact unit (SCU) or upflow clarifier. These basins are popular due to a low detention time and small footprint. In a SCU, the rapid mix is mechanically driven in the center column, the flocculation happens under the cone and sedimentation is achieved when the water is pushed through the sludge blanket and up over the weirs. These units have a good track record but are operationally much more “hands-on” than a conventional layout. Sludge blow-off takes place much more frequently due to the decreased storage space; the sludge blanket must be monitored constantly to operate correctly.

So, why the fuss over these processes? Why should operators have a goal for these unit processes in the form of turbidity? Doesn’t the filter media take out everything that remains? My best answer to these questions and in support of settled water turbidity goals is to ask operators to use their imagination for a second. The size of the average Crypto oocyst (the term used for a cyst containing a parasite’s zygote) is about six (6) microns. The anthracite media contained in most filters is between 600 and 2300 microns. The smallest filter media particles are still about 100 times larger than the average Crypto oocyst! Imagine if you are a 6-foot tall oocyst; the filter media is comparable to a 40-story tall building. Because of the great difference in size, Crypto oocysts are difficult to filter out by themselves. It is much easier, and cost effective, to capture them in floc particles and settle them out before reaching the filter. Plus, lower turbidity on the top of the filter, while not necessarily contributing to low filtered turbidity 100 percent of the time, results in longer filter runs and shorter, less frequent backwashes. That will result in less water used and less pumping, which means less overhead cost. So now we have a cost-benefit, which is what is most important to many city council members or water district board members, right?

In the next issue of *The Kansas Lifeline*, I’ll go deeper into filtration. KRWA has also created a Surface Water Treatment and Filter Study workshop to discuss the topics I have briefly described in this article. Watch for the training session dates and locations at www.krwa.net/training. If anyone would like more information on surface water treatment and/or specific process control questions, do not hesitate to contact the staff at KRWA. There are many years’ worth of experience ready to help tackle any problems operators or others in water and wastewater systems are working on. Sometimes just a new set of eyes looking at the problem from a different viewpoint can make the difference.

Daryn Martin began work with KRWA in August 2019. He previously was a Water Program Inspector and Environmental Program Administrator at KDHE’s Wichita office. Prior to joining KDHE, he worked as an operator in the El Dorado Water Treatment Plant. He holds a Class IV water operator certification.