A consecutive water supply system is a public water system that purchases or otherwise receives some or all of its finished water from another public water supply system. Most consecutive systems do not chlorinate, that is, rechlorinate the water they receive from their supplying system. Thus, consecutive systems have very little direct control over the amount of chlorine in the water.

One of the major responsibilities and requirements of any water supply system is to maintain chlorine residuals in the distribution system. A chlorine residual is important as its presence is an important indicator that contamination has not occurred and the water is safe to drink. State regulation requires that a minimum of 1.0 mg/l combined chlorine residual or 0.2 mg/l of free chlorine residual be maintained throughout and at the far ends of the distribution system. This can be a difficult challenge when a consecutive system does not have direct control over chlorination of its water.

All water supply systems are required to take at least one daily chlorine residual in the distribution system. These residuals should be taken at different locations rotating throughout the system to ensure that all parts of the distribution system have adequate chlorine residuals. These residuals should be recorded in a log or other suitable manner so that it is documented that the residuals were taken and were adequate. These records must be maintained by the utility for for at least 10 years as required by state regulations.

A consecutive system may have a minimum level of chlorine required at the point of purchase in its purchase contract with the water supplier. However, many water purchase contracts do not have a stated, numerical value for the minimum chlorine residual but may have language that states the water must meet state or other words, how long does the water remain in the system. This is affected by the miles of water lines, storage volumes and locations, water usage, number and locations of customers, and flushing practices. In this regard, the operator can only flush water lines and vary water levels in storage tanks to help keep residuals adequate.

Another important factor is the type and level of chlorine residual received from the water supplier. First, the type of residual is either free chlorine or combined chlorine. Both types of residuals have their advantages and disadvantages in being able to maintain the residual in the distribution system. For instance, free chlorine is a much better disinfectant and can be easier to maintain when fighting biofilms during warmer water temperatures. Combined chlorine
is a weaker disinfectant and can be maintained longer if biofilms do not take over in the system. (Please refer to the article on biofilms in the July 2005 issue of The Kansas Lifeline).

Second, the level of residual received from the supplier is important. Obviously, a higher residual at the point of purchase is more likely to be maintained in the system than a lower residual. Most of the time, high residuals at the point of purchase can not be expected unless that point is near the supplier’s treatment plant or well chlorination; this is because there may be a loss of residual in the supplier’s distribution system. Again, most consecutive systems do not have any direct control of the chlorine residuals received from the supplier.

**Biofilms reduce water quality**

In most situations the major cause of loss of chlorine residual in the distribution system and storage facilities is biofilms. Biofilms are microorganisms that grow on the inside surfaces of water lines and storage tanks. Chlorine loss occurs when the chlorine reacts with the biofilms. Although this loss of chlorine residual due to biofilms can happen at any time, it is much more likely to occur when the water is warmer.

Systems using water from a surface source are particularly susceptible during the summer and early fall months. Also, the problem most likely first occurs, and may only occur, in storage tanks where the water is not exchanged enough and warms. Some cities have installed continuous chlorine analyzers and recorders to monitor the residuals at elevated storage tanks.

Biofilms are also more likely to occur if ammonia or ozone has been added to the water. Under certain conditions ammonia can provide a source of food for the growth of nitrifying bacteria biofilms; the process is called nitrification. Also, ozone changes the form of natural organics in the surface water to a more biodegradable form (called assimilable organic carbon or AOC) that is more readily used as a food source for aerobic bacteria biofilms.

**Rechlorination, a likely option**

If a consecutive system cannot maintain adequate chlorine residuals with the chlorine residual from the supplier, then chlorination (that is, rechlorination) by the purchasing system should be considered. There are public water systems in Kansas that rechlorinate and others that are in the process of installing rechlorination. Rechlorination can either be at the point of purchase or elsewhere in the distribution system. Rechlorination at a pumping station is much easier to implement than on a water line or at a storage tank because the water flow rate at a pumping station is a known value.
Maintaining chlorine residuals...

Rechlorination at the point of purchase will allow a consecutive system to control the chlorine residual in that system. Also, it will allow the system to periodically “burn-out” the biofilms in its system if they occur. Burn-out is where a system goes from combined chlorine to free chlorine for two to four weeks in the summer to discourage, eliminate, or reduce biofilms in the distribution system. Some water suppliers do this for their distribution system dosage in the range of 12 to 18 mg/l of chlorine may be needed to achieve a 3.0 mg/l free chlorine residual for burn-out.

When rechlorinating water not during burn-outs, the chlorine dosage must be such that additional disinfection byproducts are minimized or not formed. This is accomplished by rechlorinating only enough to form the monochlorine form of combined chlorine. In all situations, it is most important to understand the chemistry of chlorine and ammonia reactions and to take and record precise and accurate chlorine residuals.

Also, there are additional considerations that need to be addressed when rechlorinating water that has had ammonia added by the supplier to form combined chlorine. First, the chlorine residual level from rechlorination can only be as high as the ammonia level in the water will allow. In general, this means that the residual can only be raised to the level that probably left the supplier’s treatment plant.

However, during the warmer months, the ammonia levels (and
chlorine residual levels) may decrease from the treatment plant to the point of purchase if nitrification is occurring in the supplier’s water lines or storage tanks. This can be addressed by also providing the ability of the consecutive system to add ammonia feed equipment at a later date if it is determined necessary. Again, this may not be needed year round but may be needed just in the warmer water temperature time. If ammonia addition is practiced, then KRWA recommends that the chlorine residuals be measured at the rechlorination locations by an amperimetric titrator rather than the colorimetric/DPD method.

This first and necessary step in determining whether rechlorination is needed is to take numerous chlorine residuals in the system. Make sure that enough samples are taken to determine the extent and severity of the problem. Residuals should be taken at locations throughout the system. Residuals should be taken at different times of the year to determine the effect of the weather/water temperatures. Samples should be taken at different times of the day and week especially at the point of purchase and at the storage tanks. For instance, make sure that you are getting the (lowest) residual of the water leaving the storage tank just before filling begins, or get the residual of the tank overflow.

If it is determined that a rechlorination system is necessary, then a permit application, plans, and specifications of the rechlorination system must be submitted to and approved by KDHE before it is installed. The operator or manager should check the rechlorination system at least daily to determine that the system is operating properly and that the desired resultant residual is being achieved.

KRWA staff is available to assist you in determining if you have a residual loss problem and the extent of the problem. Also, KRWA will advise on the best way and where to rechlorinate the water if that is determined necessary.

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Watch for water quality sessions at the upcoming KRWA Annual Conference, March 28 - 30

The 39th Annual Conference & Exhibition provides an excellent opportunity for operators, managers and governing body members to learn more about water quality issues. Attendees are encouraged to attend; look for these sessions related to water quality:

**Tuesday, March 28:**
- Water Distribution Workshop

**Wednesday: March 29**
- Cross Connection Policies and Enforcement
- KDHE Drinking Water Program Update (two sessions)
- Chlorine: It’s a Gas! Let’s Practice Safety First
- Stage 2 Rule Requirements: Compliance Schedule

**Thursday, March 30**
- Controlling and Reducing Disinfection Byproducts in Water
- Well Maintenance that Delivers Extra years of Service
- Certified Water Operator Forum
- Process Instrumentation for Water Treatment