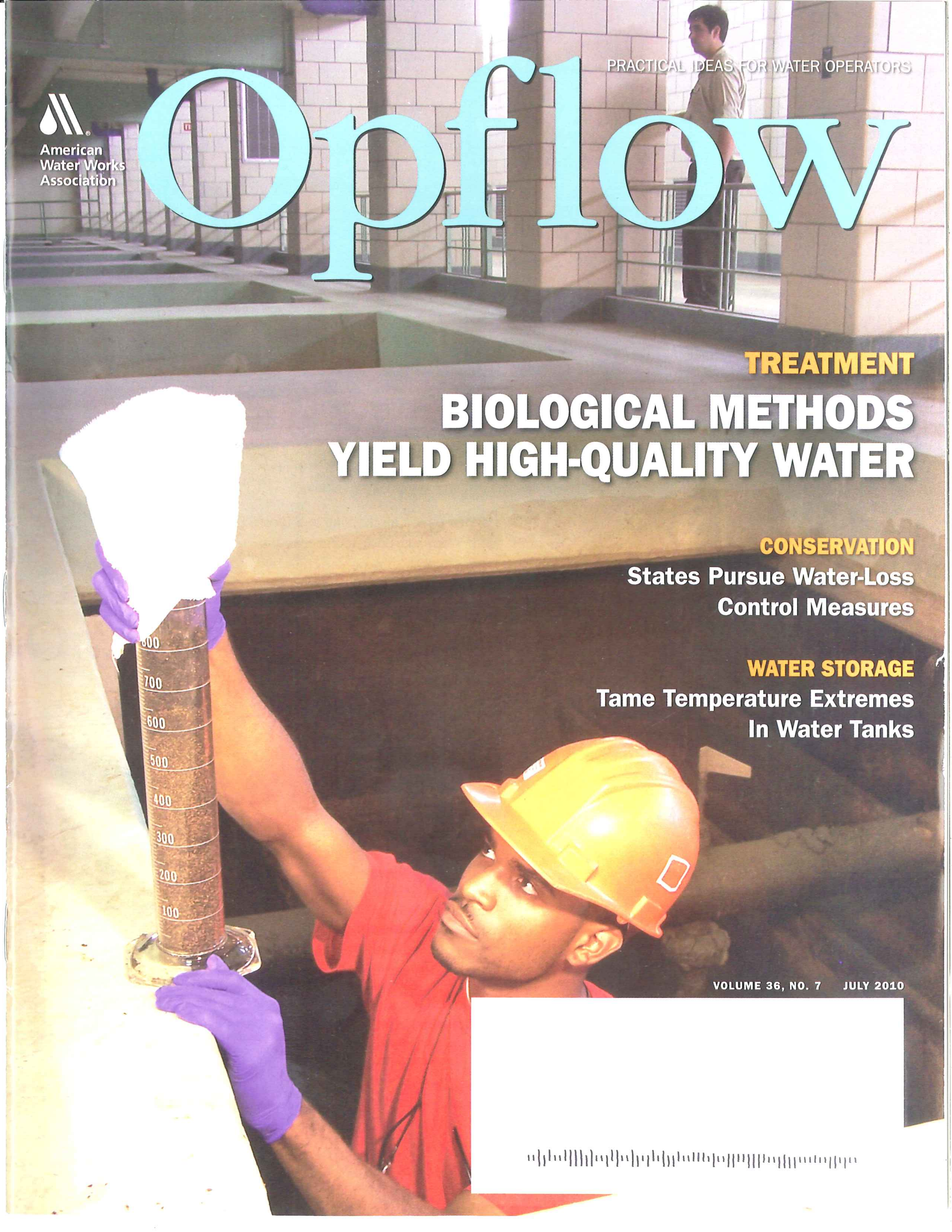
PRACTICAL IDEAS FOR WATER OPERATORS

American Water Works Association

Opflow



TREATMENT
BIOLOGICAL METHODS YIELD HIGH-QUALITY WATER

CONSERVATION
States Pursue Water-Loss Control Measures

WATER STORAGE
Tame Temperature Extremes In Water Tanks

VOLUME 36, NO. 7 JULY 2010

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Fire and Ice

Tame Temperature Extremes in Water Tanks

A Maine utility is learning to cope with storage tank stratification caused by widely varying seasonal temperatures.

FRANK S. KEARNEY SR., BRUCE P. STEVENS, AND PETER FISKE

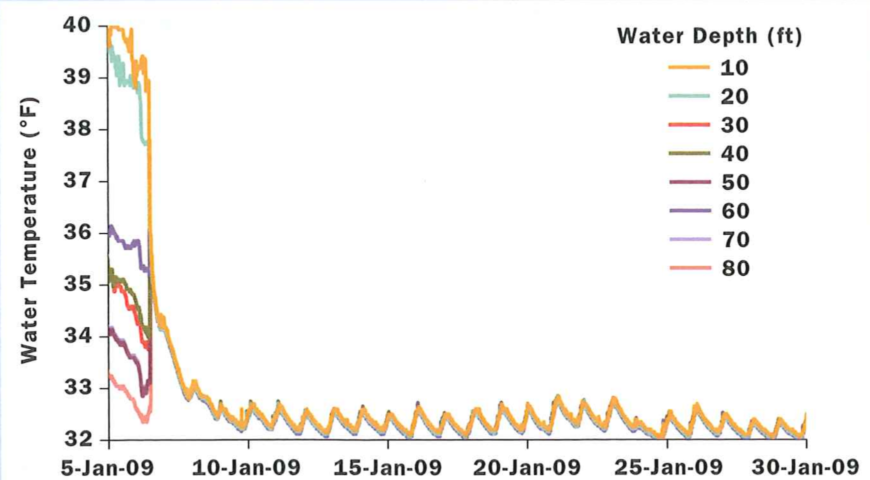
LARGE VARIATIONS IN average temperature present challenges for water operations. During cold winter months, operators must guard against freezing in water tanks and distribution lines. During hot summer months, water quality can degrade because of accelerated disinfectant loss and thermal stratification inside water storage tanks.

TEMPERATURE-RELATED CHALLENGES

Old Town, Maine—located on the Penobscot River, about 12 mi north of Bangor—is typical of many towns that have a wide range in annual average temperatures. During winter months, temperatures in central Maine fall below freezing for weeks at a time. The Old Town Water team was accustomed to dealing with cold-weather emergencies, such as broken water mains; frozen service lines, mains, and hydrants; and ice buildup inside storage tanks. After a particularly severe winter, operators discovered ice had damaged the coating of a relatively new glass-lined standpipe.

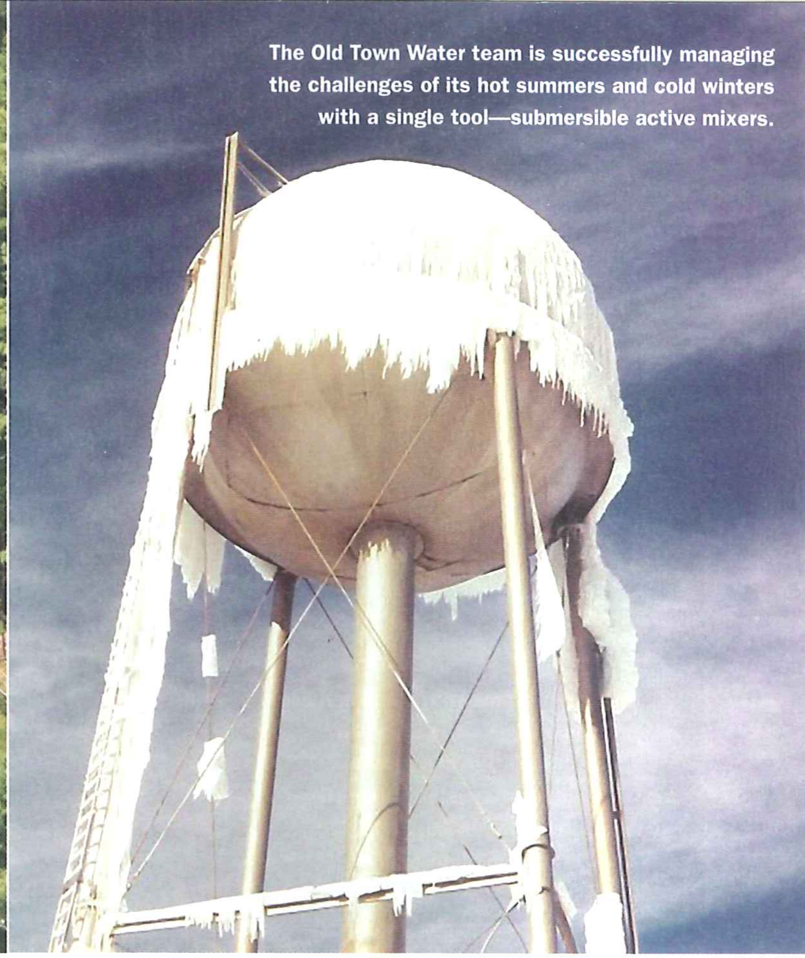
Figure 1. Temperature Data From Submerged Storage Tank Probes

Water in a storage tank was thermally stratified until Jan. 6, 2009, when a submersible mixer was installed. After 2 hours of mixer operation, the tank was completely mixed and remained well mixed for the remainder of the winter.



During summer months, different challenges emerge. Long summer days bring higher temperatures, heating water inside storage tanks. The situation causes thermal layering, with cool water from the treatment plant staying at the bottom of a tank and older, warmer, chlorine-depleted water residing in the upper 80 ft of 100-ft tanks.

The town's 8,000 residents are served by the Old Town Water District, which manages 50 mi of distribution lines and three water storage tanks. To manage poor tank turnover and to maintain consistent water quality during the summer, treatment plant operators usually increased disinfectant residual levels to 1.5 mg/L. Despite these efforts, disinfectant residuals declined as water traveled through the distribution system. The team



PHOTOGRAPHS: (LEFT/RIGHT) AERIAL PHOTO SERVICE OF MAINE. RAY FOGG AND FRANK S. KEARNEY SR./USCI, TOM STECHMANN

knew that at least part of the problem was caused by stratification in the town's water tanks.

STRATIFICATION

Inspection of the town's two glass-lined standpipes confirmed the team's concerns. Because of their shape, standpipes are particularly prone to thermal stratification. During long summer days, the sun shines on the sides of a standpipe, heating the walls and water within. Warm water rises to the top of the tank and stays there, perhaps all summer. Much denser, cool water pumped into the standpipe during each fill cycle remains at the bottom of the tank.

When team members opened the tank hatches, they felt a blast of hot, humid, stale air, indicating temperatures at the tank tops were much warmer than the temperatures at the tank bottoms. Samples taken from the upper half of each tank showed no detectable chlorine residual.

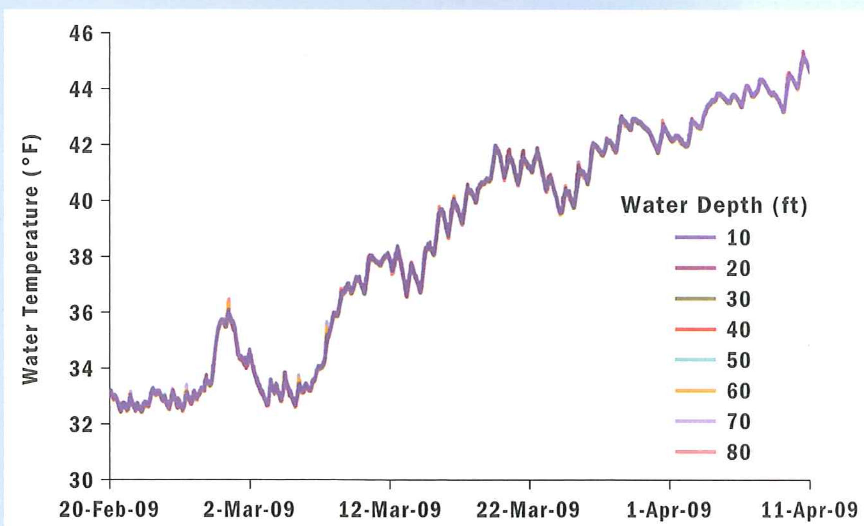
SUBMERSIBLE MIXERS

In late 2008, the district conducted a major hydrant flushing program to restore residual and then installed a submersible potable water mixer in the damaged standpipe. Another standpipe was left unmixed as a control. A 1-ft-thick layer of ice at the top of the tank had to be removed through the side hatch to make room for the mixer. Temperature measurements taken before the mixer was turned on showed that, even in winter, the tank was thermally stratified. After a few hours of mixer operation, the entire volume of water was the same temperature (Figure 1). In addition, an ice cap that had reformed at the top of the tank began to thaw. By late February, the standpipe was free of ice. However, a nearby, unmixed standpipe had significant ice until late April (photos, page 22).

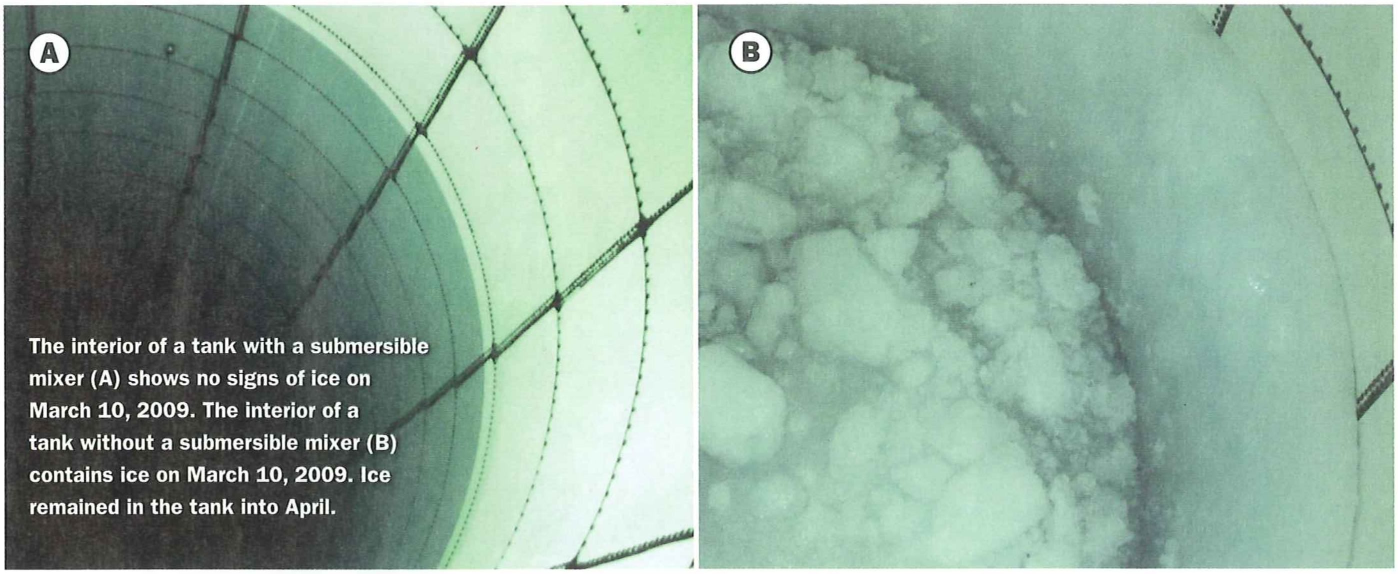
As spring turned to summer, the mixed water maintained a stable temperature.

Figure 2. Temperature Changes in Tank

Spring brought an increase in average temperature and longer periods of sunlight, both of which increased the mixed tank's average temperature.



Measurements of residual leaving the plant and in 10 sites in the distribution system show a substantial decrease in overall disinfectant residual demand after mixers were installed.



The interior of a tank with a submersible mixer (A) shows no signs of ice on March 10, 2009. The interior of a tank without a submersible mixer (B) contains ice on March 10, 2009. Ice remained in the tank into April.

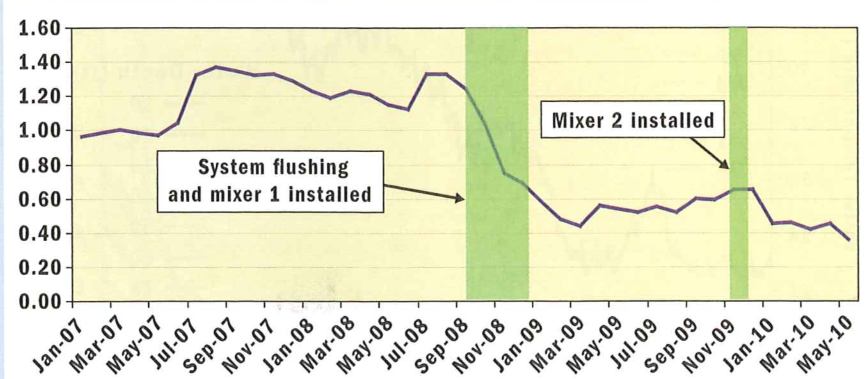
Average temperature in the standpipe rose each day, but no thermal stratification was observed (Figure 2, page 21). As a result, water temperature at the top of the tank was much lower than the temperature in the unmixed tank. Because chlorine residual evaporation occurs faster at higher temperatures, team members surmised that overall disinfectant residual losses would be less in a well-mixed tank. Testing at the top of the mixed tank confirmed residuals as high as 0.7 mg/L. Water at the top of the unmixed tank remained depleted of chlorine.

In the fall of 2009, a submersible mixer was installed in a second tank. Since that time and in response to widespread complaints about chlorine odors, operators have reduced the chlorine dose by 30 percent. Most of the complaining customers had never before noticed a chlorine odor.

Measurements of residual leaving the plant and in 10 sites in the distribution system show a substantial decrease in overall disinfectant residual demand after mixers were installed (Figure 3). Before the mixers, roughly 1.2 mg/L of disinfectant residual was consumed in the distribution system (i.e., concentration leaving the plant minus the average concentration in the system). But after the mixers were installed, residual demand fell to around 0.4 mg/L. Operators estimate that this corresponds to a chlorine/day decrease of 22 lb for post-filter chlorination, saving about $1,200/yr.

Figure 3. Average Residual Loss in Distribution System (mg/L)

Overall disinfectant residual demand in the distribution system decreased substantially after mixers were installed.



SAVINGS

For years the monthly electrical bill for the tank facility had averaged $20. With a daily operating cost for the first mixer of about $1/day, the electric bill averaged $50/month. With the second mixer operating from the same electrical service, the electric bill now averages $80/month. Both mixers operate continuously. In addition, submersible mixers have helped Old Town Water eliminate other operational costs. With more even mixing and temperatures within storage tanks, the utility is experiencing less damage to ladders and tank coatings and structures and has a more reliable water supply for fire protection.

The Old Town Water team is successfully managing the challenges of its hot summers and cold winters with a single tool—submersible active mixers. Later this year, the district will install a third mixer in a 1.5-mil-gal steel tank.