Soft Water, Hard Choice?

Problems associated with hard water are already well-documented: clogs, decreased sudsing, and unsightly residues. But can centralized softening cost-effectively solve the problems? Here's an example that says, yes.

By Michael A. Burris, P.E.

Many communities are blessed with high quality groundwater supplies, free of the microbial and organic contaminants present in our surface water supplies. However, these same communities often struggle with a different problem—elevated levels of iron (1 to 3 mg/L), manganese (0.5 to 1.0 mg/L), and calcium and magnesium hardness (300 to 500 mg/L), which cause the water to be hard.

Many groundwater treatment facilities have been designed and are operated to surgically remove just the relatively small concentrations of iron and manganese. While this prevents the aesthetic issues caused by these contaminants, the quality of the remaining water with its high hardness levels presents other costly challenges for customers. Table 1 presents the generally recognized hardness classifications for various levels of calcium and magnesium in water.

Hard water is not a health hazard. In fact, the National Research Council (National Academy of Sciences) states that drinking hard water generally contributes toward the human dietary needs of calcium and magnesium. Hard water does, however, create many aesthetic problems and increases costs for affected customers, including residential, commercial, and industrial users. These are generally characterized as follows:

Clogged appliances and pipes. Hard water deposits can form in appliances, such as coffee makers, and can build up in pipes and plumbing equipment. This buildup can reduce water flow, as well as increase the frequency of repairs.

Increased water heating costs. When hard water is heated, the minerals in it precipitate and form scale. Besides building up in tea kettles and coffee makers, mineral deposits can form an insulation barrier inside water heaters, resulting in more money spent to heat the same amount of water.

Decreased sudsing of soaps and detergents. The calcium and magnesium in hard water act on many soaps and detergents to reduce their sudsing and cleaning abilities. The soapy residue they form is abrasive and can reduce the life of garments by clinging to and weakening clothing fibers.

Increased residue on bathtubs and shower tiles. The residue formed by soap and hard water creates an unwanted sticky film on bathtubs and shower tiles.

In response to the problems posed to residential, commercial, and industrial customers associated with a hard water supply, two options are available—either the utility softens the municipal water supply, or it doesn't. When confronted with the concept of centralized softening, the initial reaction of many local officials is that they agree with the concept, but it would be much too expensive for the utility to undertake.

If a utility elects not to provide the service of softening the municipal water supply, customers are left to their own devices to deal with the problems caused by the water's high hardness. It has been estimated that when water from a public utility has been relatively hard over a number of years and the utility does not provide softening treatment, as many as 80 to 90 percent of the residential, commercial, and industrial customers install softeners. For residential customers who choose to treat the water at home, in-home ion exchange softening units are typically utilized to eliminate the aesthetic and nuisance problems of hard water.

Community Benefit

However, centralized single treatment would benefit the entire community by providing improved water quality; and the cost for the operation would be shared proportionately among all customers. While this would represent a major capital improvements project for the utility, likely costing in the millions of dollars, it may not be, from a customer's point of view, "too expensive." Some customers actually may find that they would save money each month by having the utility soften the water supply.

Upon closer examination, the costs of adding softening technology to an existing groundwater iron and manganese removal plant are not as significant as a utility might expect. In many cases, either lime/soda or membrane softening facilities can be incorporated directly into an existing iron and manganese treatment facility. For either technology, the existing filters, clearwells, and high-service pumping facilities can often be maintained, thereby significantly reducing the capital

Table 1. Water Hardness Classifications

Hardness Level as $CaCO_3$		
Grains/gal	mg/L	Hardness Classification
<4.4	<75	Low
4.5 -8.8	76-150	Moderate
8.9-14.7	151-250	Hard
>14.8	>250	Very Hard

cost of the softening upgrades.

The total cost to both the utility and to the customer to achieve a softened water supply can be demonstrated with an actual study performed for a water utility in Ohio. We'll call the community Hardwaterville. It is typical of many communities within Ohio and throughout the Midwest. The community's water source is a wellfield. The groundwater is characterized as having elevated iron and manganese levels along with hardness of 360 to 380 mg/L (as $CaCO_3$). Hardwaterville's treatment plant consists of conventional facilities for the oxidation and removal of iron and manganese, including aeration, chemical pretreatment, and rapid sand filtration. Typical plant flows range from 2.5 to 3.0 mgd.

An analysis was performed to determine the facilities required and costs incurred to add softening facilities to the Hardwaterville treatment plant. For this situation, since the existing plant was in good condition, the decision was made to investigate the addition of a membrane filtration system to supplement the existing treatment facility. The membrane system would consist of nanofiltration membranes with the capability of removing essentially all the dissolved solids from a portion of the total plant flow. The resulting near zero hardness water would be blended with product water from the existing plant in a controlled ratio to achieve a finished water hardness of about 120 mg/L (as $CaCO_3$). The membrane system would operate in series with the existing plant, i.e., a portion of the existing plant's treated and filtered water flow would serve as the feedwater for the membrane process.

It was estimated that a membrane filtration system with a capacity of 2.0 mgd would be capable of handling Hardwaterville's current and projected near-term demands. The estimated costs for Hardwaterville to construct and operate this membrane filtration system and to provide its customers with a "high quality" softened water supply are shown in Table 2.

Hardwaterville's current water distribution system services about 6,400 customer connections, including residential, commercial, and industrial accounts. Therefore, based just upon these accounts, without regard to the type of account, the estimated annual cost per customer to finance the projected $445,000 per year for the construction and operation of the plant's water softening facilities would be about $75,000 per year, or $5.80 per month.

Table 2. Estimate of Probable Costs

Capital Cost Item:	
Membrane softening facility (2.0 mgd capacity) complete with building, pumps, controls, etc. $3.5 million	
Debt service (i=6 percent; n=15 years)	$360,000/year
Operating Cost Items:	
Electrical power:	$35,000/year
Membrane replacement & chemical pretreatment:	$50,000/year
Total annual membrane softening estimated cost:	$445,000/year

Bad News,Good News

So that's the "bad news." Hardwaterville will have to implement a rate increase, and the council chambers will be filled with irate customers demanding answers. Well, there are answers for the irate customers, and the answers will reveal and explain the "good news" for all of Hardwaterville's customers.

First, consider those residential customers who have elected to install an ion exchange softening system in their home. As previously stated, surveys have found that a majority of the customers who receive hard water from their utility install a softening system in their home. Therefore, from the customers' point of view, the costs to purchase, install, and operate a home softening system must be considered a part of their total water bill. If the utility elects to undertake the task of softening, the customers' costs for their home softening systems are eliminated.

We've already seen that Hardwaterville's customers will be subjected to an increase of about $5.80 per month if the utility undertakes softening. The savings for residences with ion exchange softening systems would include the cost to purchase and install their systems and the ongoing cost for salt. The cost to purchase and install a residential ion exchange softening system may range from $1,000 to $1,500. Assuming an average cost of about $1,250 and an estimated life of ten years, the approximate annual straight-line cost to the customer is $125 per year for either pay-off or replacement of the home softening system.

Based upon conversation with customers, the average salt consumption for Hardwaterville's residences was estimated to be one 80-lb bag per month. The cost for home softener salt is about $10 per 80-lb bag; therefore, the customer's operating (salt) cost is about $10 per month, or $120 per year.

When all the costs are considered, residential customers' total water costs would be much less if the utility assumes responsibility for softening. As stated above, the bad news for Hardwaterville was an increase in the customer's water bill of $5.80 per month ($70 per year) if the utility undertakes the service of softening the municipal supply; but the good news is that customers save $20.40 per month ($245 per year) by not having to soften the water themselves. The savings from just the purchase of salt alone is almost twice the estimated increase in the customer's water bill. Commercial and industrial customers would also realize significant savings through the elimination—or reduction—of treatment costs for boiler feed water and other process water uses.

For those customers without home softeners, the economic advantages of receiving a softened municipal water supply are more difficult to quantify. However, in addition to the improved aesthetic qualities, savings can be expected in the form of fewer plumbing equipment and fixture repairs, decreased replacements of hot water tanks, decreased consumption of soaps and detergents, and lower energy costs. GE

Mr. Burris is an associate with Malcolm Pirnie, Inc., Columbus, OH.