Most of the United States’ drinking water infrastructure is nearing the end of its useful life and will require a staggering public investment during the next 20 years. Water main replacement will cost more than $1 trillion by 2035. In Minnesota the estimated cost is $5.46 billion.

Demand for water throughout the country has been decreasing, including in several Minnesota cities, which has resulted in a decrease in revenue. Rate increases or public subsidies will be needed.

To win public support for needed additional revenue, several utilities have developed strategies that include• completing a rate study by an outside consultant,
• establishing a citizen committee,
• developing a public outreach program, and
• providing updates every six months to elected officials.

City of Brooklyn Park, Minn. (population 75,900), has developed a strategy to fund infrastructure projects that has resulted in expenditures of $25 million on water supply projects in the past decade.

Typically water supply infrastructure consists of facilities and equipment to pump, divert, store, treat, and distribute safe drinking water. The drinking water infrastructure in the United States includes more than 1 million miles of pipe, which is more than four times longer than the national highway system. In addition to pipes, the infrastructure includes groundwater wells, surface-water intakes, dams, reservoirs, storage tanks, drinking water facilities (e.g., treatment plants and pumping stations), and aqueducts. The average useful life of several water infrastructure components is shown in Table 1.
DAWN OF THE REPLACEMENT ERA

From the following information, it can be concluded that the nation’s public water systems face potentially staggering public investment needs during the next 20 years:

- A large part of the US public water system dates back to the years shortly after World War II; therefore, a significant amount of buried infrastructure is at or very near the end of its useful life.
- Most distribution pipes installed in the United States from the 1800s through the 1960s were manufactured from cast iron. Because of changing materials and manufacturing techniques, pipes manufactured in the 1920s have an average life expectancy of about 100 years, whereas pipes manufactured in the post-World War II boom have an average life of about 75 years. However, this does not account for age of pipe and installation procedure, which affect the life of the pipe. Using these average life estimates and counting the years since the original installations, it appears that public water systems will be facing the need for significant pipe replacement over the next few decades.
- In many instances the population of an area has significantly increased and/or shifted geographically since the original distribution system was installed. Table 2 shows the water use for the years 1950 (when many of the current pipes were installed) and 2000. The shifting population brought significant growth to some areas of the country, which required a larger pipe network to provide water service.
- Public water systems may need to replace infrastructure and upgrade treatment plants to comply with a number of new regulations to be implemented under the Safe Drinking Water Act. Many municipalities may also need to make significant investments to upgrade or expand wastewater infrastructure or to meet regulatory mandates.
- A big cost looms to address compliance with combined sewer overflow and stormwater regulations.

The nation’s public water systems are stressed; the American Society of Civil Engineers (ASCE) gave the US water infrastructure a grade of D-minus in its 2009 Report Card for America’s Infrastructure (ASCE, 2009). Ten years ago, the US Environmental Protection Agency (USEPA) estimated that by 2020 the infrastructure would be rated as poor, very poor, or “life elapsed” (Figure 1) because of the age and deteriorating condition of nearly half of the water and sewer pipes in the United States (USEPA, 2002).

### TABLE 1  Design life of drinking water systems

<table>
<thead>
<tr>
<th>Components</th>
<th>Design Life—years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoirs and dams</td>
<td>50-80</td>
</tr>
<tr>
<td>Treatment plants—concrete structure</td>
<td>60-70</td>
</tr>
<tr>
<td>Treatment plants—mechanical and electrical</td>
<td>15-25</td>
</tr>
<tr>
<td>Trunk mains</td>
<td>65-95</td>
</tr>
<tr>
<td>Pumping stations—concrete structures</td>
<td>60-70</td>
</tr>
<tr>
<td>Pumping stations—mechanical and electrical</td>
<td>25</td>
</tr>
<tr>
<td>Distribution</td>
<td>60-95</td>
</tr>
</tbody>
</table>


### TABLE 2  US water use 1950 and 2000

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1950</th>
<th>2000</th>
<th>Change—%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population—millions</td>
<td>93.4</td>
<td>242.0</td>
<td>159</td>
</tr>
<tr>
<td>Usage—bgd</td>
<td>14</td>
<td>43</td>
<td>207</td>
</tr>
<tr>
<td>Per capita use—gpcd</td>
<td>149</td>
<td>179</td>
<td>20</td>
</tr>
</tbody>
</table>


### FIGURE 1  Projected percentage of pipe by classification, 2020

Source: USEPA, 2002
The strength and integrity of the United States’ water infrastructure is critical to its long-term health. Although the financial cost of upgrading or replacing the infrastructure is daunting, the cost of ignoring it could be catastrophic. Because of the poor condition of aging and leaky pipes, the US Geological Survey (USGS) estimated that nationally there is a daily loss of more than 6 bil gal of expensive, treated water, which is about 14% of the nation’s daily water use. It is reported that in the last 19 years in the Midwest the annual number of main breaks for large utilities has increased from 250 per year to 2,200 per year (Symmonds, 2012). In 2003, the city of Baltimore, Md. (population 619,500), reported 1,190 water main breaks—an average of more than three per day. Duluth, Minn. (population 86,300), reported 140 water main breaks per year in a 425-mile network. Hibbing, Minn. (population 16,350), reported 60–70 breaks per year in 140 miles of water mains. St. Paul, Minn. (population 285,068), has had an average of 140 breaks per year for the last 10 years in 1,200 miles of water mains.

Although utilities spend billions on infrastructure each year, public water systems face an annual shortfall of at least $11 billion in funding needed to replace aging facilities that are near the end of their useful life and to comply with existing and future federal water regulations. The shortfall does not account for any growth in the demand for drinking water during the next 20 years (ASCE, 2009). Table 3 shows data from AWWA’s Buried No Longer report regarding the investment needs in water mains from 2011 to 2035 and from 2011 to 2050 for various regions in the United States (WUC, 2012). As indicated in ASCE’s 2009 infrastructure report card for Minnesota, the drinking water infrastructure will require an investment of $5.46 billion during the next 20 years (ASCE, 2009).

Utilities in the United States are spending less money on infrastructure improvements for a variety of reasons. Utilities spend a combined total of approximately 2.4% of gross domestic product on transport and water infrastructure compared with 5% in Europe and 9% in China (Conley, 2012). These rates may be different because European infrastructure is much older than that of the United States, and China is constructing new infrastructure to meet the demands of a more affluent society. As documented in AWWA’s report (2012), restoring existing water systems as they reach the end of their useful lives and extending them to serve a growing population will cost at least $1 trillion during the next 25 years if the United States is to maintain its current level of water service. Delaying the investment may result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs.

### DECREASING DEMAND

Many water utilities across North America are experiencing declining water sales. Figure 2 shows the estimated use of water in the United States for the years 1950 through 2005.

A thorough investigation was conducted to determine the cause of declining use. The results indicated that the declining demand was mostly by residential customers and was because of the decline in the number of individuals per household and the increased use of low-flow appliances. Although there has been a clear trend of declining residential customer water use during the past

### TABLE 3  Aggregate needs for investment in water mains by region through 2035 and 2050

<table>
<thead>
<tr>
<th>Region</th>
<th>2011–2035 Totals—$ millions</th>
<th>2011–2050 Totals—$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replacement</td>
<td>Growth</td>
</tr>
<tr>
<td>Northeast</td>
<td>92,218</td>
<td>16,525</td>
</tr>
<tr>
<td>Midwest</td>
<td>146,997</td>
<td>25,222</td>
</tr>
<tr>
<td>South</td>
<td>204,357</td>
<td>302,782</td>
</tr>
<tr>
<td>West</td>
<td>82,866</td>
<td>153,756</td>
</tr>
<tr>
<td>Total</td>
<td>526,438</td>
<td>498,285</td>
</tr>
</tbody>
</table>

Source: WUC, 2012

Amounts given in 2010 dollars.
25 years, this trend may begin to flatten in the next 20 years. Both of these trends have theoretical limits on how low they can go (Rockaway et al, 2011). However, the demand is not likely to increase in the future, and this needs to be considered.

As public water systems are facing a growing financial obligation because of the need to replace or repair an aging infrastructure, there is a corresponding decrease in water demand. In Minnesota, this is partly the result of increased emphasis by the Minnesota Department of Natural Resources on conservation efforts to reduce the growing water shortage in the southeast part of the state. The economic crisis has decreased new developments, and people are moving either to rented or smaller houses. The result of this trend is reduced per-capita water demand, which results in lower revenues. Figure 3 shows examples of several cities in Minnesota that experienced a decrease in or stable water use during the past decade even though Minnesota is considered a water-rich state, unlike the western and southern parts of the United States. Water utilities are experiencing a similar pattern of water use in almost every region of the country.

**DILEMMA OF THE WATER SUPPLIER**

Public water systems are using more chemicals and employing enhanced treatment methods to meet national standards for drinking water, thus increasing the cost of operating the system. In addition, the current economic conditions are taking a toll. The dilemma for water utilities is that they already have the infrastructure in place, which needs to be maintained and upgraded irrespective of the amount of water sold to their customers. With the decrease in demand and revenue, there is an economic need driving the public water systems to increase water rates. However, rate increases are not popular, and because of the economic condition of the United States and its cities, it is difficult for water suppliers to get support for increasing rates.

Meeting this challenge requires new partnerships among utilities, states, and the federal government. Utilities need to examine their rate structure to ensure long-term viability and efficiency. States may need to streamline their programs to provide loans to utilities. The federal government may need to significantly increase loan assistance for utilities.

Forecasting, scenario building, and planning are more important than ever for understanding demand and improving predictive capacity. In addition to loan assistance from the state and federal governments, there
are various other measures that public water systems can implement to address this issue.

**Comprehensive strategy.** Public water systems and local government should develop a comprehensive local strategy that includes
- assessing the condition of the drinking water system infrastructure;
- strengthening research and development by investigating new material and technologies to determine the most cost-effective time to replace a water main rather than continually repairing it;
- working with members of the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates where necessary; and
- building managerial capacity by having staff members attend AWWA trainings, which will assist in sustainability planning.

**Management.** Better management of water and wastewater utilities can encompass practices such as asset management and environmental management systems. It is helpful to understand the full life-cycle cost of the public water system for financial viability as described in Effective Utility Management (USEPA, 2008). Maintaining an accurate inventory of infrastructure assets and quantifying renewal needs can help a utility justify large capital expenditures to its governing boards and customers, schedule renewal programs over a practical period of time, and decrease costs by improving its bond rating.

**Adequate rates and rate adjustments.** According to a 2002 US Government Accountability Office (USGAO) report, more than one quarter of
FIGURE 4  Brooklyn Park, Minn., water distribution system strategy map—planned improvements

For this maintenance plan, districts match the district street maintenance program for coordination purposes.
municipalities charge water rates that do not cover their costs. These inadequate rates contribute to the gap that exists in many systems between available funds and the costs of needed repairs and replacements. Rate restructuring and setting rates that reflect the full-cost pricing of service can help utilities capture the actual costs of operating water systems, raise revenues, and help conserve water. Stakeholder understanding and support will be essential (USEPA, 2008).

Utilities can develop assistance programs for low-income and disadvantaged groups such as senior citizens. Frequent rate adjustments can be made, forward-looking rates can be implemented, and demand-repres- sion adjustments to programs and prices can be implemented.

Decoupling of sales and profits. Separating sales and profits can be beneficial in that it caps revenues, maintains cash flows, and reduces risk in the face of declining and apparently less-predictable demand.

Expand service. Many public water systems face declining rate bases as customers move from neighborhoods served by the existing system to outlying areas. Public water systems may choose to expand their systems to these new neighborhoods, recapturing the old customers. At this point, however, the public water systems have to pay for building the new system as well as maintaining old ones, even though they may have essentially the same number of customers. It is important that public water systems charge service expansion (water availability) fees to customers or developers in the new neighborhoods to pay for the expansion costs.

Implement a fix-it-first philosophy. As suggested in the 2006 USEPA report, the state should carefully monitor where new development is occurring and should favor repairing and upgrading existing systems over new construction. State loan funds could be used to support new development in existing neighborhoods rather than in new neighborhoods, thereby improving the efficiency of existing systems and reducing the quantity of water needed.

Maintenance. Public water systems often borrow money on the bond market to pay for their capital projects. The interest rate that the utilities must pay is determined by the market’s assessment of its management and particularly a public water system’s management of its physical assets (treatment plants, pipes, and pumps). A fix-it-first policy that stresses maintenance of existing physical assets may contribute to a higher bond rating, lower borrowing costs, and result in a lower overall cost for water delivery.

As discussed previously, public water systems will need to increase

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**FIGURE 5** Brooklyn Park, Minn., public utilities condition—comparison update

<table>
<thead>
<tr>
<th>Year</th>
<th>Water Supply and Treatment</th>
<th>Water Distribution</th>
<th>Sanitary Sewer Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>Adequate: 25%, Marginal: 25%, Problem: 50%</td>
<td>190 Miles</td>
<td>180 Miles</td>
</tr>
<tr>
<td>2011</td>
<td>Adequate: 5%, Marginal: 8%, Problem: 87%</td>
<td>308 Miles</td>
<td>249 Miles</td>
</tr>
</tbody>
</table>

Brooklyn Park’s achievement goals—adequate, 90%; marginal, 8%; problem, 2%
their rates to generate sufficient revenue to perform infrastructure maintenance and to address the revenue shortfall resulting from decreasing demands. Because of the current economic situation, raising rates requires a considerable degree of political will to overcome the challenge of resistance to change. There are various options that utility staff can implement to get council members and citizens on board with planning:

**Communication.** Effectively communicating an infrastructure’s improvement needs is vital to obtain approval for the revenue required. Brooklyn Park, Minn. (population 75,800), has been successful in obtaining funding for more than $25 million of infrastructure improvements in the past 10 years. The utility provides information in an easy-to-understand format to elected officials on a regular basis, such as

- number of water main breaks and how much it costs to repair them;
- age of infrastructure and remaining useful life;
- value of water system, addressing the fact that the total value of the water system is decreasing if depreciation is more than the capital investment and addressing the depletion of the system value over the years; and
- annual condition report;
- annual operational review.

**BROOKLYN PARK, MINN.**

The city of Brooklyn Park utility staff has developed an effective program for disseminating information.

### TABLE 4  Brooklyn Park, Minn., water distribution system staffing needs

<table>
<thead>
<tr>
<th>Task/Group</th>
<th>Number of Tasks</th>
<th>Total Tasks</th>
<th>Hours</th>
<th>Adjusted Hours*</th>
<th>FTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meters</td>
<td></td>
<td>468</td>
<td>3,744</td>
<td>4,500</td>
<td>2.16</td>
</tr>
<tr>
<td>Service orders</td>
<td></td>
<td>184</td>
<td>1,472</td>
<td>1,500</td>
<td>0.72</td>
</tr>
<tr>
<td>Reads</td>
<td></td>
<td>26</td>
<td>208</td>
<td>225</td>
<td>0.11</td>
</tr>
<tr>
<td>Meter/service order group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.99</td>
</tr>
<tr>
<td>Water meter repairs</td>
<td></td>
<td>106</td>
<td>848</td>
<td>1,500</td>
<td>0.72</td>
</tr>
<tr>
<td>Water service work</td>
<td></td>
<td>115</td>
<td>920</td>
<td>2,000</td>
<td>0.96</td>
</tr>
<tr>
<td>Valve work</td>
<td></td>
<td>22</td>
<td>176</td>
<td>200</td>
<td>0.10</td>
</tr>
<tr>
<td>Water repair group</td>
<td></td>
<td>3,700</td>
<td>3,700</td>
<td></td>
<td>1.78</td>
</tr>
<tr>
<td>Hydrant work</td>
<td></td>
<td>239</td>
<td>1,912</td>
<td>2,280</td>
<td>1.10</td>
</tr>
<tr>
<td>Hydrant clearing</td>
<td></td>
<td>60</td>
<td>480</td>
<td>600</td>
<td>0.29</td>
</tr>
<tr>
<td>Hydrant group</td>
<td></td>
<td>2,880</td>
<td>2,880</td>
<td></td>
<td>1.38</td>
</tr>
<tr>
<td>Support to others</td>
<td></td>
<td>499.2</td>
<td>499.2</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Total FTE</td>
<td></td>
<td>6.40</td>
<td></td>
<td></td>
<td>6.40</td>
</tr>
</tbody>
</table>

*FTE—full-time equivalent

*Includes travel time
Because of proper planning and communicating, the city has been able to maintain its infrastructure effectively, resulting in fewer than 20 reported water main breaks annually in a system containing 308 miles of water mains. This is low compared with many other cities discussed previously. Figure 4 is Brooklyn Park’s water distribution strategy map, which shows planned improvements into 2016. This allows for the coordination of water main replacement with road reconstruction, which results in reduced costs. Figures 5 and 6 show the condition comparison over the 20-year period from 1991 to 2011.

Typically the utility management requests more staff to complete additional tasks. Brooklyn Park provides a detailed analysis, as shown in Table 4, to justify the number of required staff.

Brooklyn Park has also developed a comprehensive maintenance district program to clearly show the state of the water infrastructure (Figure 7). The city developed a rating system to highlight the areas of the system as adequate, marginal, or problematic. The same rating system is used for a comprehensive utility maintenance program for the water plant.

MANKATO, MINN.

The key to effective communication is planning in advance and effective delivery. The city of Mankato used a 40-year planning horizon to win approval for a rate increase by showing the replacement costs for the water and wastewater utility based on 4% inflation to all stakeholders including the city council. A recently completed rate study established the fund reserve as an annual bond payment, 50% of operations and maintenance (O&M), and $500,000 for emergency repairs.

Figure 8 shows the revenue generated from three rate scenarios compared with the 40-year capital and O&M needs. This information, showing different levels of service, convinced all the stakeholders, including the city council, of the need for a rate increase for long-term viability of the utilities.

**Rate study.** Conduct a rate study to show the real cost of water. For many reasons it may be beneficial for a utility to hire an outside consultant to complete a rate study, which includes the development of realistic multiyear projections of revenues and expenditures, including infrastructure improvement needs.

According to a study in Florida that analyzed the effects of a number of price blocks on residential blocks, the inclining block rate structure with more than three price blocks seems to create the strongest incentive to conserve water (Rawls et al, 1991 to 2011).
As long as cost and demand continue to shift, more frequent rate adjustments will reduce the lag in rate increases and ensure that rates are properly aligned with costs.

Citizen advisory committee. Customers are usually willing to pay for water system infrastructure improvements when they understand why they are needed. Water supply professionals have typically done an ineffective job of communicating the need. Setting up a rate committee or citizen advisory committee helps communicate the needs to elected officials. A rate committee representing members from industry, city council, citizens, and commercial interests can be formed to provide a base for broad support of a rate adjustment. The members of this committee will become the spokespeople for rate changes and will provide rational justification to elected officials making the hard decision about increasing the rates.

Community involvement. It is important to involve the communities to be served and treat them as partners. Many people are especially reluctant to give money to any organization for which they feel they have no choice or input on how the money will be used. Therefore it’s beneficial to engage stakeholders in decision-making processes by partnering with them to give them confidence that their money is well spent. External stakeholders must be part of the process that is intended to provide a thoughtful public outreach approach.

Ballot measures to obtain funding approval for infrastructure improvements have been successful in several communities. From 2008 to 2011, ballots allocating funds to transit capital or operations had a 73% success rate (Conley, 2012). When need is clearly articulated, the public appears willing to pay for infrastructure improvements.

Public outreach program. There are various public outreach programs that a utility can implement to involve the community in the planning process. Three examples follow:

- setting up conferences, workshops, and retreats to educate and inform people, and solicit community input on specific policy, issues, plans, or projects;
- developing effective media relations strategies; and
- evaluating community-impact assessments by determining the effect of a certain project on the community and its residents’ quality of life.

CONCLUSION

Public water systems potentially face a significant increase in funding for maintenance and upgrading their infrastructure. The age and condition of the US infrastructure has been addressed by USEPA, AWWA, ASCE, USGS, the American Public Works Association, and others.

The need to replace the water supply infrastructure is increasing with
a simultaneous decline in water demand, resulting in lower revenue. To fund improvements, financing is a key component of maintaining a sustainable water system. Most of the improvements discussed in this article will be funded by higher rates. Gaining acceptance from policymakers and stakeholders is an important step in achieving development of an adequate financing plan. Changing demographics and the present economic condition of the country will have an effect on financing options that will be acceptable to stakeholders and policymakers.

USEPA estimates that even with an annual 3% increase above inflation in public water system revenue, public water systems would still need an additional $45 billion annually to replace deteriorated pipes over the next 20 years. To accomplish closing this gap, here is a suggested strategy:

• communicate with stakeholders and policymakers,
• conduct a rate study to determine the real cost of water,
• form and facilitate a citizen advisory committee to address rate-setting issues,
• develop a plan for community involvement and input into the rate-setting process, and
• implement a public outreach program that is ongoing and transparent.

People are typically willing to provide support for a project, including paying more for water services, if they know the project’s importance. Having strong leaders who can effectively communicate the need to upgrade or replace infrastructure is critical in making the case and getting approval for funding.

Acceptance of a financing plan can be accomplished by operating and maintaining the public water system efficiently and effectively and conveying these achievements to the policymakers and stakeholders.

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