Buried No Longer: Confronting the U.S. Water Infrastructure Challenge

Restoring existing water systems as they reach the end of their useful lives and expanding them to serve a growing population will cost at least USD 1 trillion over the next 25 years if the United States is to maintain current levels of water service.

By American Water Works Association (AWWA)

A NEW KIND of challenge is emerging in the United States, one that for many years was largely buried in its national consciousness. Now it can be buried no longer. Much of the nation's drinking water infrastructure, more than 1 million miles of pipes beneath its streets, is nearing the end of its useful life and approaching the age at which it needs to be replaced. Moreover, the country's shifting population brings significant growth to some areas of the country, requiring larger pipe networks to provide water service.

As documented in this report, restoring existing water systems as they reach the end of their useful lives and expanding them to serve a growing population will cost at least USD 1 trillion over the next 25 years if the United States is to maintain current levels of water service. Delaying the investment can result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs. Ultimately the nation will have to face the need to "catch up" with past deferred investments, and the more this is delayed the harder the job will be when the day of reckoning comes.

In the years ahead, all US residents who pay for water service will absorb the cost of this investment, primarily through higher water bills. The amounts will vary depending on community size and geographic region, but in some communities, these infrastructure costs alone could triple the size of a typical family's water bills. Other communities will need to collect significant "impact" or development fees to meet the needs of a growing population. Numerous communities will need to invest for replacement and raise funds to accommodate growth at the same time. Investments that may be required to meet new standards for drinking water quality will add even more to the bill.

Although the challenge to the US water infrastructure has been less visible than other infrastructure concerns, it's no less important. The country's water treatment and delivery systems provide public health protection, fire protection, economic prosperity and the high quality of life its citizens enjoy. Yet most U.S. citizens pay less than USD 3.75 for every 1,000 gallons of safe water delivered to their taps.

This article demonstrates that as a nation, the United States needs to bring the conversation about water infrastructure above ground. Deferring needed investments today will only result in greater expenses tomorrow and pass on a greater burden to future generations.

The Era of Infrastructure Replacement

More than a decade ago the American Water Works Association (AWWA) announced that a new era was dawning: the replacement era, in which the United States would need to begin rebuilding the water and wastewater systems bequeathed to its citizens by earlier generations. AWWA's seminal report - Dawn of the Replacement Era - demonstrated that significant investments will be required in coming decades if the United States is to maintain the water and wastewater systems that are so essential to its citizens' way of life.

The Dawn report examined 20 water systems, using a relatively new technique to build what came to be called a "Nessie Curve" for each system. The Nessie Curve, so called because the graph follows an outline that someone likened to a silhouette of the Loch Ness Monster, revealed that each of the 20 water systems faced unprecedented needs to rebuild its underground water infrastructure - its pipe network. For each system, the future investment was an "echo" of the demographic history of the community, reflecting succeeding generations of pipe that were laid down as the community grew over many years. Most of those generations of pipe were shown to be coming to an end of their useful service lives in a relatively compressed period. Like the pipes themselves, the need for this massive investment was mostly buried and out of sight. But it threatens the country's future if the nation's citizens don't elevate it and begin to take action now.

> Much of the drinking water infrastructure in the USA, more than 1 million miles of pipes beneath its streets, is nearing the end of its useful life and approaching the age at which it needs to be replaced. Moreover, the country's shifting population brings significant growth to some areas of the country, requiring larger pipe networks to provide water service.

The present report (on which this article is based) was undertaken to extend the Dawn report beyond those 20 original cities and encompass the entire United States. The results are startling. They confirm what every water utility professional knows: the country faces the need for massive reinvestment in its water infrastructure over the coming decades. The pipe networks that were largely built and paid for by earlier generations - and passed down to current residents as an inheritance - last a long time, but they are not immortal. The nation's drinking water infrastructure - especially the underground pipes that deliver safe water to U.S. homes and businesses - is aging and in need of significant reinvestment. Like many of the roads, bridges, and other public assets on which the country relies, most of its buried drinking water infrastructure was built 50 or more years ago, in the post-World War II era of rapid demographic change and economic growth. In some older urban areas, many water mains have been in the ground for a century or longer.

Given its age, it comes as no surprise that a large proportion of US water infrastructure is approaching, or has already reached, the end of its useful life. The need to rebuild these pipe networks must come on top of other water investment needs, such

as the need to replace water treatment plants and storage tanks, and investments needed to comply with standards for drinking water quality. They also come on top of wastewater and stormwater investment needs which, judging from the most recent "gap analysis" from the US Environmental Protection Agency (USEPA), are likely to be as large as drinking water needs over the coming decades. Moreover, both water and wastewater infrastructure needs come on top of the other vital community infrastructures, such as streets, schools, etc.

Prudent planning for infrastructure renewal requires credible, analysis-based estimates of where, when, and how much pipe replacement or expansion for growth is required. This article summarizes the conclusions of a comprehensive and robust national-level analysis of the cost, timing, and location of the investments necessary to renew water mains over the coming decades. It also examines the additional pipe investments that can be anticipated can anticipate to meet projected population growth, regional population shifts, and service area growth through 2050.

This analysis is based on the insight that there will be "demographic echoes" in which waves of reinvestment are driven by a combination of the original patterns of pipe investment, the pipe materials used, and local operating environments. The report examined the reinvestment demands implied by these factors, along with population trends, to estimate needs for pipe replacement and concurrent investment demands to accommodate population growth.

Although this report does not substitute for a careful and detailed analysis at the utility level as a means of informing local decisions, it constitutes the most thorough and comprehensive analysis ever undertaken of the nation's drinking water infrastructure renewal needs. The keys to the analysis include the following:

- Understanding the original timing of water system development in the United States.
- Understanding the various materials from which pipes were made, and where and when the pipes of each material were likely to have been installed in various sizes.
- Understanding the life expectancy of the various types and sizes of pipe ("pipe cohorts") in actual operating environments.
- Understanding the replacement costs for each type and size of pipe.
- Developing a probability distribution for the "wear-out" of each pipe cohort.

Key Findings

The Needs are Large

Investment needs for buried drinking water infrastructure total more than USD 1 trillion nationwide over the next 25 years, assuming pipes are replaced at the end of their service lives and systems are expanded to serve growing populations. Delaying this investment could mean either increasing rates of pipe breakage and deteriorating water service or suboptimal use of utility funds, such as paying more to repair broken pipes than the long-term cost of replacing them. Nationally, the need is close to evenly divided between replacement due to wear-out and needs generated by demographic changes (growth and migration).

Household Water Bills will Go Up

Important caveats are necessary here because there are many ways that the increased investment in water infrastructure can be allocated among customers. Variables include rate structures, how the investment is financed, and other important local factors. But the level of investment required to replace worn-out pipes and maintain current levels of water service in the most affected communities could in some cases triple household water bills. This projection assumes the costs are spread evenly across the population in a "pay-as-you-go" approach (See "The Costs Keep Coming" below). With respect to the cost of growth, other caveats are important. Many communities expect growth to pay or help pay for itself through developer fees, impact fees, or similar charges. In such communities, established residents will not be required to shoulder the cost of population growth to the extent that these fees recover those costs. But regardless of how the costs of replacement and growth are allocated among builders, newcomers, or established residents, the total cost that must be borne by the community will still rise.

There are Important Regional Differences

The growing national need affects different regions in different ways. In general, the South and the West will face the steepest investment challenges, with total needs accounting for considerably more than half the national total. This is largely attributable to the fact that the population of these regions is growing rapidly. In contrast, in the Northeast and Midwest, growth is a relatively small component of the projected need. However, the population shifts away from these regions complicate the infrastructure challenge, as there are fewer remaining local customers across whom to spread the cost of renewing their infrastructure.

This regional perspective reveals the inherent difficulty of managing infrastructure supply and demand. Although water pipes are fixed in place and long-lasting, the population that drives the demand for these assets is very mobile and dynamic. People move out of one community, leaving behind a pipe network of fixed size but with fewer customers to support it. They move into a new community, requiring that the water system there be expanded to serve the new customers.

There are Important Differences Based on System Size

As with many other costs, small communities may find a steeper challenge ahead on water infrastructure. Small communities have fewer people, and those people are often more spread out, requiring more pipe "miles per customer" than larger systems. In the most affected small communities, the study suggests that a typical three-person household could see its drinking water bill increase by as much as USD 550 per year above current levels, simply to address infrastructure needs, depending as always on the caveats identified above. In the largest water systems, costs can be spread over a large population base. Needed investments would be consistent with annual per household cost increases ranging from roughly USD 75 to more than USD 100 per year by the mid-2030s, assuming the expenses were spread across the population in the year they were incurred.

The Costs Keep Coming

The national investment the United States faces will roughly double from about USD 13 billion a year in 2010 to almost USD 30 billion annually by the 2040s for replacement alone. If growth is included, needed investment must increase from a little over USD 30 billion today to nearly USD 50 billion over the same period. This level of investment must then be sustained for many years if current levels of water service are to be maintained. Many utilities will have to face these investment needs year after year, for at least several decades. That is, by the time the last cohort of pipes analyzed in this study (predominantly the pipes laid between the late 1800s and 1960) has been replaced in, for example, 2050, it may soon thereafter be time to begin replacing the pipes laid after 1960, and so on. In that respect, these capital outlays are unlike those required to build a new treatment plant or storage tank, where the capital costs are incurred up front and aren't faced again for many years. Rather, infrastructure renewal investments are likely to be incurred each year over several decades. For that reason, many utilities may choose to finance infrastructure replacement on a "pay-as-you-go" basis rather than through debt financing.

Postponing Investment Only Makes the Problem Worse

Overlooking or postponing infrastructure renewal investments in the near term will only add to the scale of the challenge the country faces in the years to come. Postponing the investment steepens the slope of the investment curve that must ultimately be met. It also increases the odds of facing the high costs associated with water main breaks and other infrastructure failures. The good news is that not all of the USD 1 trillion investment through 2035 must be made right now. There is time to make suitable plans and implement policies that will help address the longer-term challenge. The bad news is that the required investment level is growing, as more pipes continue to age and reach the end of their effective service lives.

As large as the cost of reinvestment may be, not undertaking it will be worse in the long run by almost any standard. Aging water mains are subject to more frequent breaks and other failures that can threaten public health and safety (such as compromising tap water quality and fire-fighting flows). Buried infrastructure failures also may impose significant damages (for example, through flooding and sinkholes), are costly to repair, disrupt businesses and residential communities, and waste precious water resources. These maladies weaken our economy and undermine our quality of life.

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This suggests that a crucial responsibility for utility managers now and in the future is to develop the processes necessary to continually improve their understanding of the "replacement dynamics" of their own water systems.

Those dynamics should be reflected in an Asset Management Plan (AMP) and, of course, in a long-term capital investment plan. The 2006 AWWA Report Water Infrastructure at a Turning Point includes a full discussion of this issue.

Conclusion

Because pipe assets last a long time, water systems that were built in the latter part of the 19th century and throughout much of the 20th century have, for the most part, never experienced the need for pipe replacement on a large scale. The dawn of the era in which these assets will need to be replaced puts a growing financial stress on communities that will continually increase for decades to come. It adds large and hitherto unknown expenses to the more apparent above-ground spending required to meet regulatory standards and address other pressing needs.

It is important to reemphasize that there are significant differences in the timing and magnitude of the challenges facing different regions of the country and different sizes of water systems. But the investments we describe in this report are real, they are large, and they are coming.

The United States is reaching a crossroads and faces a difficult choice. The nation can incur the haphazard and growing costs of living with aging and failing drinking water infrastructure. Or, the United States can carefully prioritize and undertake drinking water infrastructure renewal investments to ensure its water utilities can continue to reliably and cost-effectively support the public health, safety, and economic vitality of U.S. communities. AWWA undertook this report to provide the best, most accurate information available about the scale and timing of these needed investments.

It is clear the era AWWA predicted a decade ago - the replacement era - has arrived. The issue of aging water infrastructure, which was buried for years, can be buried no longer. Ultimately, the cost of the renewal we face must come from local utility customers, through higher water rates.

However, the magnitude of the cost and the associated affordability and other adverse impacts on communities - as well as the varying degrees of impact to be felt across regions and across urban and rural areas - suggest that there is a key role for states and the federal government as well. In particular, states and the federal government can help with a careful and cost-effective program that lowers the cost of necessary investments to our communities, such as the creation of a credit support program - for example, AWWA's proposed Water Infrastructure Finance and Innovation Authority (WIFIA).

Finally, in many cases, difficult choices may need to be made between competing needs if water bills are to be kept affordable.

Water utilities are willing to ask their customers to invest more, but it's important this investment be in things that bring the greatest actual benefit to the community. Only in that spirit can we achieve the goal to which we all aspire, the reliable provision of safe and affordable water to all Americans.

This article is an adapted excerpt from AWWA's original Buried No Longer report, which can be downloaded in its entirety at www.awwa.org/buriednolongerreport. AWWA offers valued resources to water professionals around the world.