KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

56. Provide copies of the AWWA studies and documents cited and relied upon by Mr. O'Neill in his Direct Testimony.

Response:

Please see attached for the following studies and documents:

Footnote 2: AWWA, 2001. *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure*. AWWA, Denver.

Footnote 3: AWWA, 2012. *Buried No Longer: Confronting America's Water Infrastructure Challenge*. AWWA, Denver.

Footnote 5: American Society of Civil Engineers, *"Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future"* (2016),

Footnote 6: *Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness, Section 2.4 Water Utilities*, p.69-73 (Sep. 16, 2015)

Footnote 7: Clean Water Council, "*Sudden Impact: An Assessment of Short Term Economic Impacts of Water and Wastewater Construction Projects in the United States,*" 2008.

Footnote 9: U.S. Conference of Mayors, "*Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Value to the National Economy*", issued August 14, 2008.

Footnote 10: US EPA 2011 Drinking Water Infrastructure Needs Survey and Assessment Fifth Report to Congress

Footnote 11: U.S. Department of Education, National Center for Education Statistics.

Footnote 12: EPA - National Primary Drinking Water Regulations

Footnote 14: Climate Change Impacts in the United States, ch. 17 – Southeast and the Caribbean (Partial Document that includes Cover Page, Executive Summary and Chapter 17)

Footnote 2 Document

AWWA, 2001. *Dawn of the Replacement Era: Reinvesting in Drinking Water Infrastructure*. AWWA, Denver.

Dawn of the Replacement Era

Reinvesting in Drinking Water Infrastructure

An Analysis of Twenty Utilities' Needs for Repair and Replacement of Drinking Water Infrastructure

American Water Works Association
Dedicated to Safe Drinking Water

A Study Sponsored by The AWWA Water Industry Technical Action Fund

May 2001

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Dawn of the Replacement Era

EXECUTIVE SUMMARY

The importance of safe drinking water to public health and the nation's economic welfare is undisputed. However, as we enter the 21st Century, water utilities face significant economic challenges. For the first time, in many of these utilities a significant amount of buried infrastructure—the underground pipes that make safe water available at the turn of a tap—is at or very near the end of its expected life span. The pipes laid down at different times in our history have different life expectancies, and thousands of miles of pipes that were buried over 100 or more years ago will need to be replaced in the next 30 years. Most utilities have not faced the need to replace huge amounts of this infrastructure because it was too young. Today a new age has arrived. We stand at the dawn of the replacement era.

Extrapolating from our analysis of 20 utilities, we project that expenditures on the order of $250 billion over 30 years might be required nationwide for the replacement of worn-out drinking water pipes and associated structures (valves, fittings, etc). This figure does not include wastewater infrastructure or the cost of new drinking water standards. Moreover, the requirement hits different utilities at different times and many utilities will need to accelerate their investment. Some will see rapidly escalating infrastructure expenditure needs in the next 10–20 years. Others will find their investment decisions subject to a variety of factors that cause replacement to occur sooner or at greater expense, such as urban redevelopment, modernization, coordination with other city construction, increasing pipe size, and other factors.

Overall, the findings confirm that replacement needs are large and on the way. There will be a growing conflict between the need to replace worn-out infrastructure and the need to invest in compliance with new regulatory standards under the Safe Drinking Water Act. In addition, the concurrent demands for investment in wastewater infrastructure and compliance with new Clean Water Act regulations, including huge needs for meeting combined sewer overflow (CSO) and stormwater requirements, will compete for revenue on the same household bill.

Ultimately, the rate-paying public will have to finance the replacement of the nation's drinking water infrastructure either through rates or taxes. AWWA expects local funds to cover the great majority of the nation's water infrastructure needs and remains committed to the principle of full-cost recovery through rates. However, many utilities may face needs that are large and unevenly distributed over time. They must manage a difficult transition between today's level of investment and the higher level of investment that is required over the long term. Facing an inexorable rise in infrastructure replacement needs driven by demographic forces that were at work as much as 100 years ago, compounded by the negative effects of changing demographics on per-capita costs in center cities, many utilities face a significant challenge in keeping water affordable for all the people they serve.

Meeting this challenge requires a new partnership in which utilities, states, and the federal government all have important roles. Utilities need to examine their rate structures to assure long-term viability. States need to streamline their programs. And the federal government needs to significantly increase assistance for utilities.

To better understand this problem, the American Water Works Association undertook studies of 20 large and medium utilities. The findings and recommendations of this report provide the basis for this new partnership to achieve the goal to which we all aspire—the provision of safe and affordable drinking water for all Americans.

Findings:

- Water utilities must make a substantial reinvestment in infrastructure over the next 30 years. The oldest cast iron pipes, dating to the late 1800s, have an average life expectancy of about 120 years. Because of changing materials and manufacturing techniques, pipes laid in the 1920s have an average life expectancy of about 100 years, and pipes laid in the post-World War II boom can be expected to last about 75 years. The replacement bill for these pipes will be hard on us for the next three decades and beyond.

- Most utilities are just now beginning to face significant investments for infrastructure replacement. Indeed, it would have been economically inefficient to make large replacement investments before now. The utilities we studied are well managed and have made the right decisions. But the bills are now coming due, and they loom large.

- On average, the replacement cost value of water mains is about $6,300 per household in today's dollars in the relatively large utilities studied. If water treatment plants, pumps, etc., are included, the replacement cost value rises to just under $10,000 per household, on average.

- Demographic shifts are a significant factor in the economics of reinvestment. In some older cities, the per-capita replacement value of mains is more than three times higher than the average in this sample due to population declines since 1950.

- By 2030, the average utility in the sample will have to spend about three and a half times as much on pipe replacement due to wear-out as it spends today. Even so, the average utility will also spend three times as much on repairs in that year as it spends today, as the pipes get older and more prone to breakage.

- The water utilities studied concurrently face the 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 also face significant needs for investments in wastewater infrastructure and compliance. This concurrent demand significantly increases the financial challenge they face.

- Overall, in the 20 utilities studied, infrastructure repair and replacement requires additional revenue totaling about $6 billion above current spending over the next 30 years. This ranges from about $550 per household to almost $2,300 per household over the period. These household impact figures do not include compliance with new regulations or the cost of infrastructure replacement and compliance for wastewater.

- The pattern and timing of the need for additional capital will be different in each community, depending on its demographically driven replacement "wave."
- Household impacts will be two to three times greater in smaller water systems ($1,100 to $6,900 per household over 30 years) due to disadvantages of small scale and the tendency for replacement needs to be less spread out over time.
- Because of demographic changes, rate increases will fall disproportionately on the poor, intensifying the challenge that many utilities face keeping water affordable to their customers.

Recommendations:

America needs a new partnership for reinvesting in drinking water infrastructure. There are important roles at all levels of government.

1) Measures by Utilities and Local Governments

Although the AWWA analysis has looked at the infrastructure issue in the aggregate, many key issues must be addressed at the local utility level. Utilities should develop a comprehensive local strategy that includes:

- Assessing the condition of the drinking water system infrastructure.
- Strengthening research and development
- Working with the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates where necessary.
- Building managerial capacity.

2) Reform of State Programs

The states too have an important role to play in addressing our infrastructure funding needs. States may need to match an appropriate share of any new federal funds that are provided for infrastructure assistance. Moreover, states need to reform their existing programs to make them more effective. States should commit to:

- Respecting the universal eligibility of all water systems for federal assistance.
- Streamlining their programs for delivery of assistance and allow alternative procurement procedures that save money.
- Making their financing mechanisms more attractive by committing to grants and very low or negative interest loans.
- Using federal funds in a timely fashion or face the reprogramming of those funds to other states.

3) A Significant Increase in Federal Assistance

The federal government has a critical role to play in preventing the development of a gap in water infrastructure financing. AWWA recommends either changing and expanding the existing Drinking Water State Revolving Fund and other drinking water programs, or creating a new, infrastructure-focused fund. The federal role should include:

- Significantly increased federal funding for projects to repair, replace, or rehabilitate drinking water infrastructure.
- An increase in federally supported research on infrastructure management, repair and replacement technologies.
- Steps to increase the availability and use of private capital.

Reinvesting in Drinking Water Infrastructure

Dawn of the Replacement Era

Introduction

The importance of safe drinking water to the nation's public health and economic welfare is undisputed. About 54,000 community drinking water systems provide drinking water to more than 250 million Americans. By keeping water supplies free of contaminants that cause disease, our public water systems reduce sickness and related health costs as well as absenteeism in the workforce. By providing safe and sufficient supplies of water, America's public water systems create direct economic value across nearly every sector of the economy and every region of the country. However, significant economic changes are confronting the water profession as we enter the 21st Century. The new century poses new challenges in sustaining the infrastructure—particularly the underground pipes—that provides the broad public benefits of clean and safe water.

Recognizing that we are at the dawn of a major change in the economics of water supply, the American Water Works Association (AWWA) has undertaken an analysis of the infrastructure challenge facing utilities. The project involved correlating the estimated life of pipes with actual operations experience in a sample of 20 utility systems geographically distributed throughout the nation (see Figure 1). Projecting future investment needs for pipe replacement in those utilities yields a forecast of the annual replacement needs for a particular utility, based on the age of the pipes and how long they are expected to last in that utility. This analysis graphically portrays the nature of the challenge ahead of us. It also serves as the foundation for AWWA's call for a new national partnership to address the looming need to reinvest in our drinking water infrastructure.

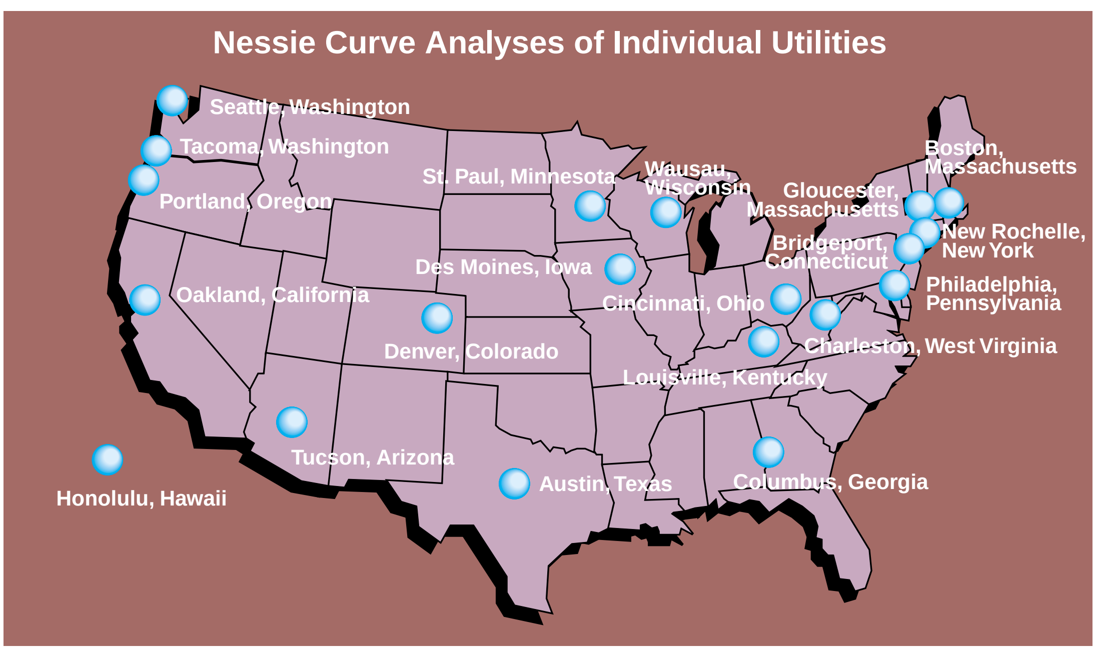


Figure 1

FINDINGS

Pipes are expensive, but invisible.

Most people do not realize the huge magnitude of the capital investment that has been made to develop the vast network of distribution mains and pipes—the infrastructure—that makes clean and safe water available at the turn of a tap. Water is by far the most capital intensive of all utility services, mostly due to the cost of these pipes, water infrastructure that is literally a buried treasure beneath our streets. But buried means out of sight. And as the old saying goes, out of sight means out of mind. Moreover, most of our pipes were originally installed and paid for by previous generations. They were laid down during the economic booms that characterized the last century's periods of growth and expansion. So not only do we take these pipes for granted because we can't see them, we also take them for granted because, for the most part, we didn't pay for them initially. What's more, they last a long time (some more than a century) before they cost us very much in maintenance expense near the end of their useful lives or ultimately need replacement. For the most part, then, the huge capital expense of the pipes is a cost that today's customers have never had to bear. It has always been there, but it's always been invisible to us.

The original pattern of water main installation from 1870 to 2000 in 20 utilities analyzed by AWWA is graphically presented in Figure 2. This graph reflects the total cost in current dollars of replacing the pipes laid down between 1870 and 1998 in the 20 utilities studied. It is a reflection of the development of these utilities, and in turn, mirrors the overall pattern of population growth in large cities across the country. There was an 1890s boom, a World War I boom, a roaring '20s boom, and the massive post-World War II baby boom.

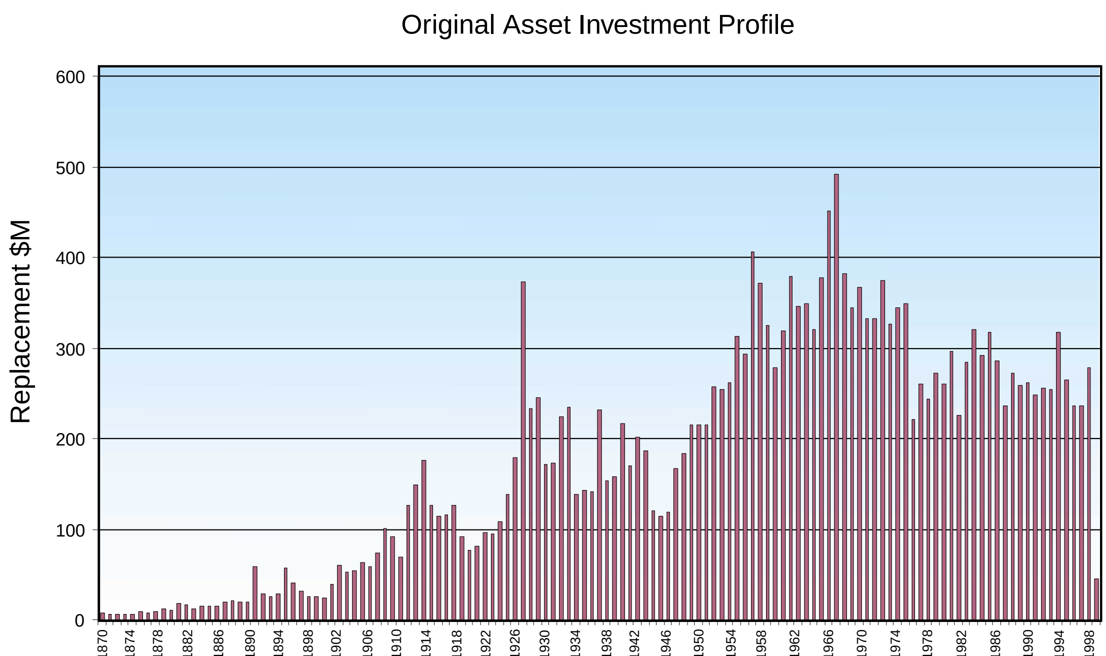


Figure 2

The cumulative replacement cost value of water main assets (that is, the cost of replacing water mains in constant year 2000 dollars) has increased steadily over the last century in our sample of 20 utilities. In aggregate across our sample of utilities, the replacement value of water mains in today's dollars is about $6,300 per household. If water treatment plants, pumps, etc., are included, this figure rises to just under $10,000 per household. This is more than three times what it was in 1930 in constant dollar terms. The difference is not due to inflation; rather, there is simply more than three times as much of this infrastructure today as there was in 1930, in order to support improved service standards and the changing nature of urban development.

In general, then, there is a lot more water infrastructure in place today on a per-capita basis, implying an increased per-capita share of the liability for replacing these assets as they wear out. This invisible replacement liability has been accumulating gradually over several generations of water system customers, managers and governing boards. They have not had to recognize this liability because the bill was not yet due. For many utilities, board/council/commission relationships and customer relationships have developed in recent decades in the absence of a recognized need for significant investment in replacing the utility's assets as they age and wear out.

Pipes are hearty, but ultimately mortal.

The oldest cast iron pipes—dating to the late1800s—have an average useful life of about 120 years. This means that, as a group, these pipes will last anywhere from 90 to 150 years before they need to be replaced, but on average they need to be replaced after they have been in the ground about 120 years. Because manufacturing techniques and materials changed, the roaring '20s vintage of cast-iron pipes has an average life of about 100 years. And because techniques and materials continued to evolve, pipes laid down in the Post-World War II boom have an average life of 75 years, more or less. Using these average life estimates and counting the years since the original installations shows that these water utilities will face significant needs for pipe replacement over the next few decades.

The modern public water supply industry has come into being over the course of the last century. From the period known as the "Great Sanitary Awakening," that eliminated waterborne epidemics of diseases such as cholera and typhoid fever at the turn of the last century, we have built elaborate utility enterprises consisting of vast pipe networks and amazing high-tech treatment systems. Virtually all of this progress has been financed through local revenues. But in all this time, there has seldom been a need to provide for more than modest amounts of pipe replacement, because the pipes last so very long. We have been on an extended honeymoon made possible by the long life of the pipes and the fact that our water systems are relatively young. Now that honeymoon is over. From now on and forevermore, utilities will face significant requirements for pipe repair, rehabilitation, and replacement. Replacement of pipes installed from the late1800s to the 1950s is now hard upon us, and replacement of pipes installed in the latter half of the 20th Century will dominate the remainder of the 21st.

We believe that we stand today at the dawn of a new era—the replacement era—for water utilities. Over the next three decades, utilities will be in an adjustment period during which they will incorporate the costs of pipe replacement in routine utility spending. This will require significant adjustments in utility revenues. The magnitude of the need and the invisibility of that need to the person on (top of) the street will make this a particularly challenging adjustment. The need for significantly greater investment in pipe replacement is all the more difficult to convey because it was never there before. It's hard to explain why it's going to cost more to do the same job in the future than it cost in the past.

Many water systems all across America have seen this day coming and have already begun to ramp up their expenditures on pipe rehabilitation and replacement. But for many utilities this problem is just emerging and is enormous in scope. For them the water supply business will never be the same.

Back to the future: pipe replacement needs are a "demographic echo."

To understand the nature and scope of the emerging infrastructure challenge, AWWA undertook an analysis of 20 utilities throughout the nation. The analysis projects future investment needs for pipe replacement in the 20 utilities and provides a forecast called a "Nessie Curve." The Nessie Curve is a graph of the annual replacement needs in a particular utility, based on when pipes were installed and how long they are expected to last in that utility before it becomes economically efficient to replace them. There are, of course, a number of factors that can require the replacement investment to be made earlier. In many cities, for example, there are urban redevelopment efforts or similar major construction projects that could require up-sizing or other modernization of the pipe network before the pipes reach the end of their useful lives.

Data on repair and replacement needs for each of the 20 cities in our sample is presented in Appendix A. This information is presented for each city as a "Nessie Curve," that is, a projection of the city's economically efficient investment in pipe repair and replacement, based on the city's original pipe installation profile and how long the pipes last in that utility. The aggregate Nessie Curve for all 20 utilities is presented in Figure 3. The rising wave shape suggests why the curve is named after the Loch Ness Monster.

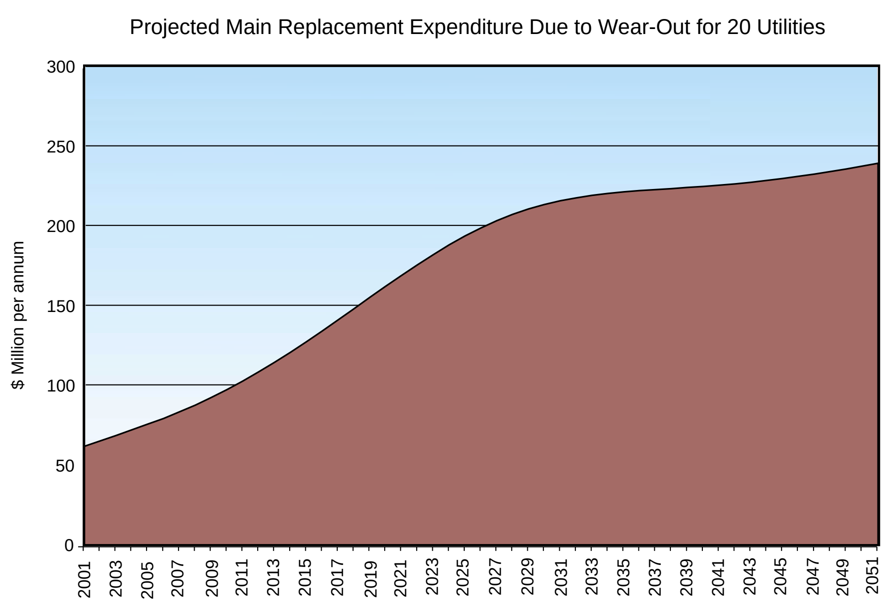


Figure 3

The Nessie Curve reflects an "echo" of the original demographics that shaped a particular utility. It is very similar to the echo of demographics that predicts future liabilities for the Social Security Trust Fund. Indeed, this is exactly the same type of problem that faces Social Security. Historical demographic trends—in our case, pipes laid down as long as a century ago—created a future financial obligation that is now coming due. By modeling the demographic pattern and knowing the life expectancy of the pipes, we can estimate the timing and magnitude of that obligation.

Just as in Social Security, a threat to affordability arises when there were powerful demographic and economic trends at work originally, but the liability arrives at a later time when the demographic and economic conditions have changed. In the water business, the challenge is magnified by pipes that last through several generations of customers before they need to be replaced.

Reflecting the pattern of population growth in large cities over the last 120 years, the Nessie Curves in Appendix A forecast investment needs that will rise steadily like a ramp, extending throughout the 21st Century. The curves show that replacement expenditures will have to rise steadily for the next 30 years. By 2030, the utilities in our sample of 20 will have to spend on average over three-and-a-half times as much per year as they do now (in constant dollars) to replace pipes that have reached the end of their economic lives. Some of the utilities in our sample will encounter the steepest part of the incline in the first 10 years. Others will encounter most of the rise over 20 years, while some will experience a sustained increase over 30 years.

Of course, every city has a different demographic history. In addition, numerous local factors will affect the life of a utility's pipes and therefore its Nessie Curve. Each utility has a unique set of circumstances and therefore a different set of infrastructure funding challenges in the future. Nonetheless, demographics will produce the same type of lagged replacement schedule in any major city.

If that were not enough of a challenge, there is an important corollary. As pipe assets age, they tend to break more frequently. But it is not cost-effective to replace most pipes before, or even after, the first break. Like the old family car, it is cost-efficient for utilities to endure some number of breaks before funding complete replacement of their pipes.

Considering the huge wave of aging pipe infrastructure created in the last century, we can expect to see significant increases in break rates and therefore repair costs over the coming decades. This will occur even when utilities are making efficient levels of investment in replacement that may be several times today's levels. In the utilities studied by AWWA, there will be a three-fold increase in repair costs by the year 2030 despite a concurrent increase of three and a half times in annual investments to replace pipes.

It is important to note that a Nessie Curve is a prediction, not a destiny. That is, a utility can choose to manage its infrastructure replacement needs in various ways. For example, the utility may accept increased break repair costs up to a point and delay the replacement of an old pipe, rehabilitate certain pipes to "buy time," or adopt other asset management techniques to extend the life of the pipes as long as possible. Nevertheless, it appears inevitable that many utilities will face substantial increases in infrastructure investments over the next 30 years, to replace pipes laid down as long as 120 years ago.

A final observation from our sample of 20 Nessie Curves is that the large "demographic wave" of replacement needs is only just now upon us. We are just now at the time when there is a compelling need to significantly increase the levels of replacement spending in most utilities. Importantly, there is no evidence that utilities are "behind the curve" or that America is in ruins. That is not the nature of the challenge. We are not faced with making up for a historical gap in the level of replacement funding. In fact, break rates in our sample of 20 utilities are within a range that is considered representative of best management practices for water utilities, indicating that the utilities have made efficient decisions and managed well up to this point. The challenge is ramping up utility budgets to prevent a "replacement gap" from developing in the near future. Unfortunately, keeping up with replacement needs is about to get a lot harder than ever before, and it's going to stay that way. We are coming face-to-face with a serious challenge that could become a crisis if we ignore it.

Water infrastructure is local and therefore vulnerable to demographic changes.

Water utilities are the last natural monopolies. The large investment required in pipe networks makes it impossible to have more than a single provider of water service within a given area. These large investments are also a major source of financial vulnerability for water utilities as the result of the very fixed nature of the assets and the very mobile nature of the customers. When populations grow, the infrastructure is expanded, but when people move away, the pipe assets and the liability for repair and replacement remain behind, creating a financial burden on the remaining customers.

Figure 4 is a plot of U.S. Census population data for Philadelphia from 1850 to 1996. Over the 100 years from 1850 to 1950, the population grew from 100,000 to 2 million people. But from 1950 to the end of the century, Philadelphia lost 25 percent of its population, dropping to 1.5 million. This picture tells a story that was replicated again and again

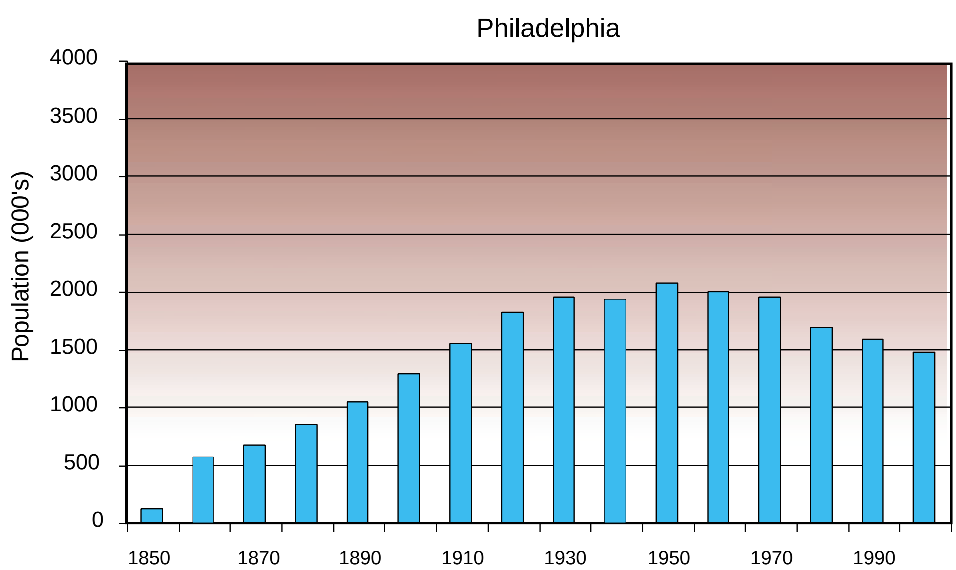


Figure 4

throughout the Rustbelt cities of the Northeast and Midwest. The effect is to significantly increase the burden of replacement funding on the remaining residents of the city.

As previously discussed, the average per-capita value of water main assets in place today across our sample of 20 utilities is estimated to be three times the amount that was present in 1930. In Philadelphia, however, that ratio is almost eight times the value in 1930 due to population declines since about 1950. This problem, known as “stranded capacity” (essentially, capital facilities that are not matched by rate revenue from current customers), is typical of Rustbelt demographics and adds considerably to the challenge of funding replacement in these cities.

Urban demographic history also explains many other dimensions of the infrastructure replacement challenge facing the water industry. Both gains and losses in urban populations created small system infrastructure problems in their wake. During the first half of the 20th Century, many of the people swelling the populations of the urban centers came from smaller rural towns, leaving small water system infrastructure behind to struggle with fewer customers. In the latter half of the century, the departure of big city residents for the suburbs fueled an explosion of new, small water systems in suburban areas. Today about half of all small water systems are within Standard Metropolitan Statistical Areas defined by the U.S. Census. Built in boom times, many of these suburban systems were not built to enduring standards, creating another liability. When these systems are absorbed by larger metropolitan systems, it is commonly necessary to completely rebuild them.

The pattern reflected in Sunbelt cities is the other side of the story from that in the Rustbelt. These cities are experiencing rapid growth and expansion which places capital financing demands upon them that are truly the opposite side of the coin. When water utilities are expanding, they must build some of the most expensive components—new source development, storage facilities, transmission mains, and treatment plants—in advance of population growth in order to serve people when they arrive. This is, in effect, another form of stranded capacity—capital facilities that must be paid for despite the fact the customers are not yet in place. Investor-owned utilities are, in fact, generally prohibited by state regulatory commissions from recovering such costs in rates.

Demographic change thus places financial strain on all our public water systems. It is the same whether they are large or small; urban or rural or suburban; and Rustbelt or Sunbelt. The inescapable fact is that water infrastructure is fixed while populations are mobile. The result is a form of “market failure”—an adverse side effect of market activity that creates an unfunded liability. America derives tremendous economic strength from the fact that it has a highly mobile labor force. When people move around, however, there are costs imposed on the local water infrastructure. It is the same whether it is people moving from rural towns to the city, from the city to the suburbs, or from the Rustbelt to the Sunbelt. Our labor mobility imposes a significant cost on water utilities on both the giving end and the receiving end of this market process, while the benefits are generally disseminated throughout the national economy.

Replacement of water treatment plants is also coming due.

Replacement of water treatment assets presents a different picture from that of the pipes, but greatly complicates infrastructure funding for utilities. Major investments in water and wastewater treatment plants were made in several waves following the growing understanding of public health and sanitary engineering that evolved during the 20th Century. Of course, the installation pattern of treatment assets also reflects major population growth trends. But whereas pipes can be expanded incrementally to serve growth, treatment must be built in larger blocks. Investments in treatment thus present a more concentrated financing demand than investments in pipes.

Treatment assets are also much more short-lived than pipes. Concrete structures within a treatment plant may be the longest lasting elements in the plant, and may be good for 50 to 70 years. However, most of the treatment components themselves typically need to be replaced after 25 to 40 years or less. Replacement of treatment assets is therefore within the historical experience of today's utility managers. Even so, many treatment plants built or overhauled to meet EPA standards over the last 25 years are too young to have been through a replacement cycle. Many are about due for their first replacement in the next decade or so.

The concurrent need to finance replacement of pipes and of treatment plants greatly increases the challenge facing utilities. Figure 5 presents a Nessie Curve showing both pipe replacement and treatment replacement needs for the Bridgeport Hydraulic Company. Similar Nessie curves for a number of other utilities are included in Appendix A.

The distinguishing characteristic of this graph is the manner in which spending for the replacement of pipes rises like a ramp over the first part of the century, pushing up the overall level of annual expenditure required. Whereas pipe repair and replacement are generally funded out of current revenues, treatment costs are typically debt-financed. As

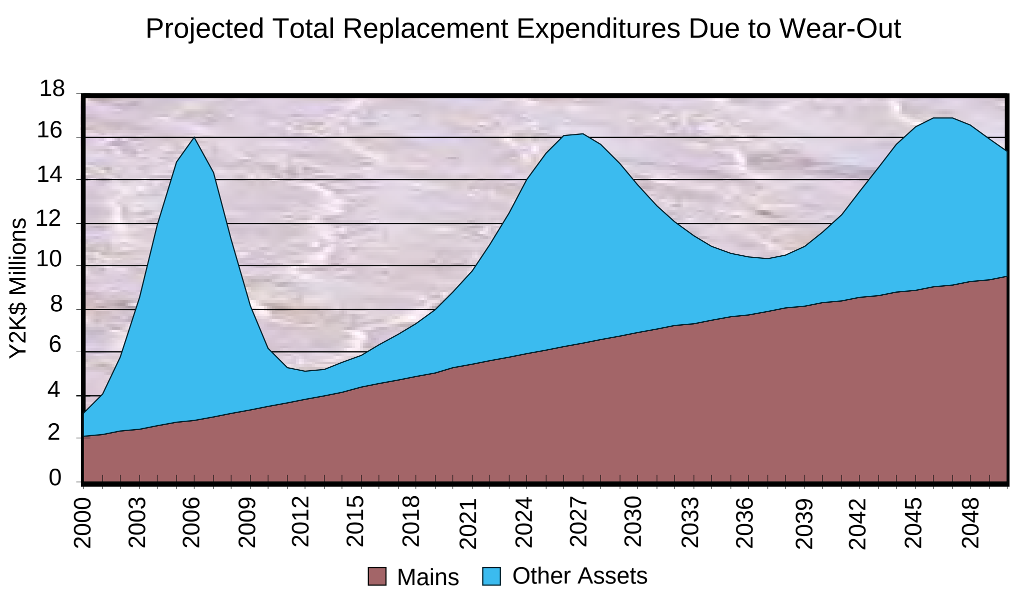


Figure 5

utilities face ever rising costs for repair and replacement of pipes, more and more of the utility's rate revenue will be required for those investments. This will leave the utility with increasingly weakened credit every time it gets to another "treatment hump," unless rates can be raised to match the slope of the curve. A final point to note about the treatment cost estimates used in developing Figure 5 and others like it in Appendix A is that these do not include the cost of new drinking water regulations likely to be implemented over the coming decades.

Increased expenditures are needed to climb the ramp and avoid a gap.

The Water Infrastructure Network (WIN) has developed a "gap analysis" to estimate the total increased spending that is required by water and wastewater utilities in order to avoid getting behind in funding infrastructure replacement over the next 20 years.[1] The first step in the WIN estimate is accomplished by extrapolating from Census data on historical utility expenditures for 20 years into the future. The resulting baseline expenditure forecast is then examined to see how much it must be increased in order to meet new expenditure "needs" for both new EPA compliance requirements and infrastructure repair and replacement over the same 20-year period. The "gap" between the baseline expenditure forecast and the future "needs" forecast is the amount of additional expenditure that must be forthcoming in order for water and wastewater utilities to maintain their critical infrastructure in a healthy condition.

The findings of this "gap analysis" indicate that the baseline expenditures of water utilities must be increased by about $300 billion over 20 years to keep up with both compliance and infrastructure needs. In similar fashion, the baseline expenditure trend in wastewater utilities must be increased by about $400 billion to meet such needs. Taken together, and accounting for the cost of capital, WIN has estimated that water and wastewater utilities together need to increase their investments in infrastructure by almost $1 trillion over the next 20 years.

The WIN "gap analysis" is easily misunderstood. Many have interpreted it to mean that a trillion-dollar deficiency already exists. It is important to stress that the gap estimate represents the challenge ahead—the ramp that we must climb—in increasing utility expenditures in order to avoid such a deficiency. The AWWA Nessie Curve analysis of 20 utilities indicates that we are not now behind in maintaining our water infrastructure. There is no current crisis in these 20 utilities. Rather, they are challenged with finding significant additional funds over the next 30 years for investments in repair and replacement, in order to avoid getting behind.

Extrapolation from aggregate baseline trends, such as in the WIN gap analysis, is akin to "technical analysis" of the stock market using charts, graphs and trending techniques. Investment analysts typically like to supplement such "technical analysis" with "fundamental analysis" of the situation existing within individual companies. The AWWA Nessie Curve analysis provides this type of supplemental perspective on increased expenditure needs.

[1]Water Infrastructure Network (WIN), Clean & Safe Water for the 21st Century, April 2000.

As illustrated in Figure 5, the Nessie Curve analysis indicates that expenditures on infrastructure repair and replacement must be significantly ramped-up over a period extending from 2000 through 2030. The steep rise is shown to level off after that, but it does not go away. Expenditures will have to continue to climb, albeit more gradually, throughout most of the rest of the 21st Century. This shape is the signature pattern of the new replacement era that we have entered. It is not a short-term "hump" that we have to get over. The shape of the challenge is that of a sustained rise in expenditures. This period of ramping-up is going to be a period of significant adjustments.

The Nessie Curves of the individual utilities shown in Appendix A present wide-ranging needs for increased expenditure for replacement of pipes and treatment assets due to wear-out. In the 20 utilities studied, such needs total about $6 billion above current spending over the next three decades. On a household basis, needs range from $550 to $2,300 over 30 years. These figures do not include the prospective costs of numerous new SDWA regulations likely to be implemented over the coming decade, nor any costs from the wastewater or stormwater side of the urban utility business. Moreover, as seen in Appendix A, the utilities vary widely in the timing of these needs; some face sharp needs in the next 10 years, while others don't face their highest needs for 10 or 20 years. The slope and the "humpy" patterns of increasing capital requirements are unique to each utility.

Our sample of 20 utilities represents relatively large water utilities. On a per household basis, the total 20-year capital needs for replacement illustrated in our sample is about the same as that estimated by EPA for large water systems in their newly released Drinking Water Needs Survey.[2]

The EPA Drinking Water Needs Survey uses a site visit methodology and a large sampling program to document needs in small systems and is probably the best information available on small system needs. Extrapolating from EPA's estimated 20-year capital need for small systems, we project the total 30-year expenditure for infrastructure repair and replacement in small systems might be in a range of $1,490 per household to $6,200 per household.

The result of this "fundamental analysis" using Nessie Curves is not inconsistent with the order of magnitude of the need that WIN estimates to be facing water utilities ($300 billion over 20 years). Extrapolation from our 20 sets of Nessie Curves suggests that the need might be on the order of $250 billion nationally and extend over three decades. However, the Nessie Curve forecast is based on an assumption that pipes are left in the ground until their economic life is over. The reality in utility operation is that myriad other influences can cause the replacement need to arise sooner. These include urban redevelopment, modernization, coordination with other city construction schedules, increasing pipe size, and other factors.

[2] U.S. Environmental Protection Agency, 1999 Drinking Water Infrastructure Needs Survey (EPA 816-R-01-004), February 2001.

Addressing affordability is the heart of the challenge.

The central question for policy makers and utilities is whether the increased rate of infrastructure spending that utilities must face over the next 30 years can be financed by the utilities themselves at rates customers can afford. AWWA remains, committed to the principle that utilities should be self-sustaining through their rates. For many utilities, however, the degree of change involved in adapting to the dawning replacement era, the adverse effect of demographic change on per household costs, and the competing demand for investment in wastewater and other municipal services, will combine to present a significant affordability challenge.

There are two related dimensions to the affordability concern. First is the ability of utilities to finance the needed additional expenditures within their rates. Second is the impact of higher rates on households.

In developing this study, AWWA brought together a group of utility managers from across the country to discuss infrastructure issues. This group characterized the question from a local perspective as an "affordability gap" or a "reality gap" and defined it as "the difference between what you think you should be spending on infrastructure and what you or your customers can afford to spend in reality." This characterization of the problem reflects the difficulty of obtaining significant utility rate increases. Rate increases are best received when implemented gradually in a number of installments over several years. Unfortunately, the rate increases required to meet the challenges of pipe replacement that utilities now face cannot be smoothly implemented in many cases.

There is small likelihood that the $550 to $2,300 per household projected to be required for infrastructure repair and replacement in our 20 utilities over the next 30 years can be spread evenly or taken on gradually over that period. As illustrated in Appendix A, some Nessie curves present a steeper funding challenge and some present a gentler slope due to local variations in the historical demographic trends. There are "humps" on the up-ramp for replacement of treatment plants and other equipment. Additional "humpy" expenditures for compliance with anticipated new regulations are not included. In small systems, the estimated $1,490 to $6,200 range of household impact is likely to be even more concentrated since the original demographics were themselves more concentrated.

Compliance-driven requirements to replace treatment plants and invest to meet new mandates will also dominate expenditures and push aside the more subtle need for investments in pipe replacement. This is exacerbated by the fact that the costs of water and wastewater service appear on the same bill in most communities. Thus, the needs to replace wastewater treatment plants and to replace wastewater lines compete with drinking water needs for the same consumer dollar. Sewer pipes generally impose higher unit replacement costs than water pipes, owing to their inherent characteristics (size, depth, etc.). Figure 6 presents a Nessie curve for a combined water and wastewater utility showing replacement funding needs for both water and wastewater pipes and other assets (treatment, pumping, etc.). The figure illustrates the typical relationship between water supply and wastewater costs—wastewater facilities cost noticeably more to replace.

The combined repair and replacement needs for water and wastewater infrastructure amount to a significant financing challenge in their own right. But the cost of compliance

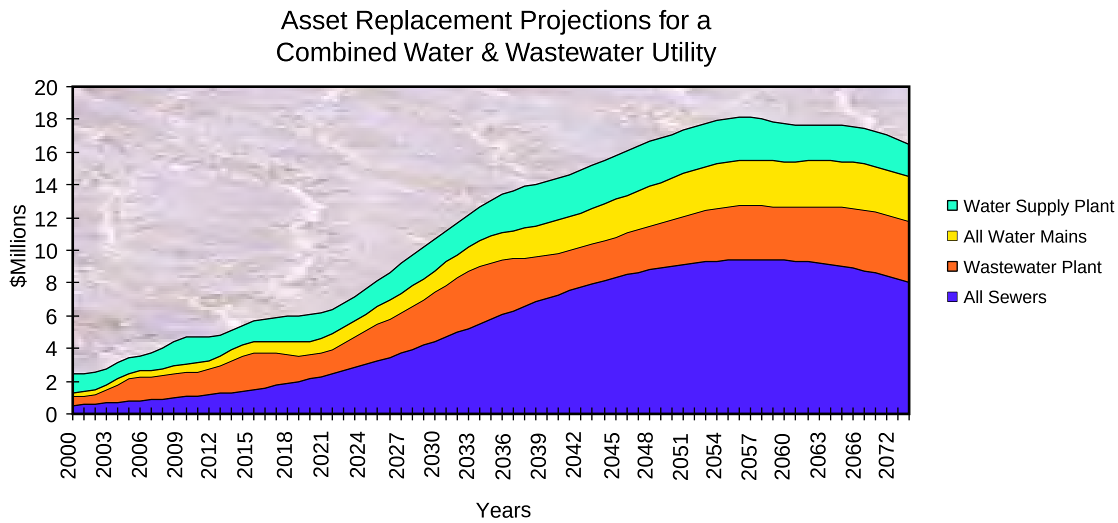


Figure 6

with combined sewer overflow (CSO) and stormwater regulations may dwarf everything else in water and wastewater utilities. The scale of the expenditure required in these programs may sweep everything else aside in some utilities, causing deferral of other needs and allowing a "gap" to open up. Note that CSO and stormwater compliance costs are not included in Figure 6.

To avoid an infrastructure gap, utilities are going to have to increase expenditures to keep up with both compliance requirements and infrastructure replacement. If rate increases do not keep pace with the increased rate of expenditures, the financial ratios used to evaluate a utility's creditworthiness will deteriorate, making it more difficult and more expensive to raise capital.

If a utility attempts to balance a deficiency in allowable rates by deferring infrastructure expenditures, then the stage is set for an infrastructure investment gap to begin to develop, creating a future liability for the utility and its customers. With the new accounting requirements being implemented under the Governmental Accounting Standards Board Statement No. 34 (GASB 34), such a deferral of infrastructure expenditures will be reported to the financial markets and begin to impair the utility's credit rating and ability to raise capital.

Since the Nessie Curve represents replacement timing based on the economic life of the pipes, it follows that deferral of replacement will produce higher overall costs due to increased repairs than would be the case if replacement occurred on time. If replacement is deferred too far beyond the economic trade-off point between replacement and repair costs, the repair cost burden will spiral upwards and have significant impacts on utility cash flows. Such a scenario will indeed impair a utility's ability to repay debt and will be made plain to the credit markets by the new GASB 34 requirements.

In either of these scenarios—rates that don't keep up with expenditures or expenditures that don't keep up with needs—the bottom line is the same. If both expenditures and rate revenues cannot be increased at the required rate, then the utility's credit may be impaired, and it may face even higher costs as a result. For some utilities, there is the potential for this to become a vicious cycle—a financial trap. These systemic financial risks are the reason why we have a clear and present need for an enhanced partnership between utilities, states and the federal government. We need to provide the means to assist utilities "up the ramp and over the humps." We need to minimize the credit risks utilities face over the next three decades as we make the adjustments in rates required to assure sustainability in the new replacement era.

The second, and all important, dimension of the affordability challenge is the bottom-line impact of increased water rates on household budgets. AWWA believes it is critical to avoid sudden and significant changes in rates that can induce "rate shock" among customers. The broader issue involved in rate shock ties back to the pivotal role of safe drinking water in promoting public health.

America has by far the safest drinking water in the world. Standards promulgated under the Safe Drinking Water Act aspire to the highest levels of technology and treatment optimization known to science. As we push farther into the limits of science and technology, we unavoidably encounter diminishing returns in terms of quantifiable health benefits at the same time that we must take on increasing marginal costs. Many new standards relate to very subtle health concerns that are difficult to substantiate and quantify. Yet, to be protective of health, there is a tendency to err on the side of safety, especially when the threats may relate to sensitive subpopulations such as children, the unborn, the elderly and the health-impaired.

This is where the issue of rate shock must be brought into focus as a public health concern. Whenever the sensitive subpopulations we are striving to protect are also among the low-income segment of the population and are forced to forego medical care or nutrition in order to pay their utility bills, we could be doing more harm than good. The fact that we are now entering a significantly more expensive replacement era in water infrastructure makes it all the more difficult to maintain the right balance in this aspect of public health. By some comparisons, it may appear that water is still cheap and there is room to increase water rates. But such comparisons are not relevant to low-income households. The only comparison that matters in these households is the size of the incremental increase. If it is large enough to trigger a budget substitution that negatively affects family health—for example, giving up a prenatal visit in order to pay a utility bill—then we may be losing ground.

Over the past decade, utilities have formed an increasingly closer partnership with EPA, states, the environmental community, the public health community and other groups to continue to make progress for public health despite significant scientific challenges. This partnership must now be broadened to address the financial challenges of infrastructure replacement in order to preserve the fruits of our labors in the public health arena.

RECOMMENDATIONS

Considering all of these facts, the American Water Works Association believes it is time for a new American partnership for clean and safe water. This partnership requires that all levels of government and utilities play a role in working through the significant challenges ahead. Specifically, we recommend:

1) Measures by Utilities and Local Governments

The infrastructure funding issue varies from place to place, reflecting the age, character and history of the community. Although AWWA has looked at the infrastructure issue in the aggregate, many key questions must be asked and answered at the local utility level. The development of a comprehensive local strategy can bring these elements into focus and create a new "reality" that will help make infrastructure repair and replacement more affordable. Such a comprehensive strategy includes:

- **Assessing the condition of the drinking water system infrastructure.** Over the last few decades, utilities around the world have been developing innovative new approaches to managing long-lived buried infrastructure. In North America and overseas, some utilities are already taking advantage of tools such as geographic information systems, using new information to advance the state of the art and aggressively managing infrastructure replacement. Planning tools can help identify and plan for needed investment decades in advance of the actual need for funds. We should learn from, adapt, and use such tools.
- **Strengthening research and development.** Although there is not likely to be a single "silver bullet" to solve infrastructure management problems, an impressive array of technological tools have been moving through the research and development process in recent years. Efforts to develop and deliver such tools should be strengthened.
- **Working with the public to increase awareness of the challenge ahead, assess local rate structures, and adjust rates as necessary.** For many years, water and wastewater utilities have been nicknamed "the silent service." Utilities have quietly provided an extremely reliable supply of high-quality water at relatively low rates compared to other public utilities and services. Partly as a result, a large number of utilities, particularly smaller ones, do not have appropriate rate structures. The 1996 SDWA requirement for Consumer Confidence Reports provides a vehicle for many utilities to take the first step in broadening their dialogue with customers and the public at-large. Comprehensive, focused, and strategic communications programs serve the dual function of providing consumers with important information about their water systems and building support for needed investments in infrastructure.
- **Building the managerial capacity of many water systems.** Congress took new steps in the 1996 SDWA Amendments to assure the institutional capacity of small systems applying for state revolving fund loans. Much more remains to be done in this area. EPA, in conjunction with water associations, could sponsor training programs on appropriate rate structures, designed specifically to deliver assistance to small systems in planning for full cost recovery through rates.

2) Reform of State Programs

The states, too, have an important role to play in addressing our infrastructure funding needs. States may need to match an appropriate share of any new federal funds that are provided for infrastructure assistance. Moreover, they need to reform their existing programs to make them more effective. For example, some states have not allowed larger systems to access the existing state revolving fund, or have excluded investor-owned systems. Some states encumber their revolving funds with nonproductive red tape, charge high loan origination and other fees, or charge loan rates that are equivalent to market rates. Some states preclude the use of alternate procurement methods that minimize infrastructure procurement costs. For example, the "design/build" process for infrustructure procurement has been documented to save 20–40% of construction costs for new treatment plants in some cases. Public procurement laws in many states, while not explicitly banning design/build, mandate a process that prevents its use where local authorities have determined it would be advantageous.

The result is that, in many states, revolving loan funds have not proved to be useful or attractive even to drinking water utilities desperately in need of capital. States should commit to:

- Respecting the universal eligibility of all water systems for federal assistance.
- Streamlining their programs for delivery of assistance and allowing alternative procurement procedures that save money.
- Making their financing mechanisms more attractive by committing to grants and very low or negative interest loans.
- Using federal funds in a timely fashion or facing the reprogramming of those funds to other states.

3) A Significant Increase in Federal Assistance

After accounting for the cost savings that can come from best practices in asset management, the development of new technologies, efforts to increase ratepayer awareness and support, and possible alternative compliance scenarios, for many utilities there is likely to remain a gap between the required expenditure increases and the practical ability to raise water rates. This gap could grow over the next few decades as infrastructure built in the late-1800s to mid-1900s must be repaired, replaced, and rehabilitated at the same time that we are trying to enhance the level of water treatment under the Safe Drinking Water Act (SDWA).

AWWA remains committed to the principle that utility operations should be fully supported by rates. In the long run, the objectives must be to manage the costs of replacing pipes and treatment plants and ensure financial sustainability through local rate structures. However, many utilities are going to face a period of adjustment in adapting to the new reality of the replacement era described in this report. Many utilities and their customers will need additional assistance in working through extraordinary replacement needs in the next 20 years.

The difference between drinking water utilities' current expenditures for infrastructure replacement and the needed level of expenditure is estimated by WIN to be about $11 billion per year over the next 20 years. If the federal government were to provide half the cost of this gap, the federal share of total utility spending would amount to under 12 percent of total utility spending. For comparison, the federal share of investment in roads, bridges, and airports is 80 percent.

To prevent the development of a gap in critical water infrastructure financing, AWWA recommends either changing and expanding the existing Drinking Water State Revolving Fund and other drinking water programs or creating a new, infrastructure-focused fund. Such a fund should provide:

- Significantly increased federal funding.
- Clear eligibility of projects to repair, replace, or rehabilitate drinking water infrastructure.
- Universal eligibility of all water systems, both public and investor owned, regardless of size.
- Ability to make grants or loans in any combination and to use other financing tools to leverage public and private capital.
- Reasonable terms and conditions such as demonstration of system viability and ability to repay a loan.
- Streamlined procedures for those accessing the funds.

Research is a critical component of a comprehensive federal program on infrastructure. Research stimulates the development of new techniques and unleashes American ingenuity. It offers the chance to save billions of dollars over the years to come through more efficient management, repair, and replacement technologies. The federal government should significantly increase its support for research on infrastructure management, repair and replacement technologies, methods for extending pipe life, and other means of advancing the art while lowering the cost of infrastructure management.

Finally, the federal government should take other important steps to better access and leverage public and private capital. Congress should consider:

- Development of a national water infrastructure financing bond bank similar to Fannie Mae.
- Tax code and other reforms to increase the availability and use of private capital. This could include steps such as the removal of constraints on private activity bonds, development of subsidized bond insurance, provision of federal loan guarantees, and improved investment tax credit incentives.

CONCLUSION

Considering when pipes were laid down in many water systems and how long they can be expected to last, it is clear that a new age—the replacement era—has arrived for water utilities. Over the next 30 years, infrastructure replacement needs will compete with compliance needs for limited resources. Clearly, infrastructure needs and compliance with the Safe Drinking Water Act can't be approached as separate issues, but need to be addressed together.

Only in the true spirit of a new partnership, as outlined in this report, can we think most broadly about these issues. Only in this spirit can we achieve the goals to which we all aspire: the provision of safe and affordable water to all Americans.

Reinvesting in Drinking Water Infrastructure

Dawn of the Replacement Era

APPENDIX A

20 Sets of Nessie Curves

This appendix presents results of infrastructure expenditure needs analyses conducted for 20 water utilities across the United States. The "Nessie Curve" technique employed in this study produces a forecast of water main and other asset repair and replacement expenditure requirements based on how those assets "wear out" over the course of their economic life. While this study has focused on projecting economically efficient replacement and repair costs from wear-out, there are other reasons why assets might be replaced sooner, such as needs relating to urban redevelopment, system improvements, coordination with other city construction, and increasing pipe size. The curves also focus only on existing assets and take no account of new assets needed to support growth or compliance with new SDWA regulations in the coming decades.

For each utility, results are summarized in several Nessie Curves illustrating different perspectives. For each utility there is an estimate of the total replacement cost value of the utility's assets in today's dollars. There is also an indication of whether the utility was studied with respect to mains only, or whether it was studied with respect to a wider range of assets (including treatment plants). In viewing the charts, it is important to remember whether the utility is an "apple" (mains only) or an "orange" (all assets).

The charts presented cover the next 50 years, primarily to better illustrate the characteristic shapes of the replacement "echo" while also identifying differences in the timing of major replacement requirements between the participating utilities. All values are constant year 2000 dollars. The forecasts assume zero inflation.

The first chart is entitled. "Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)." In this graph, the total cost for replacement and repair due to aging is projected over the next 50 years at the household level.

The second chart, entitled "Projected Total Expenditures Due to Wear-Out" is similar to the first chart, showing the relative requirements for replacement expenditures and repair expenditures for the assets studied in each utility, expressed in total dollar outlays for the utility.

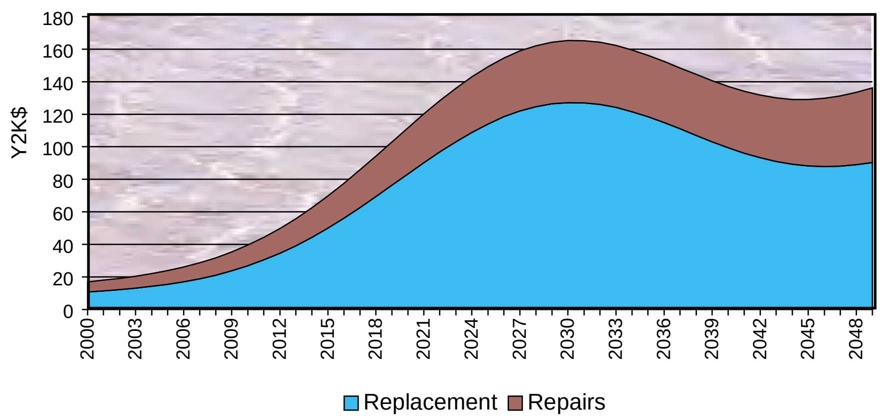
For the utilities that were studied with respect to all assets, there is a third chart on the page entitled, "Projected Total Replacement Expenditures Due to Wear-Out." This chart projects replacement investment only, showing the relative contributions to 50-year replacement needs of mains versus other assets (treatment, pumping, etc.). For utilities that were studied only with respect to mains, this third chart is omitted from the summary page for that utility.

Index of Nessie Curves

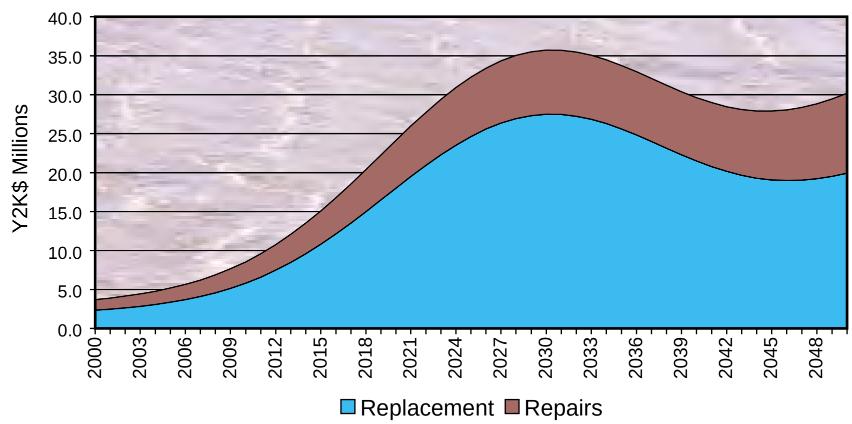
Austin, Texas

Asset Sets Modeled: Water Mains — Estimated Replacement Value $2,348 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



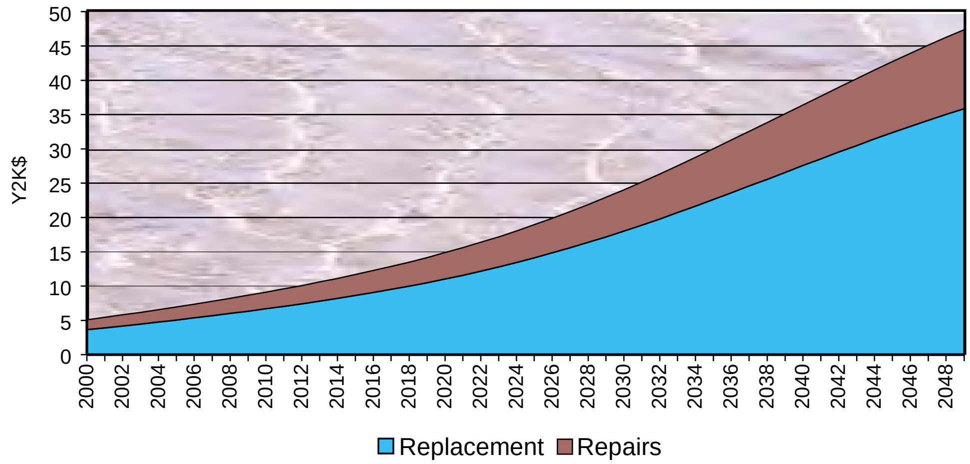
Projected Total Expenditures Due to Wear-Out



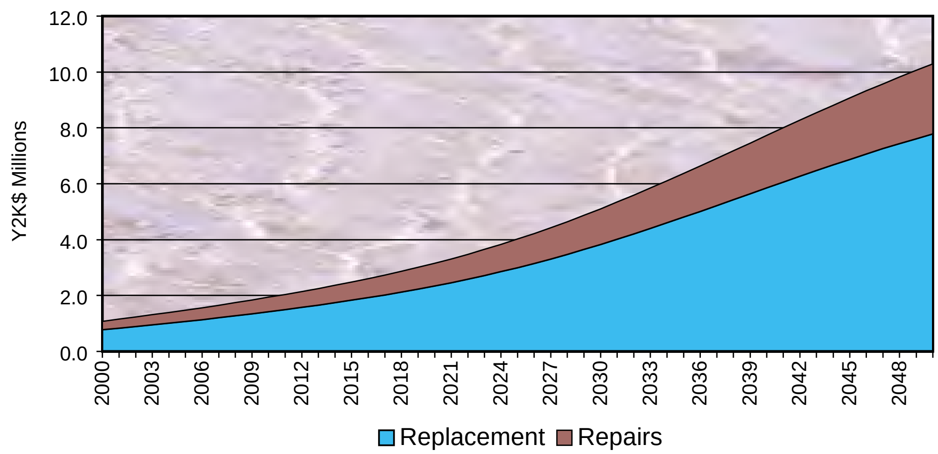
Boston, Massachusetts

Asset Sets Modeled: Water Mains —
Estimated Replacement Value $694 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)

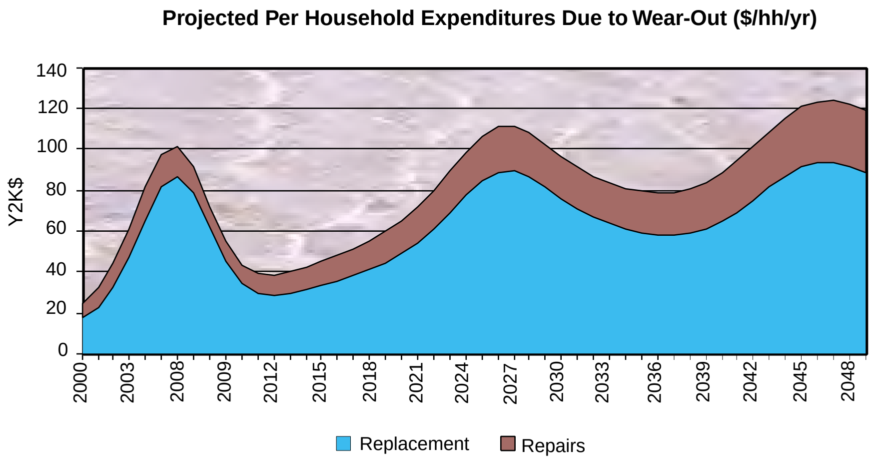


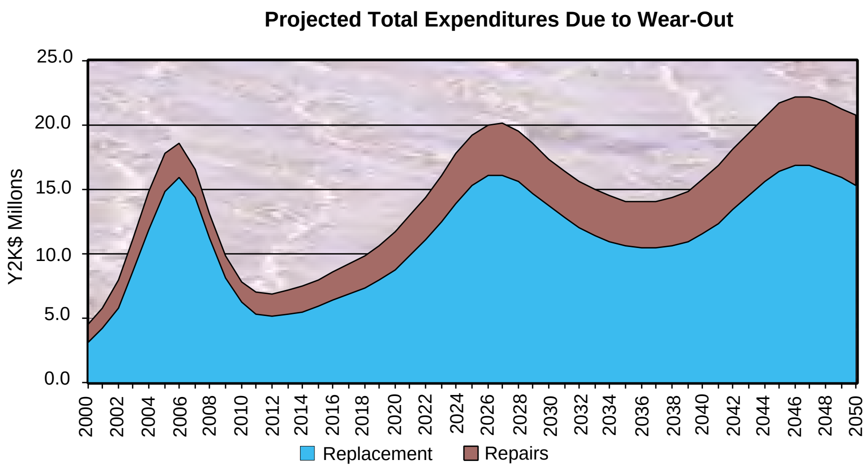
Projected Total Expenditures Due to Wear-Out

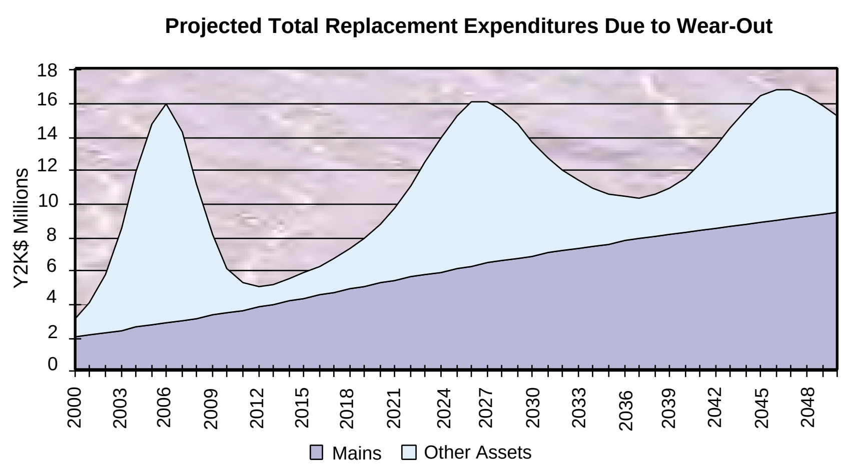


BHC, Bridgeport, Connecticut

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,663 M

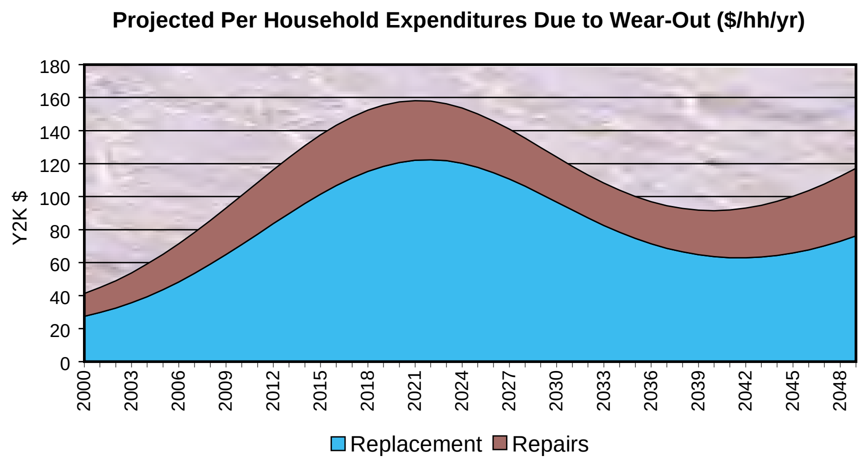


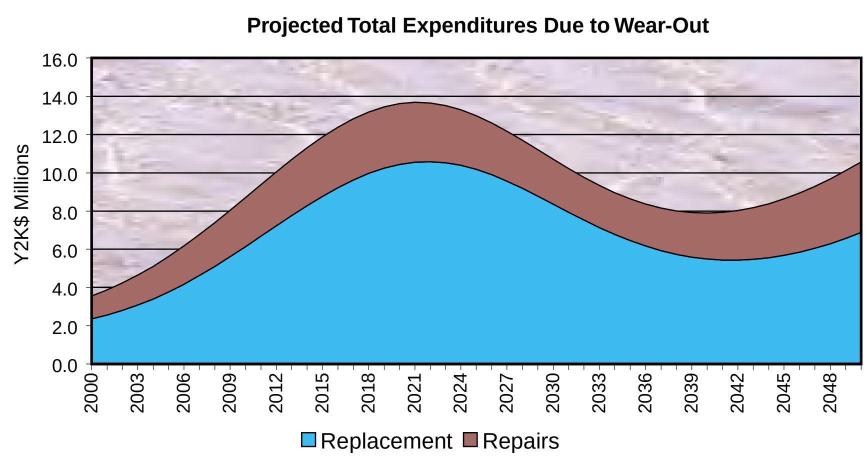


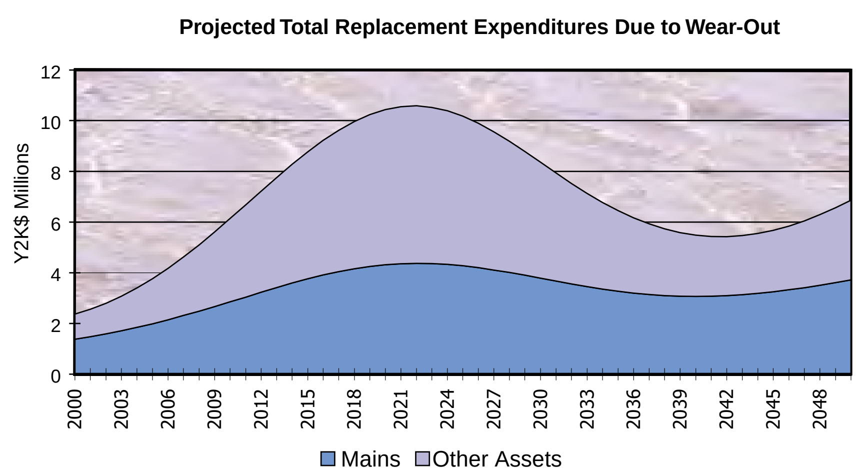


West Virginia American, Charleston, WV

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $650 M

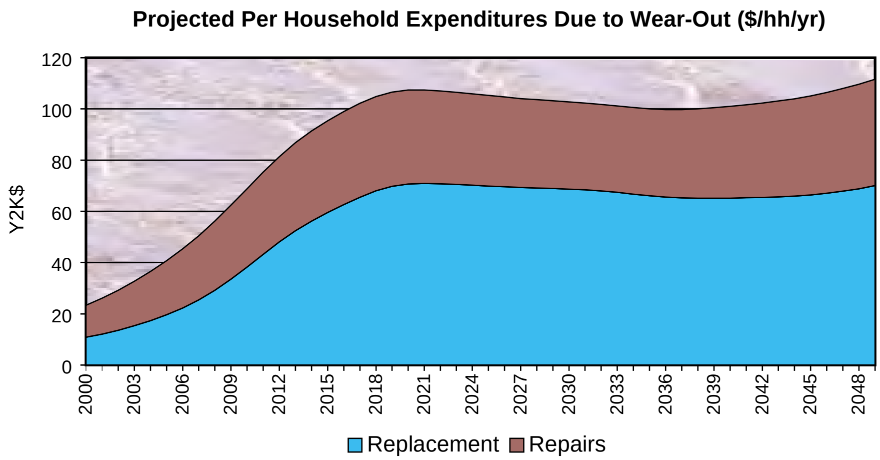


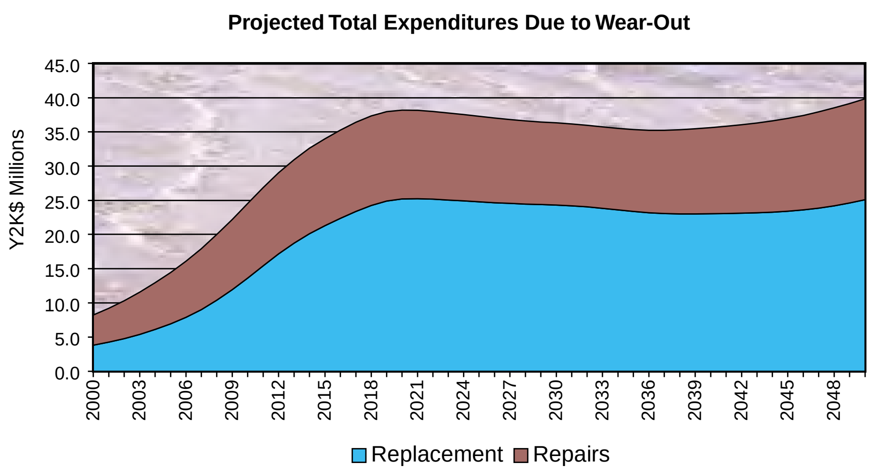


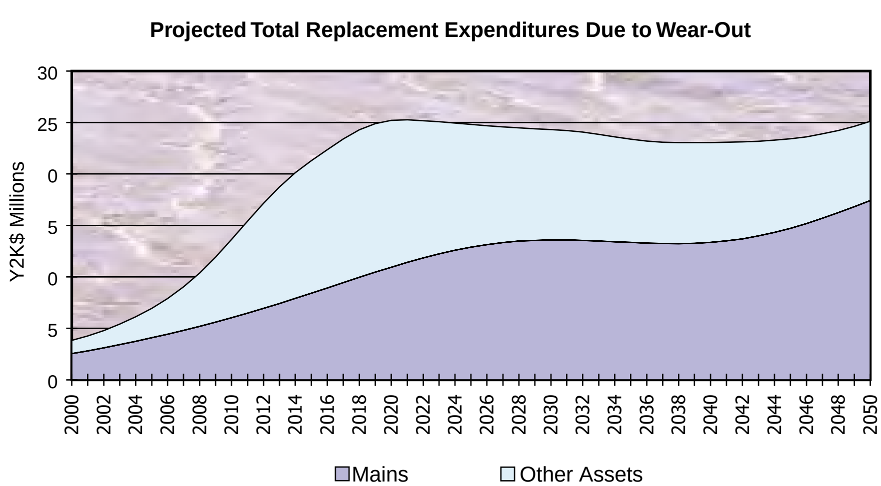


Cincinnati, Ohio

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $2,042 M

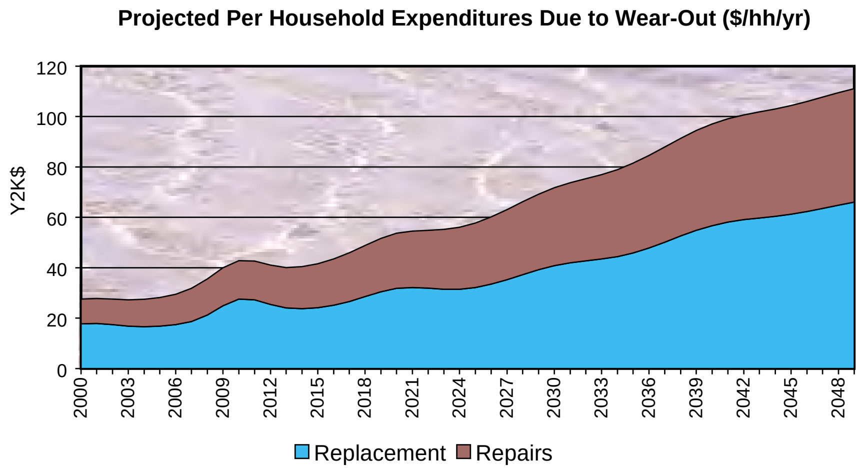


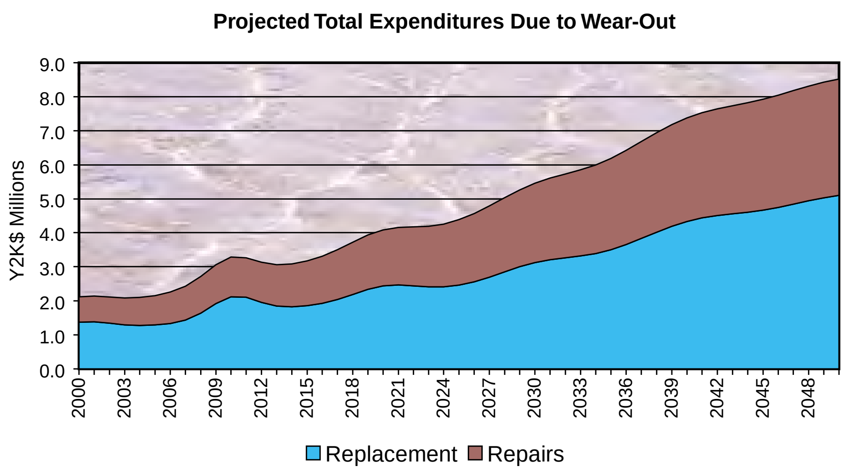


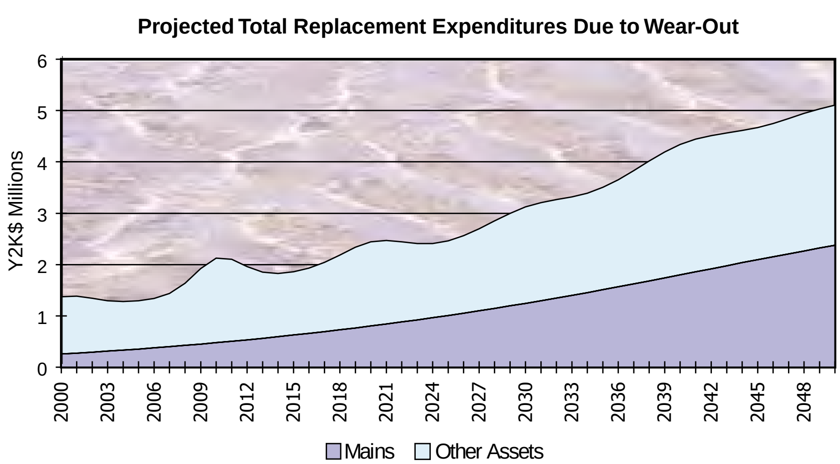


Columbus, Georgia

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $648 M



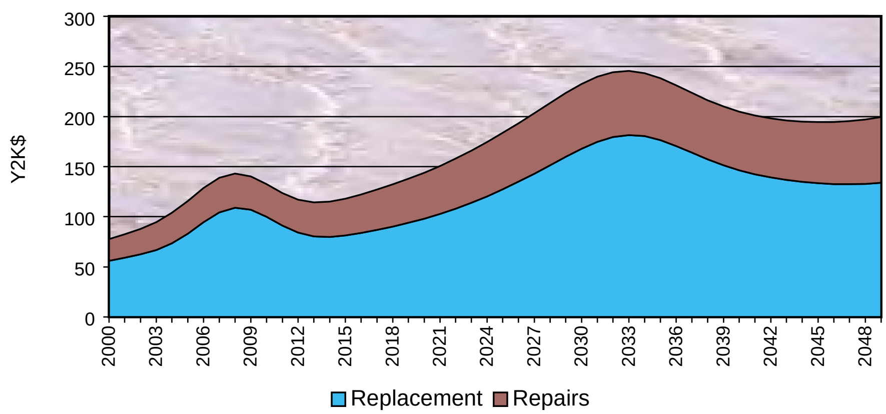




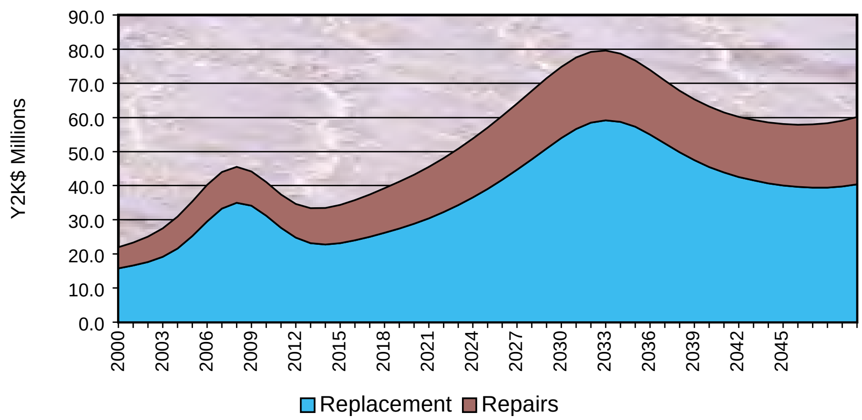
Denver, Colorado

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $5,583 M (Includes Major Dams)

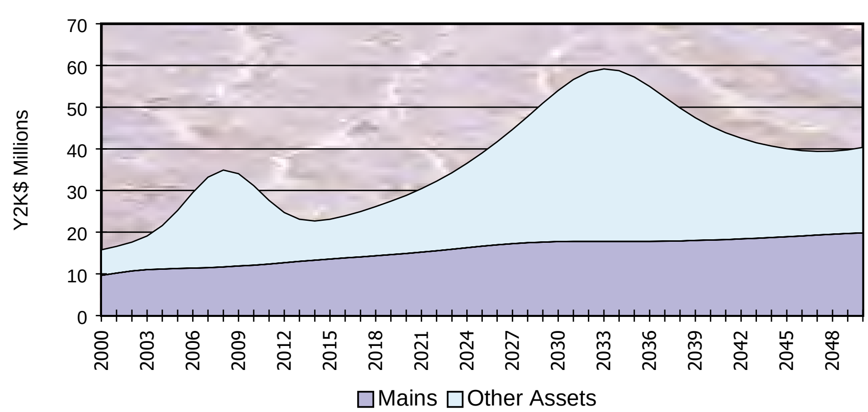
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



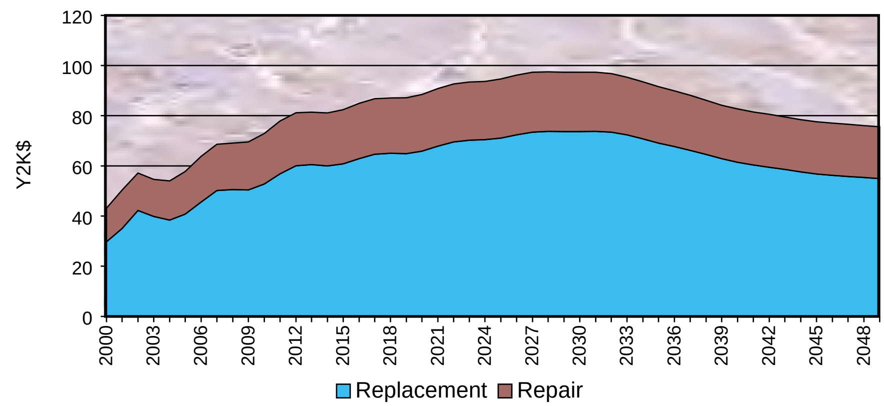
Projected Total Replacement Expenditures Due to Wear-Out



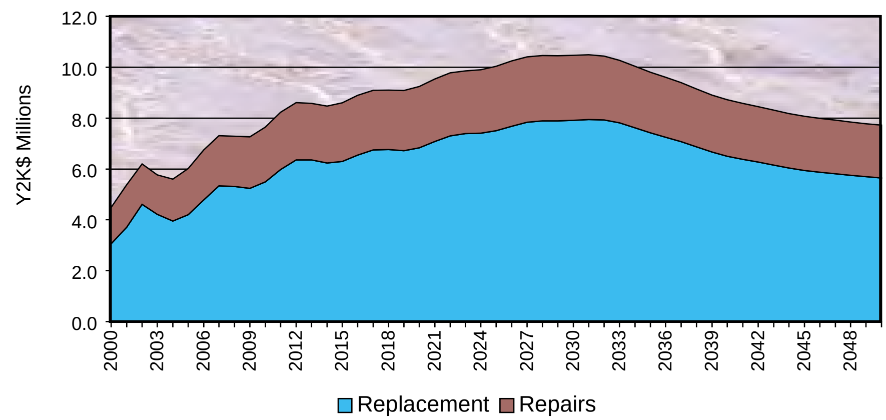
Des Moines, Iowa

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $524 M

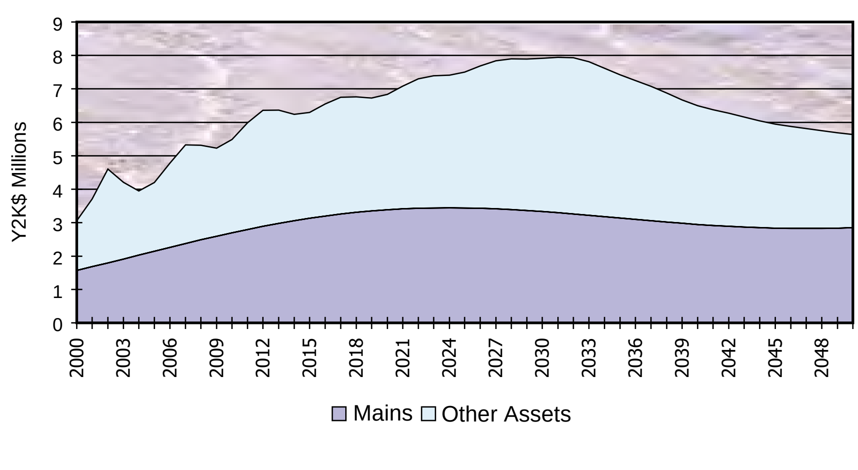
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out



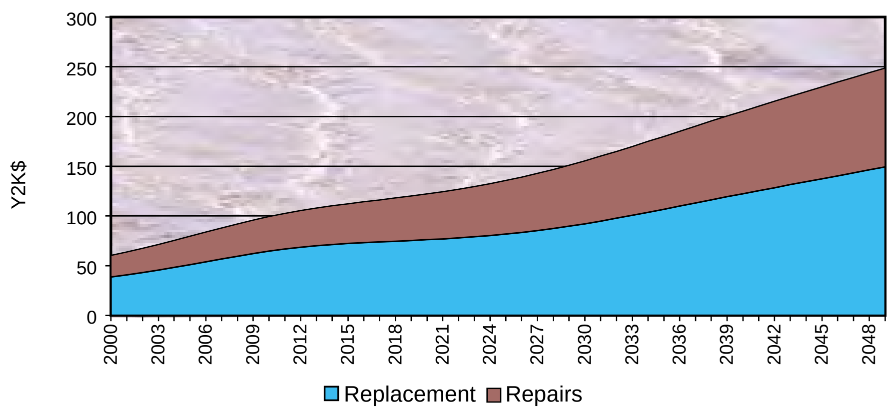
Projected total Replacement Expenditures Due to Wear-Out



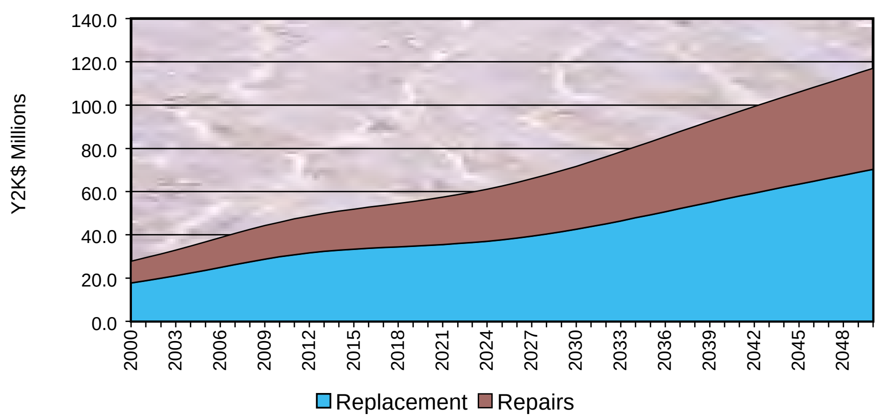
East Bay MUD, Oakland, California

Asset Sets Modeled: Water Mains & Water Supply Plant —
Estimated Replacement Value $8,110 M

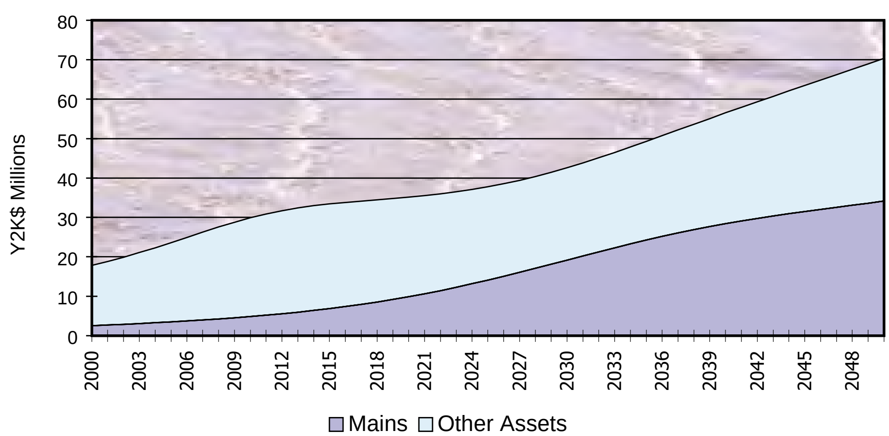
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



Projected Total Expenditures Due to Wear-Out

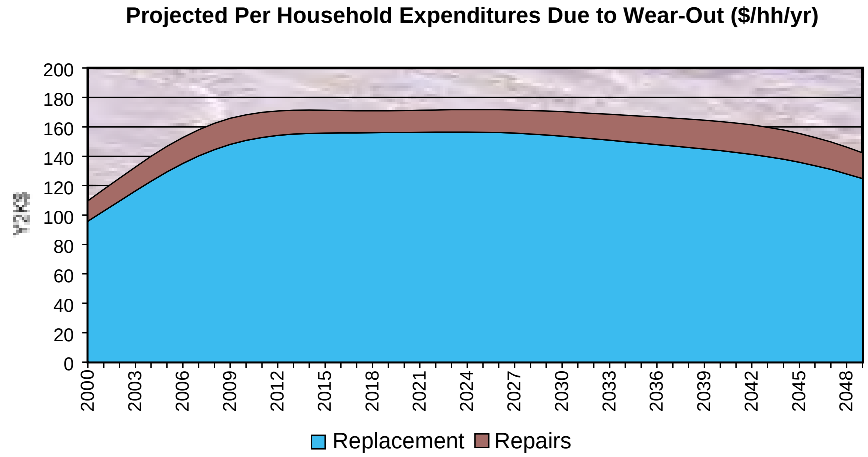


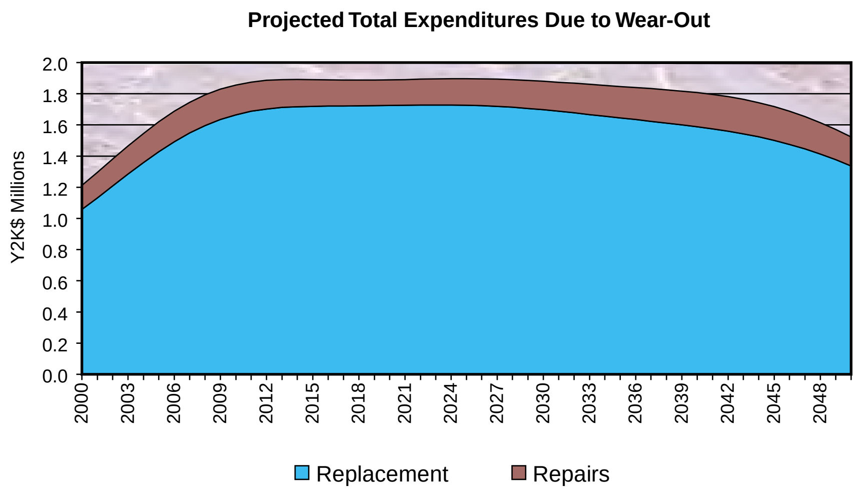
Projected Total Replacement Expenditures Due to Wear-Out

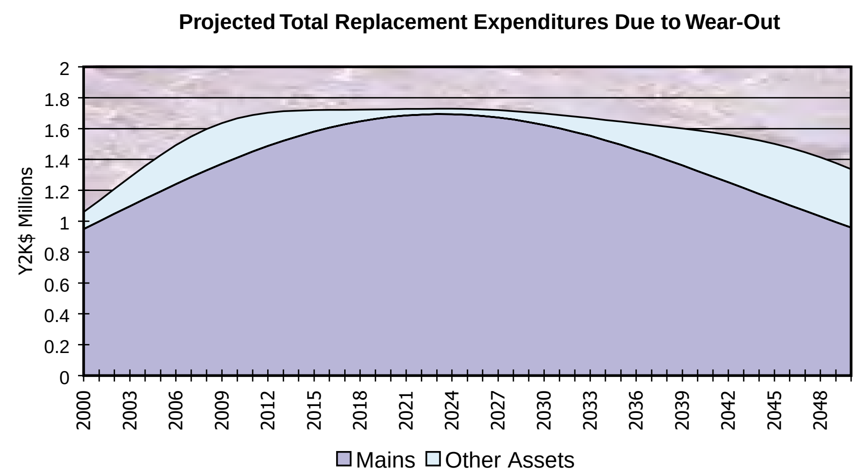


Gloucester, Massachusetts

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $116 M

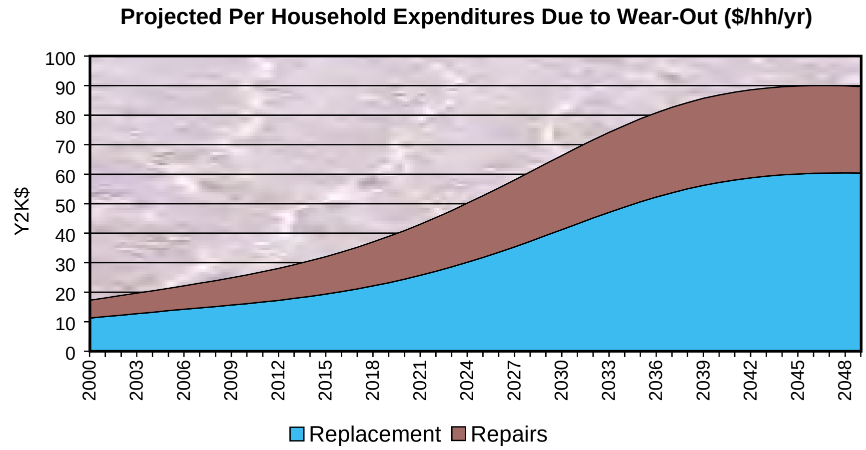


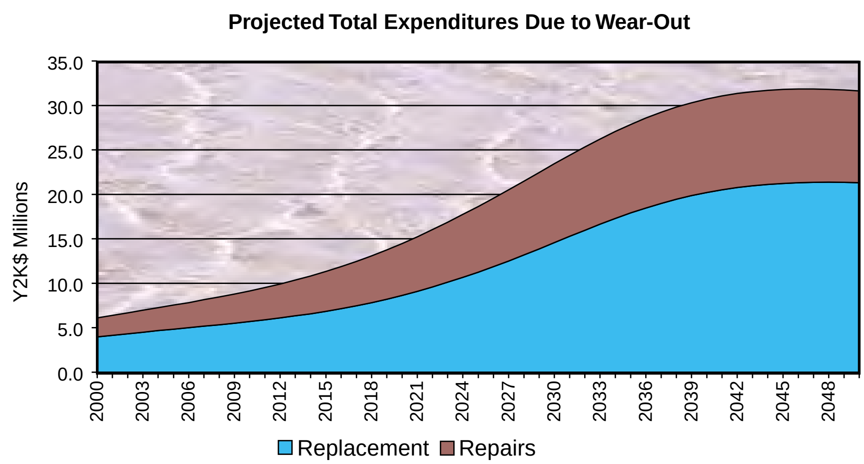


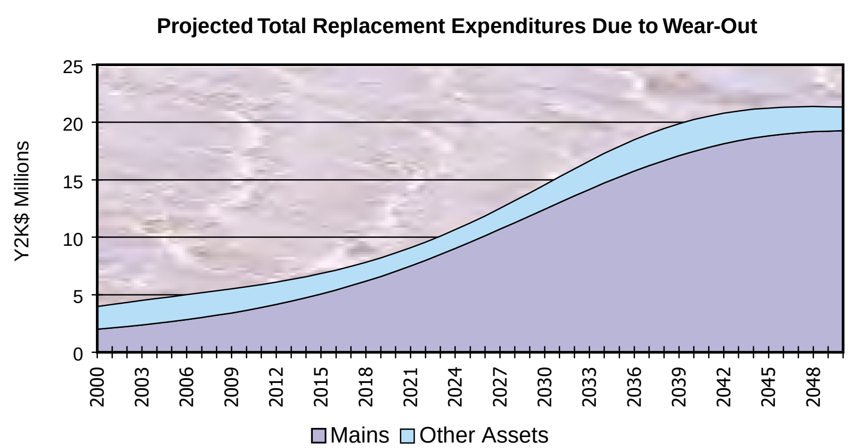


Honolulu, Hawaii

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,272 M



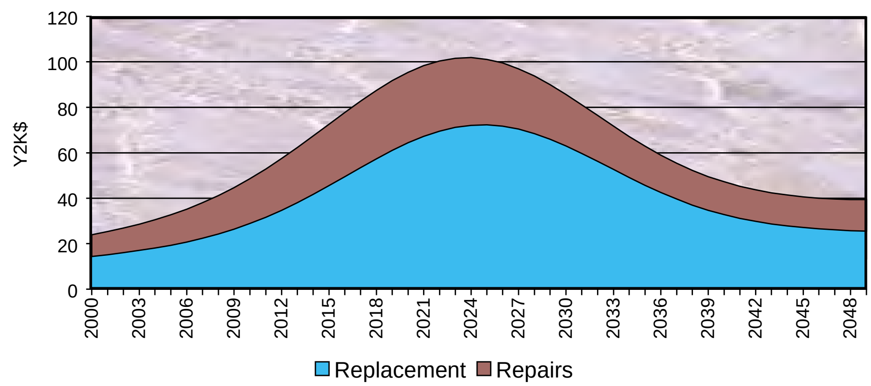




Louisville, Kentucky

Asset Sets Modeled: Water Mains — Estimated Replacement Value $1,343 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



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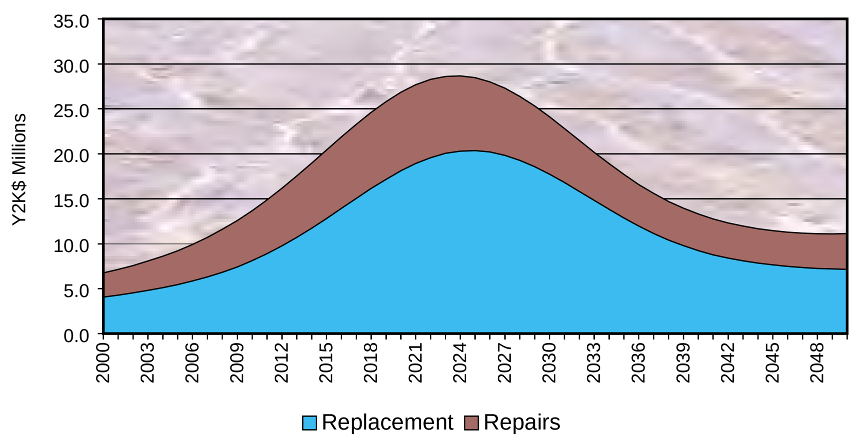
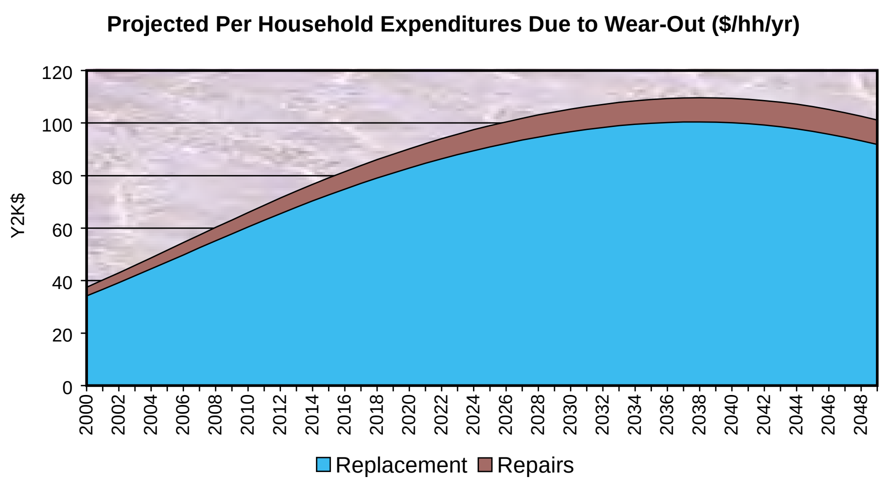
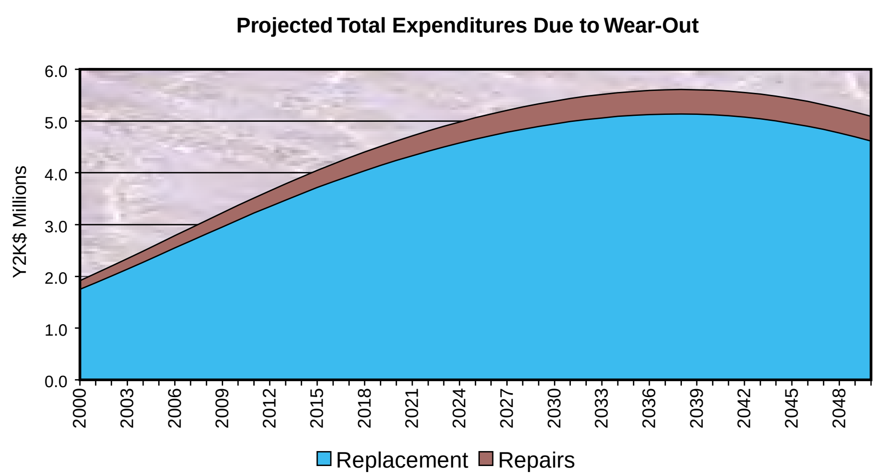


United Water, New Rochelle, New York

Asset Sets Modeled: Water Mains — Estimated Replacement Value $325 M





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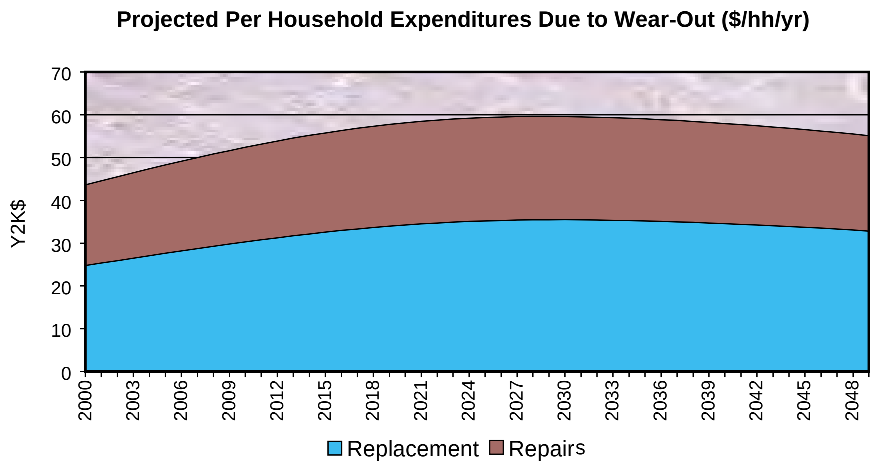

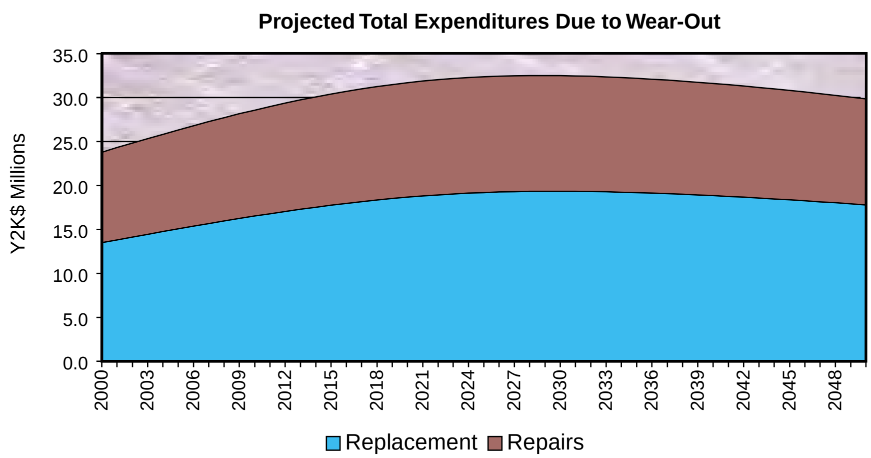

Portland, Oregon

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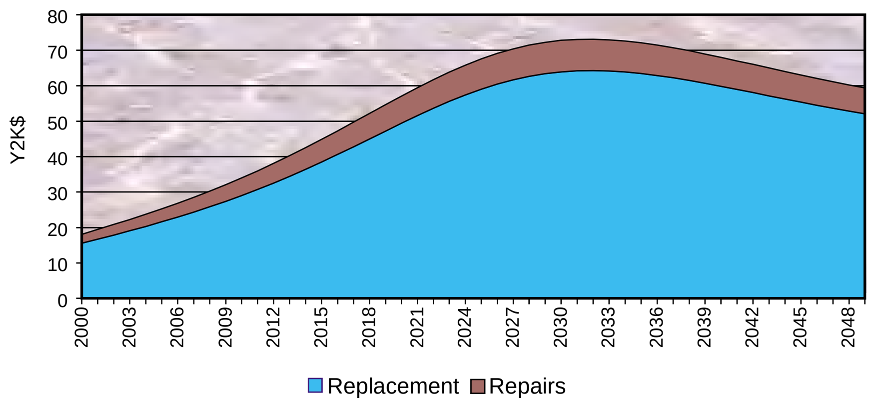

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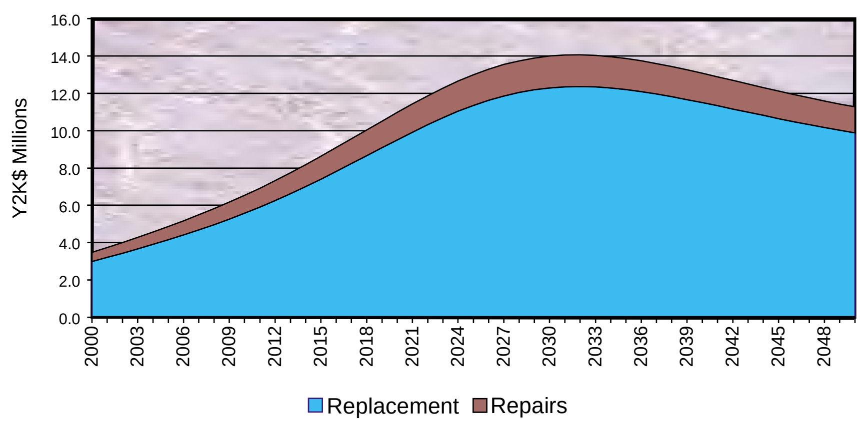

St. Paul, Minnesota

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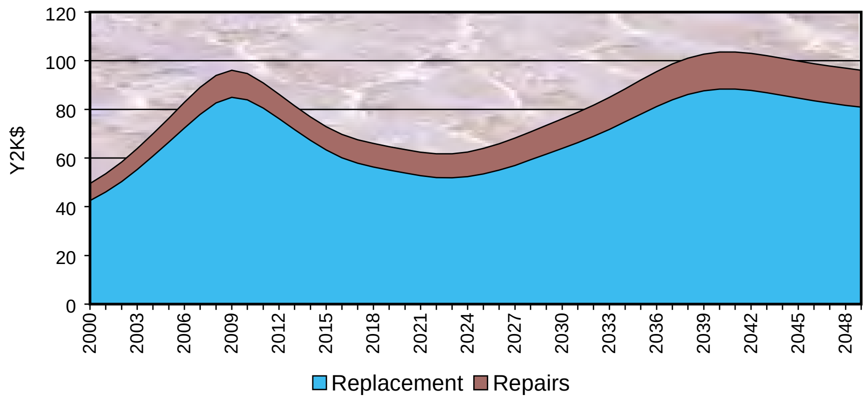
Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



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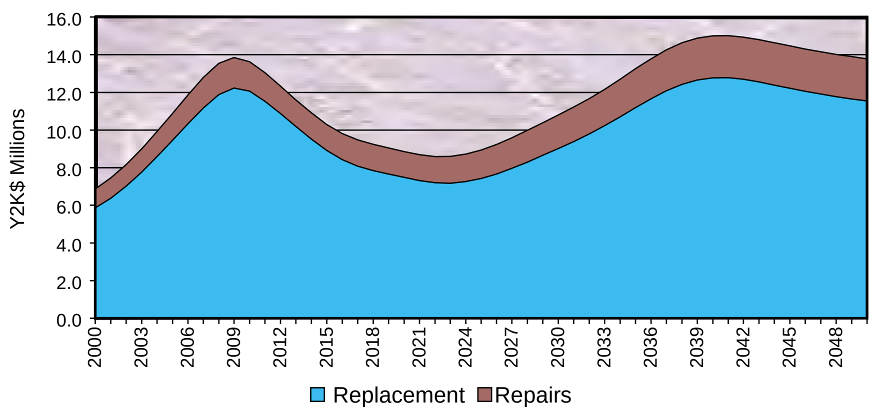

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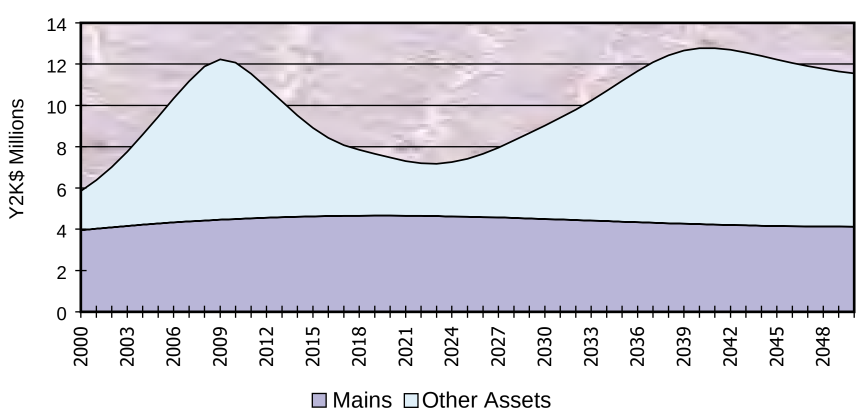

Seattle, Washington

Asset Sets Modeled: Water Mains — Estimated Replacement Value $1,713 M

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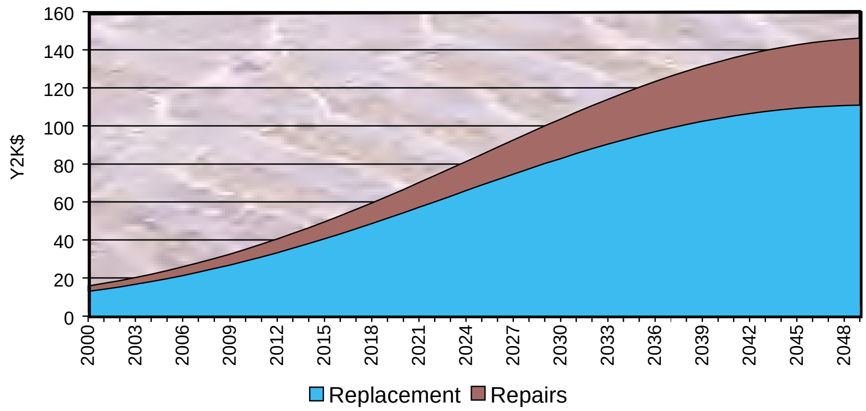

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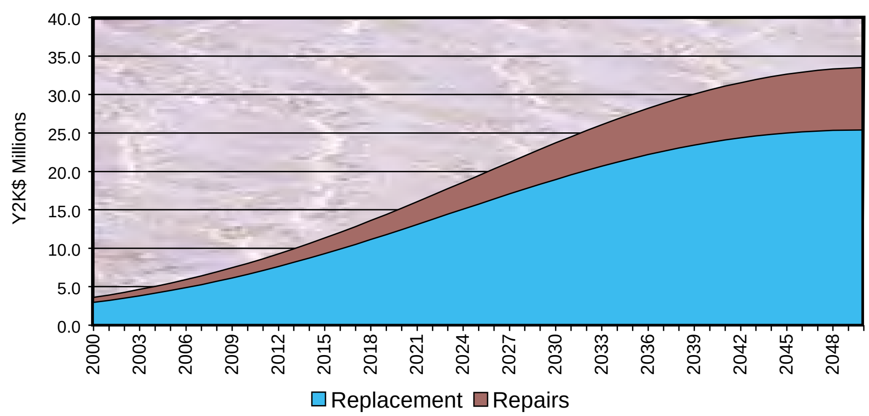

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Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,100 M

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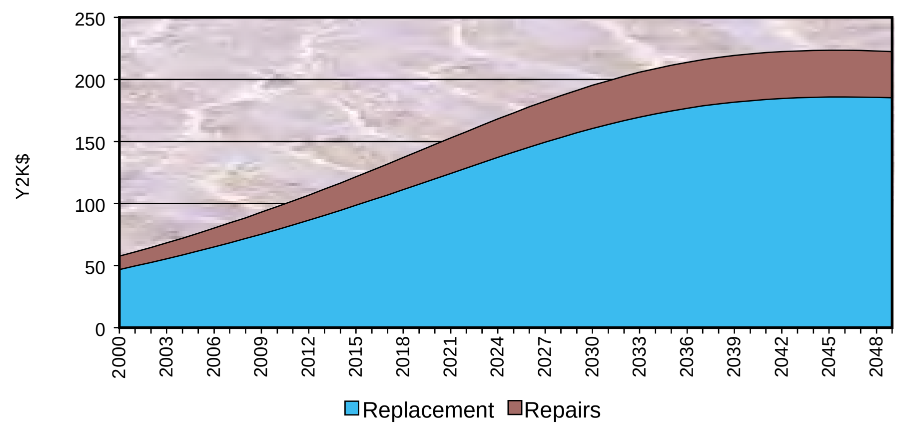

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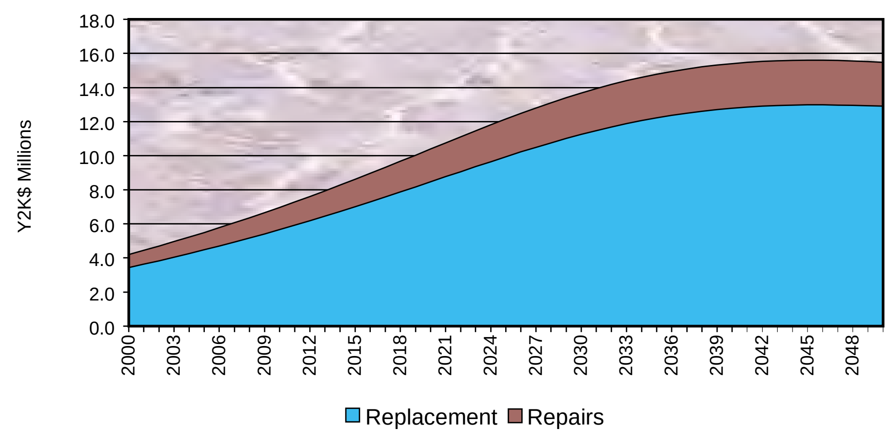

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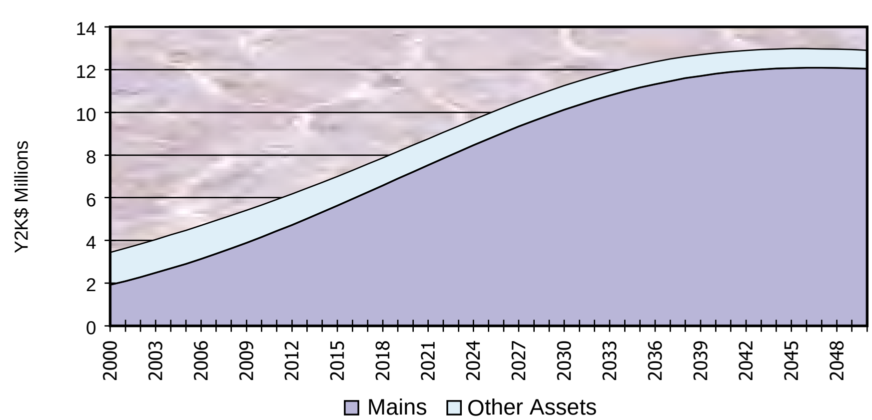

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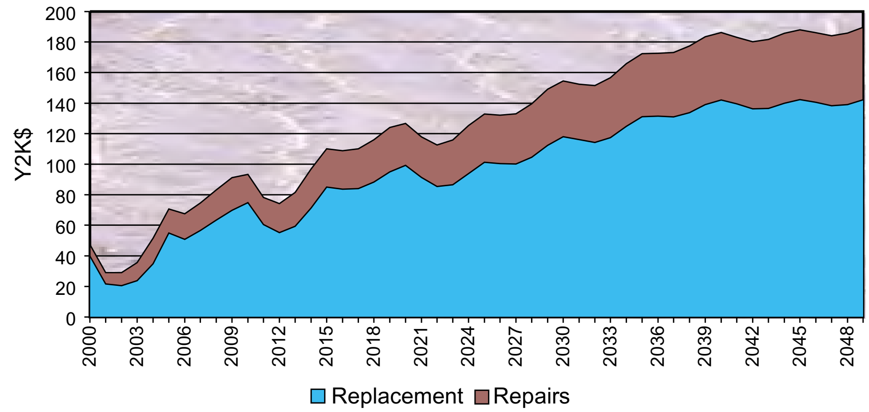
Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $1,852 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



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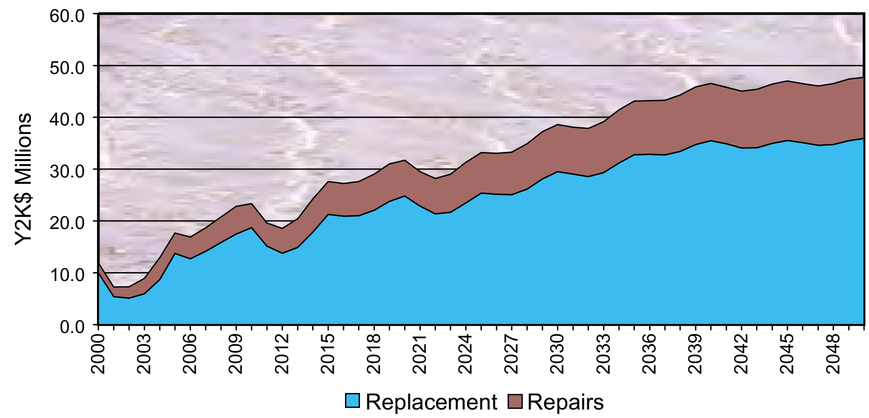

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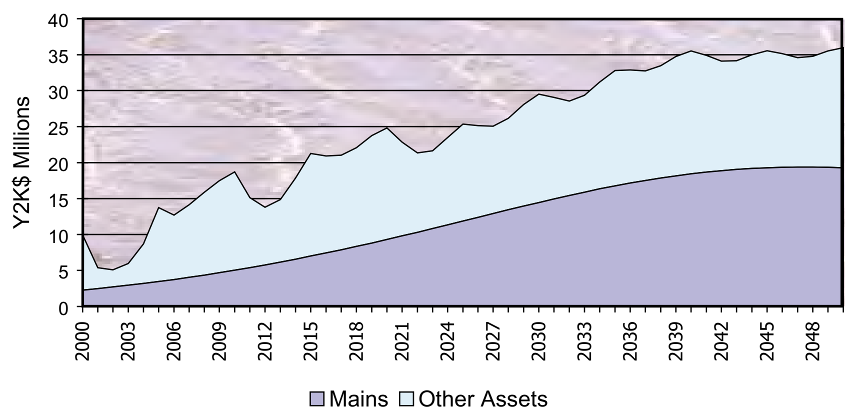
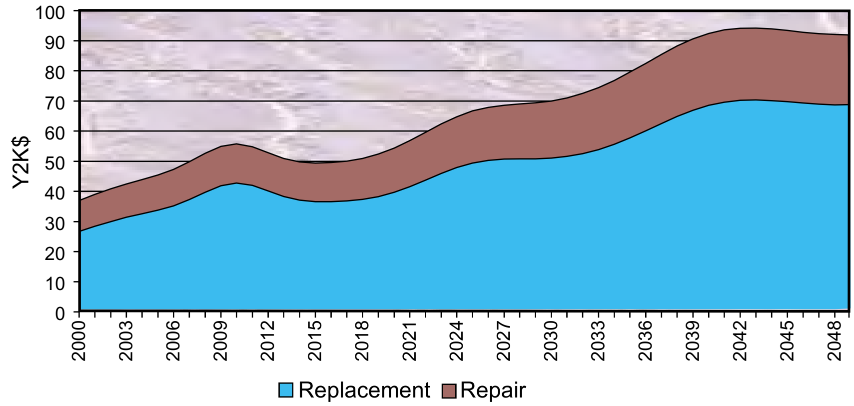


Wausau, Wisconsin

Asset Sets Modeled: Water Mains & Water Supply Plant — Estimated Replacement Value $84 M

Projected Per Household Expenditures Due to Wear-Out ($/hh/yr)



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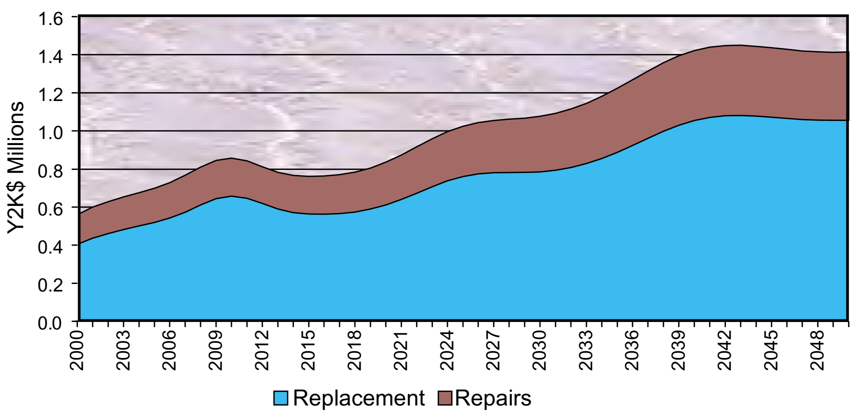

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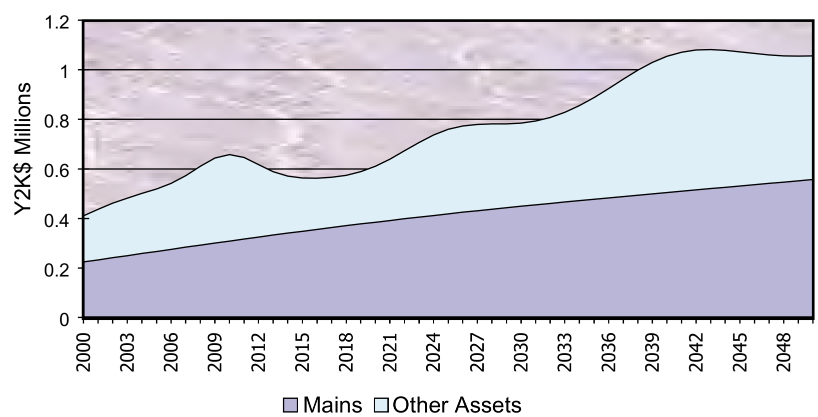

Reinvesting in Drinking Water Infrastructure

Dawn of the Replacement Era

APPENDIX B

ACKNOWLEDGMENTS

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Cincinnati, Ohio

Columbus Water Works
Columbus, Georgia

Denver Water Board
Denver, Colorado

Des Moines Water Works
Des Moines, Iowa

East Bay Municipal Utility District
Oakland, California

City of Gloucester
Gloucester, Massachusetts

Board of Water Supply
Honolulu, Hawaii

Louisville Water Company
Louisville, Kentucky

United Water New Rochelle
New Rochelle, New York

Philadelphia Water Department
Philadelphia, Pennsylvania

Portland Water Bureau
Portland, Oregon

St. Paul Regional Water Services
St. Paul, Minnesota

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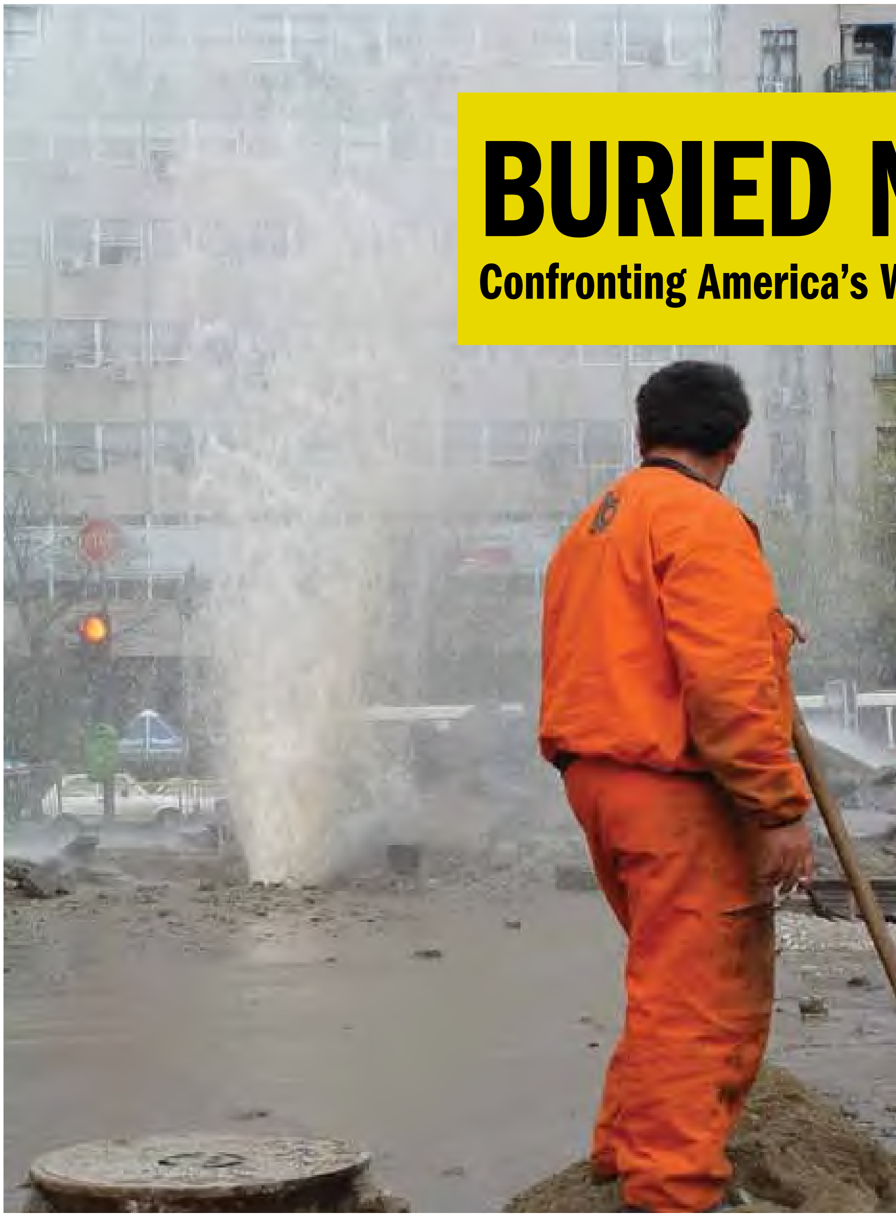
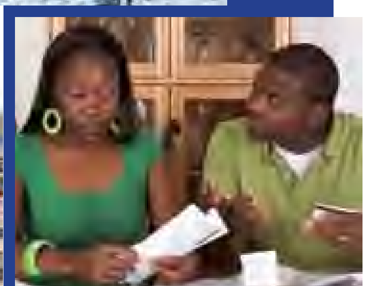
Footnote 3 Document

AWWA, 2012. *Buried No Longer: Confronting America's Water Infrastructure Challenge*. AWWA, Denver.



BURIED NO LONGER:

Confronting America's Water Infrastructure Challenge



American Water Works Association

The Authoritative Resource on Safe Water®

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This report was developed by the American Water Works Association under the direction of its Water Utility Council, through Stratus Consulting in Boulder, Colorado. Significant portions of the analyses described in this report were initiated or developed by John Cromwell, who unfortunately passed away before this project was completed. John was a true visionary, a wonderful friend and colleague, and an ardent believer in promoting sound management of water system infrastructure. We hope this report does proper service to John's intent, integrity and passion. Special recognition is also due to Bob Raucher, who completed the work with great attention to detail, patience and outstanding professionalism.

Haydn Reynolds is the developer of the Nessie Model and managed all the empirical investigations in this report. His continued engagement in the development of this report has been exemplary, as has been his willingness to address the many questions involved in the transition of the final report preparation from John Cromwell to Bob Raucher and others at Stratus Consulting. Finally, but not least, a number of AWWA utility members did significant work on this project, including Dave Rager (who chairs the Water Utility Council), Mike Hooker (who was WUC chair when the report was initiated), Aurel Arndt (who chairs the advisory work group on this project), and Joe Bella, John Sullivan, Richard Talley, Robert Walters, and Dave Weihrauch, all of whom made significant contributions as members of the advisory work group.

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Funding for this project was provided by the Water Industry Technical Action fund (WITAF). WITAF is funded through AWWA organizational member dues. It supports activities, information, and analysis to advance sound and effective drinking water legislation, regulation and policy.

Introduction. A new kind of challenge is emerging in the United States, one that for many years was largely buried in our national consciousness. Now it can be buried no longer. Much of our drinking water infrastructure, the more than one million miles of pipes beneath our streets, is nearing the end of its useful life and approaching the age at which it needs to be replaced. Moreover, our 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 $1 trillion over the next 25 years, if we are 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 we will have to face the need to “catch up” with past deferred investments, and the more we delay the harder the job will be when the day of reckoning comes.

In the years ahead, all of us 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 our water infrastructure has been less visible than other infrastructure concerns, it’s no less important. Our water treatment and delivery systems provide public health protection, fire protection, economic prosperity and the high quality of life we enjoy. Yet most Americans pay less than $3.75 for every 1,000 gallons of safe water delivered to their taps.

This report demonstrates that as a nation, we need 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 our children and grandchildren. It’s time to confront America’s water infrastructure challenge.

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 our nation would need to begin rebuilding the water and wastewater systems bequeathed to us by earlier generations. Our seminal report—*Dawn of the Replacement Era*—demonstrated that significant investments will be required in coming decades if we are to maintain the water and wastewater systems that are so essential to our 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 our future if we don't elevate it and begin to take action now.

The present report was undertaken to extend the *Dawn r*eport beyond those 20 original cities and encompass the entire United States. The results are startling. They confirm what every water utility professional knows: we face the need for massive reinvestment in our water infrastructure over the coming decades. The pipe networks that were largely built and paid for by earlier generations—and passed down to us 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 America'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 our 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 US Environmental Protection Agency's (USEPA) most recent "gap analysis"—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 report summarizes 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 we 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 examines the reinvestment demands implied by these factors, along with population trends, in order 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 our analysis include the following:

1. Understanding the original timing of water system development in the United States.
2. 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.
3. Understanding the life expectancy of the various types and sizes of pipe ("pipe cohorts") in actual operating environments.
4. Understanding the replacement costs for each type and size of pipe.
5. Developing a probability distribution for the "wear-out" of each pipe cohort.

Methodology

For this report, we differentiated across four water system size categories*:

- Very small systems (serving fewer than 3,300 people, representing 84.5% of community water systems).
- Small systems (3,300 to 9,999 served, representing 8.5% of community water systems).
- Medium-size systems (10,000 to 49,999 served, representing over 5.5% of systems). And,
- Large systems (serving more than 50,000 people, representing 1.5% of community water systems).

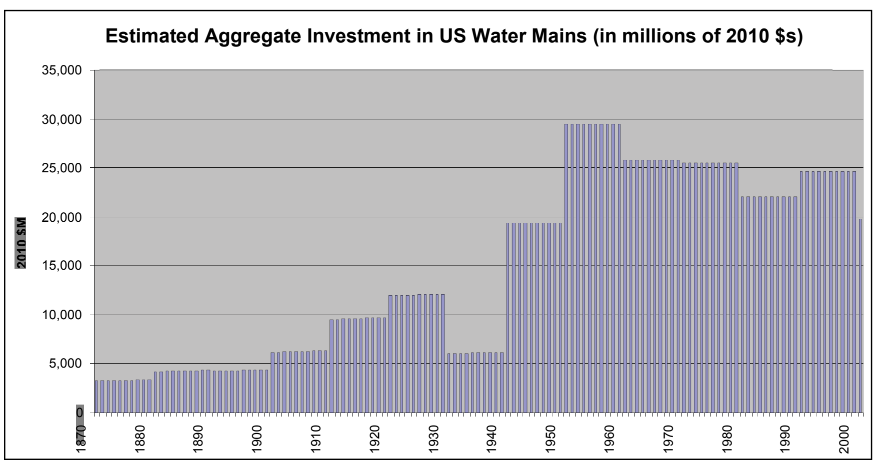
** Note that the water system size categories used in this analysis are not identical to the size categories USEPA uses for regulatory purposes. Note also that although data were analyzed based on these four size categories, some of the graphs that accompany this report combine medium-size and small systems. This is done for simplicity in the visual presentation, when the particular dynamics being represented are closely similar for medium-size and small systems.*

Next, we divided the country into four regions (Northeast, Midwest, South, and West), as shown in Figure 1. These regions are not equal in population, but they roughly share certain similarities, including their population dynamics and the

Figure 1: Regions Used in This Report

historical patterns of pipe installation driven by those dynamics. Data published by USEPA, the water industry, and the US Census Bureau were tapped to obtain a solid basis for regional pipe installation profiles by system size and pipe diameter. The US Census Bureau has produced a number of retrospective studies of the changes in urban and rural circumstances between 1900 and 2000 that proved especially useful in this analysis. The report also used the AWWA Water/Stats database, the USEPA Community Water Supply Survey, and data from the 2002 Public Works Infrastructure Survey (PWIS) as essential inputs in the analysis.

Figure 2: Historic Investment Profile for All US Water Systems, 1850-2000



In addition, we conducted a limited survey of professionals in the field concerning pipe replacement issues and other relevant "professional knowledge." The national aggregate for the original investment in all types and sizes of pipes is shown in Figure 2, while Figure 3 shows the aggregate current replacement value of water pipes by pipe material and utility size, totaling over $2.1 trillion.

Figure 3: Aggregate Replacement Value of Water Pipes by Pipe Material and Utility Size (millions 2010 $s)

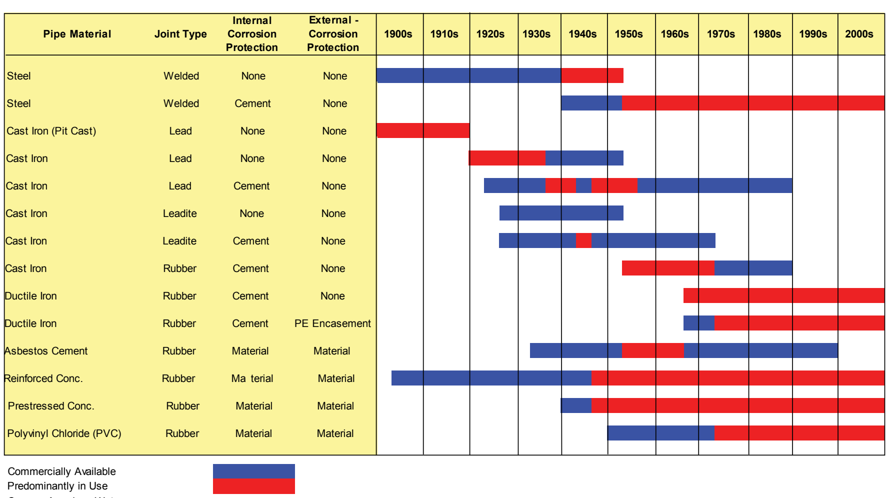
Region	CI	CICL	DI	AC	PV	Steel	PCCP	TOTAL
Northeast Large	48,958	8,995	5,050	2,308	1,875	335	0	67,522
Northeast Medium & Small	66,357	61,755	28,777	26,007	16,084	5,533	6,899	211,411
Northeast Very Small	14,491	15,992	10,661	7,281	7,937	329	462	57,152
Midwest Large	37,413	9,151	3,077	2,504	1,098	784	512	54,539
Midwest Medium & Small	74,654	92,106	51,577	37,248	30,506	8,682	11,152	305,925
Midwest Very Small	37,597	28,943	25,464	12,428	19,720	601	828	125,581
Southeast Large	30,425	28,980	29,569	21,229	14,936	9,337	7,227	141,703
South Medium & Small	54,772	98,608	140,079	103,659	102,804	21,394	17,160	538,475
South Very Small	43,183	24,998	49,791	34,529	47,823	1,461	1,244	203,028
West Large	15,448	16,055	28,949	14,774	14,723	7,443	6,215	103,607
West Medium & Small	15,775	50,145	70,355	50,541	48,885	12,276	9,806	257,782
West Very Small	16,344	11,199	17,910	13,166	17,245	545	453	76,862
Total	455,416	446,927	461,258	325,674	323,637	68,719	61,957	2,143,589

CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

Finally, we used historical data on the production and use of seven major types of pipe with 14 total variations (Figure 4) to estimate what kinds of pipe were installed in water systems in particular years. This was validated by field checking with a sample of water utilities as well as checking against the original Nessie analysis. Together these steps resulted in the development of 16 separate inventories (four regions with four utility sizes in each region), with seven types of pipe in each inventory, *thus providing the most comprehensive picture of the nation's water pipe inventory ever assembled.* Note that in some of the report's graphs, "long-" and "short-lived" versions of certain pipe materials are combined, for purposes of visual simplicity in the presentation.

In order to consider growth, it was also necessary to examine population trends across rural, suburban, and urban settings over the past century. US Census Bureau

Figure 4: Historic Production and Use of Water Pipe by Material



Source: American Water

projections of demographic trends allowed the development of infrastructure need profiles for growth through 2050 in each of the regions and utility size categories (for the latter purpose, city size was used as a proxy for utility size).

The study generally assumes that utilities continue efforts to manage the number of main breaks that occur per mile of pipe rather than absorb increases in pipe failures. That is, the study assumes utilities will strive to maintain current levels of service rather than allow increasing water service outages. We assume that each utility's objective is to make these investments at the optimal time for maintaining current service levels and to avoid replacing pipes while the repairs are still cost-effective. Ideally, pipe replacement occurs at the end of a pipe's "useful life"; that is, the point in time when replacement or rehabilitation becomes less expensive in going forward than the costs of numerous unscheduled breaks and associated emergency repairs.

With this data in hand and using the assumptions above, we projected the "typical" useful service life of the pipes in our inventory using the "Nessie Model"™. The model embodies pipe failure probability distributions based on many utilities' current operating experiences, coupled with insights from extensive research and professional experiences with typical pipe conditions at different ages and sizes, according to pipe material. The analysis used seven different types of pipe in three diameters and addressed pipe inventories dating back to 1870. Estimated typical service lives of pipes are

Figure 5: Average Estimated Service Lives by Pipe Materials (average years of service)

Derived Current Service Lives (Years)	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (LSL)	AC (SSL)	PVC	Steel	Conc & PCCP
Northeast Large	130	120	100	110	50	80	80	100	100	100
Midwest Large	125	120	85	110	50	100	85	55	80	105
South Large	110	100	100	105	55	100	80	55	70	105
West Large	115	100	75	110	60	105	75	70	95	75
Northeast Medium & Small	115	120	100	110	55	100	85	100	100	100
Midwest Medium & Small	125	120	85	110	50	70	70	55	80	105
South Medium & Small	105	100	100	105	55	100	80	55	70	105
West Medium & Small	105	100	75	110	60	105	75	70	95	75
Northeast Very Small	115	120	100	120	60	100	85	100	100	100
Midwest Very Small	135	120	85	110	60	80	75	55	80	105
South Very Small	130	110	100	105	55	100	80	55	70	105
West Very Small	130	100	75	110	60	105	65	70	95	75

LSL indicates a relatively long service life for the material resulting from some combination of benign ground conditions and evolved laying practices etc.
SSL indicates a relatively short service life for the material resulting from some combination of harsh ground conditions and early laying practices, etc.

Figure 6: Aggregate Needs for Investment in Water Mains Through 2035 and 2050, by Region

2011-2035 Totals			
(2010 $M)	**Replacement**	**Growth**	**Total**
Northeast	$92,218	$16,525	$108,744
Midwest	$146,997	$25,222	$172,219
South	$204,357	$302,782	$507,139
West	$82,866	$153,756	$236,622
Total	**$526,438**	**$498,285**	**$1,024,724**

2011-2050 Totals			
(2010 $M)	**Replacement**	**Growth**	**Total**
Northeast	$155,101	$23,200	$178,301
Midwest	$242,487	$36,755	$279,242
South	$394,219	$492,493	$886,712
West	$159,476	$249,794	$409,270
Total	**$951,283**	**$802,242**	**$1,753,525**

reflected in Figure 5. Note that the *actual* lives of pipes may be quite different in a given utility. Because pipe life depends on many important local variables as well as upon utility practices, predicting the actual life expectancy of any given pipe is outside the scope of this study. Many utilities will have pipes that last much longer than these values suggest while others will have pipes that begin to fail sooner. However, these values have been validated as national "averages" by comparing them to actual field experience in a number of utilities throughout the country. The model also includes estimates of the indicative costs to replace each size category of pipe, as well as the cost to repair the projected number of pipe breaks over time according to pipe size.

The analysis of pipe replacement needs is compiled in the Nessie Model by combining the demographically based pipe inventories with the projected effective service lifetimes for each pipe type. This yields an estimate of how much pipe of each size in each region must be replaced in each of the coming 40 years. Factoring in the typical cost to replace these pipes, we derive an estimate of the total investment cost for each future year. The model then derives a series of graphs (the Nessie curves) that depict the amount of spending required in each future year to replace each of the different pipe types by utility size and region. Aggregating this information, we derived the dollar value of total drinking water infrastructure replacement needs over the coming 25 and 40 years for each utility size category per region, and for the United States.

Key Findings

1. The Needs Are Large. *Investment needs for buried drinking water infrastructure total more than $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).

Over the coming 40-year period, *through 2050, these needs exceed $1.7 trillion.* Replacement needs account for about 54% of the national total, with about 46% attributable to population growth and migration over that period.

Figure 6 (previous page) shows aggregate needs for investment in water mains through 2050, due to wear-out and population growth.

2. 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). Figures 7 and 8 illustrate the increasing cost of water that can be expected by households for replacement, and for replacement plus growth, respectively. The utility categories shown in these figures are presented to depict a range of household cost impacts, from the least-to-the-most affected utilities.

Figure 7: Costs per Household for Water Main Replacement by Utility Size and Region

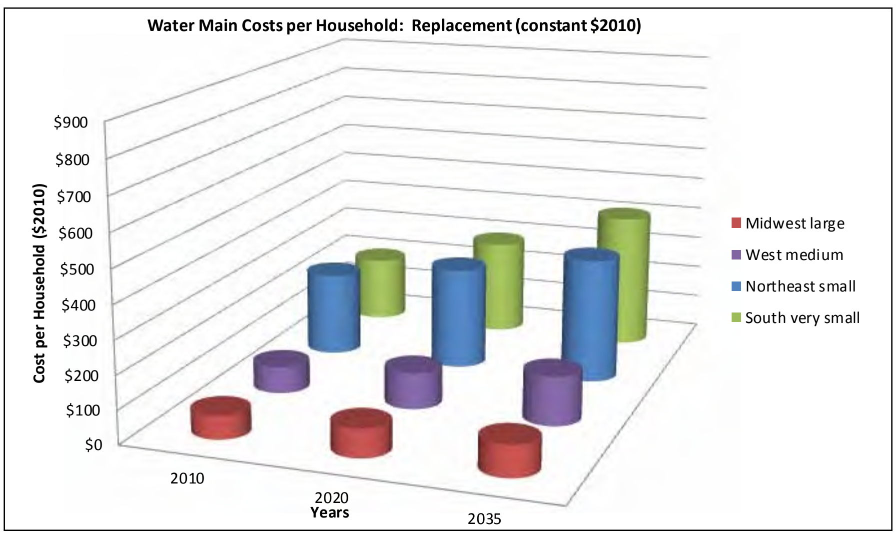
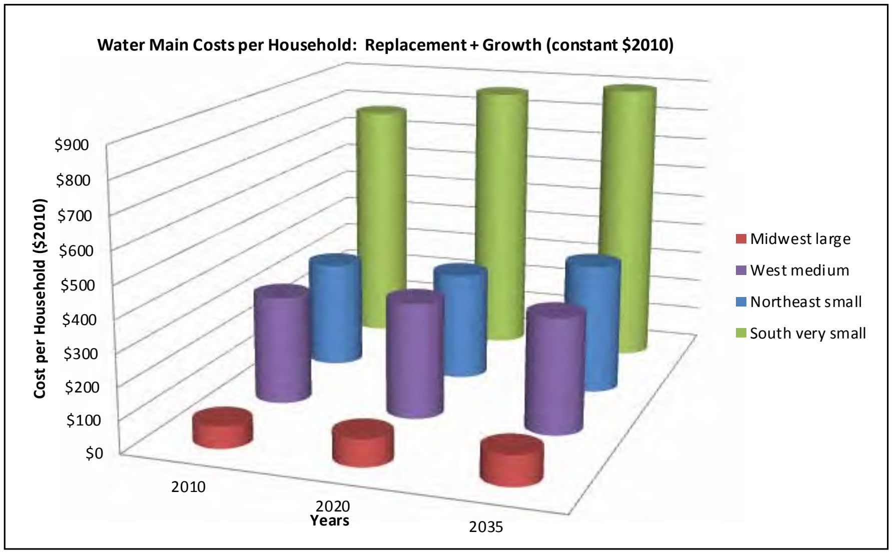


Figure 8: Costs per Household for Water Main Replacement Plus Growth

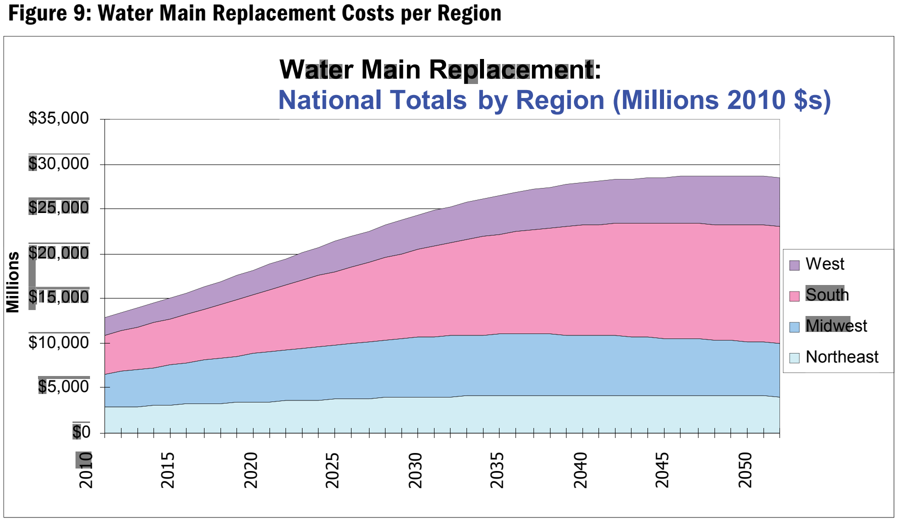


With respect to the cost of growth, other caveats are important. Many communities expect growth to pay or help pay for itself through developer fees, impact fees, or similar charges. In such communities, established residents will not be required to shoulder the cost of population growth to the extent 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.*

3. 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 (see Figures 6 and 9). 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.

Figure 9: Water Main Replacement Costs per Region



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.

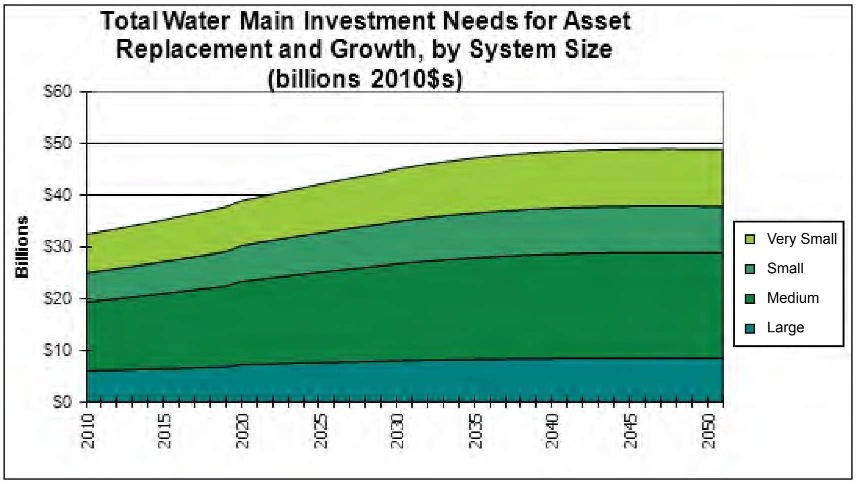
4. There Are Important Differences Based on System Size.

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 $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 $75 to more than $100 per year by the mid-2030s, assuming the expenses were spread across the population in the year they were incurred. Figure 10 illustrates the differing total costs of required investment by system size.

5. The Costs Keep Coming. The national-level investment we face will roughly double from about $13 billion a year in 2010 to almost $30 billion annually by the 2040s for replacement alone. If growth is included, needed investment must increase from a little over $30 billion today to nearly $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.*

Figure 10: Total Water Main Replacement and Growth Needs by System Size



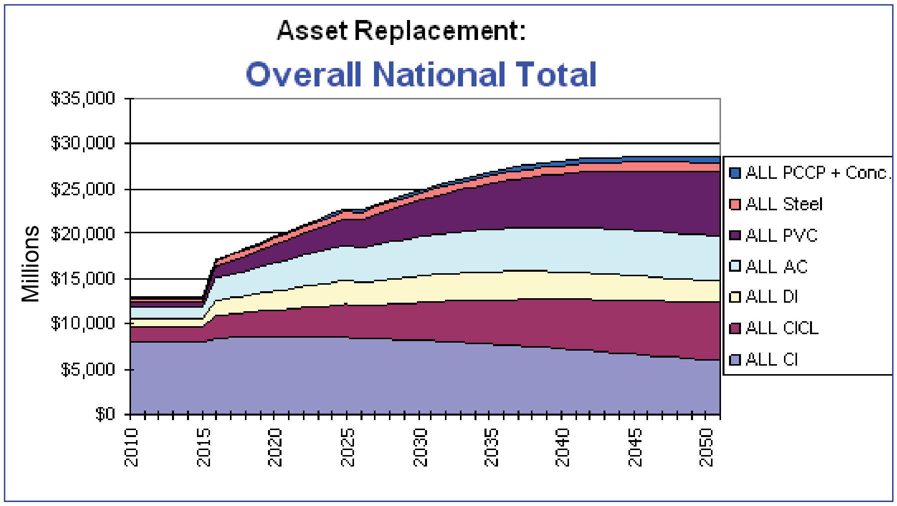
6. Postponing Investment Only Makes the Problem Worse.

Overlooking or postponing infrastructure renewal investments in the near term will only add to the scale of the challenge we face in the years to come. Postponing the investment steepens the slope of the investment curve that must ultimately be met, as shown in Figure 11 (next page). 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 $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 daunting as the figures in this report are, the prospect of not making the necessary investment is even more chilling. 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. As large as the cost of reinvestment may be, **not** undertaking it will be worse in the long run by almost any standard.

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.

Figure 11: Effect of Deferring Investment Five Years with a Ten-Year Make-Up Period



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. We can incur the haphazard and growing costs of living with aging and failing drinking water infrastructure. Or, we can carefully prioritize and undertake drinking water infrastructure renewal investments to ensure that our water utilities can continue to reliably and cost-effectively support the public health, safety, and economic vitality of our 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.

Additional Information and Resources.

A full and robust infrastructure analysis is an indispensable tool for decision making by water and wastewater utilities. This report does not substitute for such detailed local analysis for purposes of designing an infrastructure asset management program for individual utilities.

Additional information is available from AWWA concerning asset management. Particular attention should be given to the WITAF reports *Dawn of the Replacement Era, Avoiding Rate Shock, Thinking Outside the Bill* and *Water Infrastructure at a Turning Point.* In addition, Manual M1, *Principles of Water Rates, Fees, and Charges*, and the AWWA Utility Management Standards may be helpful. For more information, visit the AWWA Bookstore at **www.awwa.org/store.**

A number of graphs and figures from this report are also available through the AWWA website at **www.awwa.org/infrastructure.** They include:

Estimated Distribution of Mains by Material
Northeast and Midwest
South and West

Proportion of 2010 Systems Built by Year
Northeast
Midwest
South
West

Investment for Replacement Plus Growth, by Region and Size of Utility

Northeast
Large
Medium
Small
Very Small

Midwest
Large
Medium
Small
Very Small

South
Large
Medium
Small
Very Small

West
Large
Medium
Small
Very Small

Household Cost of Needed Investment by Region and Size of Utility

Northeast
Large
Medium
Small
Very Small

Midwest
Large
Medium
Small
Very Small

South
Large
Medium
Small
Very Small

West
Large
Medium
Small
Very Small

www.awwa.org/infrastructure

Estimated Distribution of Mains by Material Over Time
Northeast & Midwest Regions

	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (LSL)	AC (SSL)	PVC	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (SSL)	AC (LSL)	PVC	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	AC (LSL)	Steel	Conc & PCCP
	<6 inch diameter								6-10 inch diameter								>10 inch diameter						
1870	100%								100%								100%						
1880	100%								100%								100%						
1890	100%								100%								100%						
1900	100%								100%								100%						
1910	100%								100%								100%						
1920	100%								100%								100%						
1930	50%	30%	20%						50%	30%	20%						50%	30%	20%				
1940	20%	60%	20%						20%	60%	20%						20%	40%	20%			20%	
1950		60%				20%	20%			60%				20%	20%			40%			10%	20%	30%
1960		50%			10%	20%	20%			50%			10%	20%	20%			35%		5%	10%	20%	30%
1970		20%			40%			40%		20%			40%			40%				50%		20%	30%
1980				25%	30%			45%				25%	35%			40%				60%		15%	25%
1990				50%	5%			45%				50%	5%			45%				60%		15%	25%
2000				55%				45%				55%				45%				60%		15%	25%
2010				55%				45%				55%				45%				60%		15%	25%
2020				55%				45%				55%				45%				60%		15%	25%
2030				55%				45%				55%				45%				60%		15%	25%

Steel and PCCP pipe not in widespread use in sizes under 10 inches.

CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

The regions are combined because they share similar dynmaics for this distribution.

Note:
"LSL" indicates a relatively long service life for the material resulting from some combination of benign ground conditions and evolved laying practices etc.

"SSL" indicates a relatively short service life for the material resulting from some combination of harsh ground conditions and early laying practices etc.

Estimated Distribution of Mains by Material Over Time
South & West Regions

	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (LSL)	AC (SSL)	PVC	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	DI (SSL)	AC (LSL)	AC (SSL)	PVC	CI	CICL (LSL)	CICL (SSL)	DI (LSL)	AC (LSL)	Steel	Conc & PCCP
	<6 inch diameter								6-10 inch diameter								>10 inch diameter						
1870	100%								100%								100%						
1880	100%								100%								100%						
1890	100%								100%								100%						
1900	100%								100%								100%						
1910	100%								100%								100%						
1920	100%								100%								100%						
1930	50%	30%	20%						50%	30%	20%						50%	30%	20%				
1940		70%	30%							70%	30%							50%	30%			20%	
1950		25%				40%	35%			25%				40%	35%			40%			15%	25%	20%
1960		25%		2%	3%	40%	30%			25%		2%	3%	40%	30%			40%		5%	10%	25%	20%
1970		10%		10%	10%	40%		30%		10%		10%	10%	40%		30%				45%	10%	25%	20%
1980				25%	25%			50%				30%	30%			40%				60%		20%	20%
1990				45%	5%			50%				50%	5%			45%				60%		20%	20%
2000				50%				50%				50%				50%				60%		20%	20%
2010				50%				50%				50%				50%				60%		20%	20%
2020				50%				50%				50%				50%				60%		20%	20%
2030				50%				50%				50%				50%				60%		20%	20%

Steel and PCCP pipe not in widespread use in sizes under 10 inches.

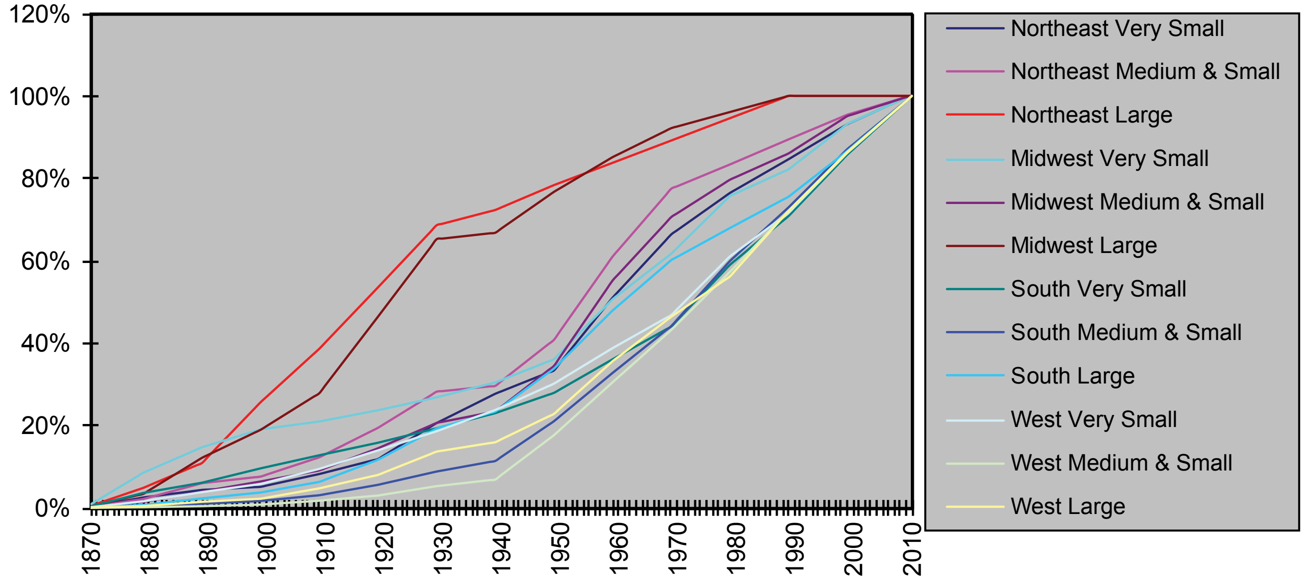
CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

The regions are combined because they share similar dynmaics for this distribution.

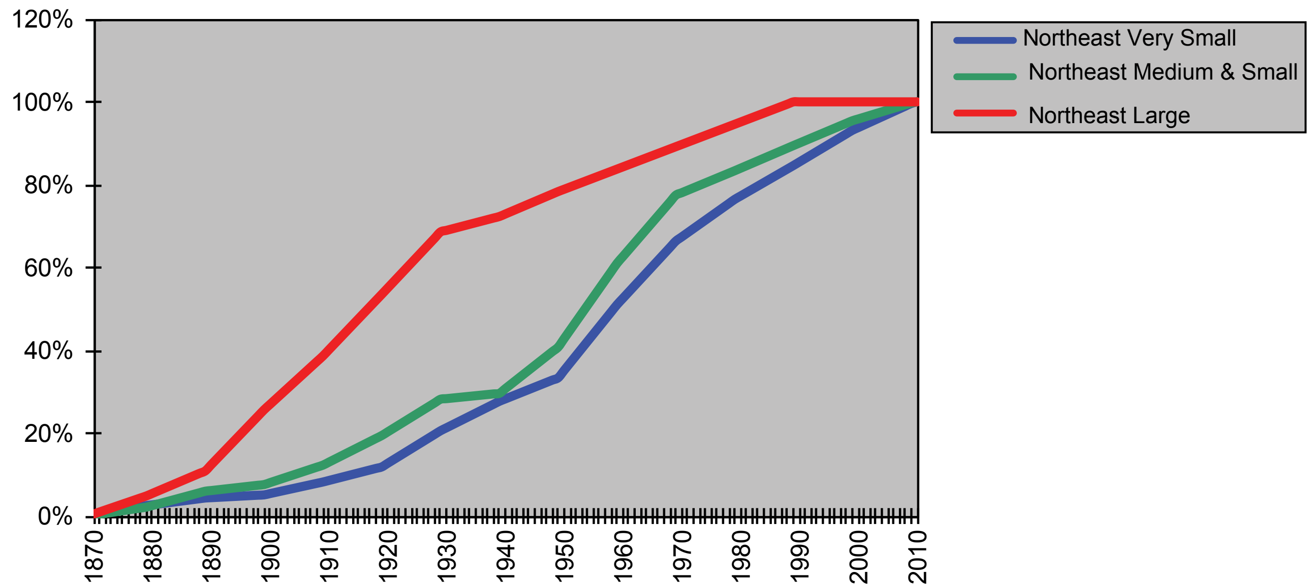
Note:
"LSL" indicates a relatively long service life for the material resulting from some combination of benign ground conditions and evolved laying practices etc.

"SSL" indicates a relatively short service life for the material resulting from some combination of harsh ground conditions and early laying practices etc.

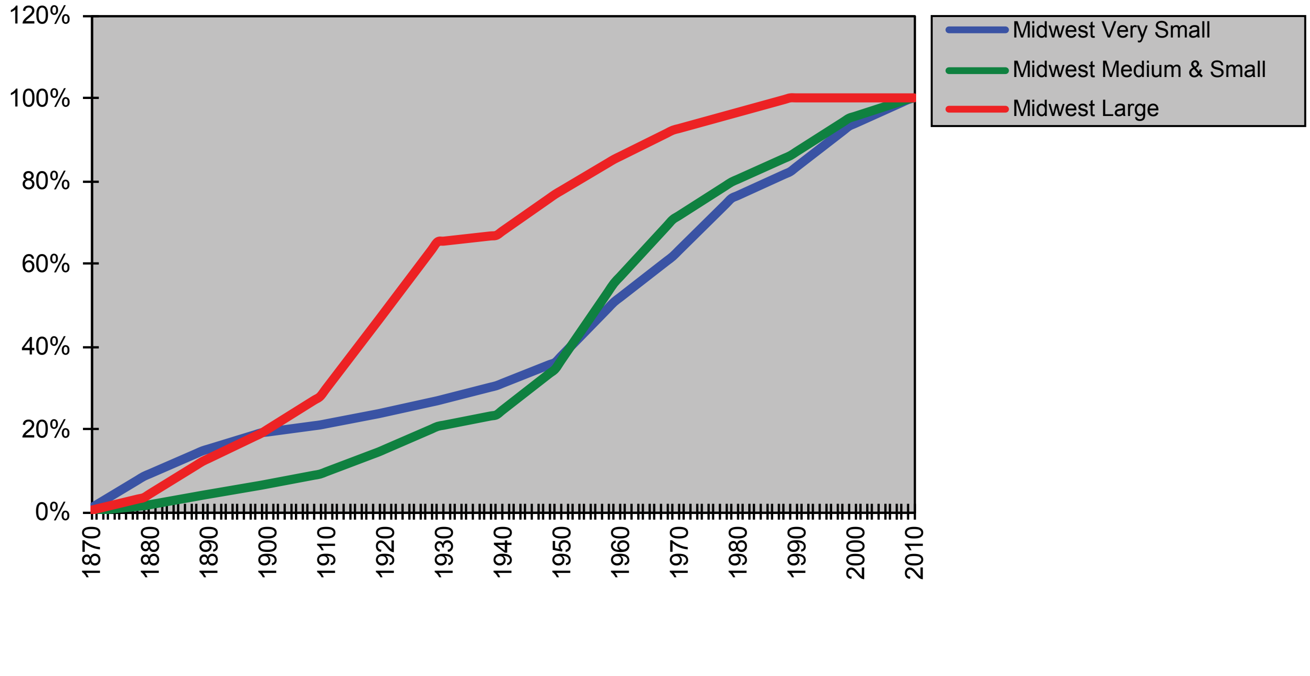
Proportion of Current System Built by Decade: All Regions



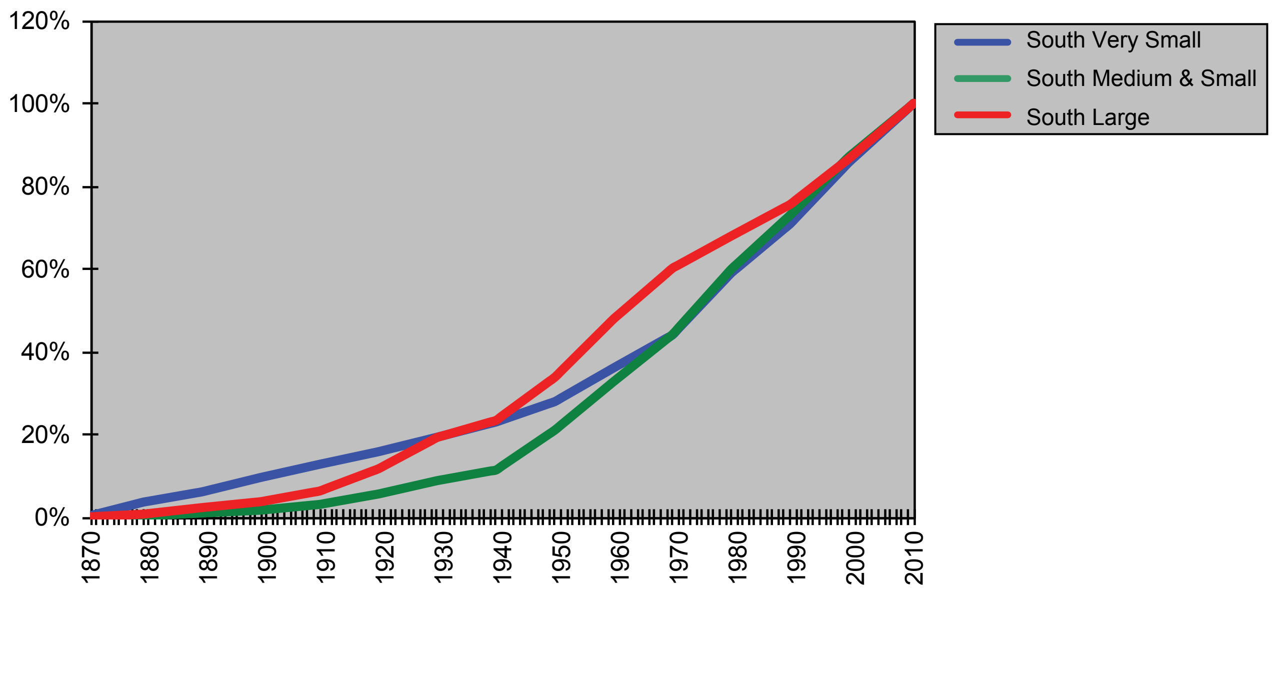
Proportion of Current System Built by Decade: Northeast



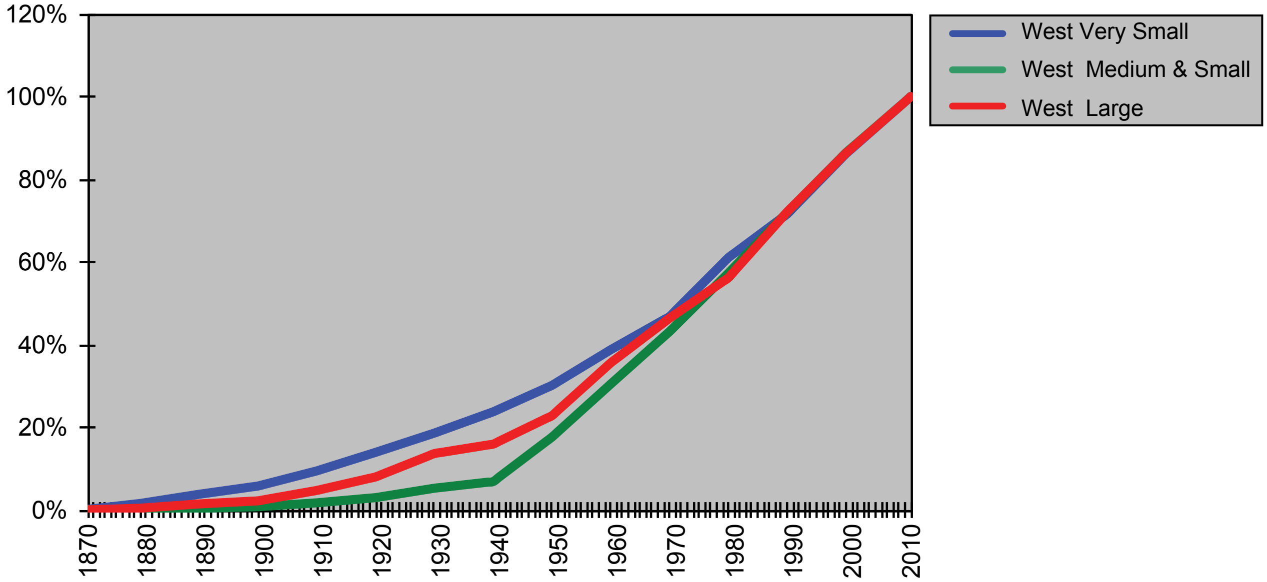
Proportion of Current System Built by Decade: Midwest



Proportion of Current System Built by Decade: South

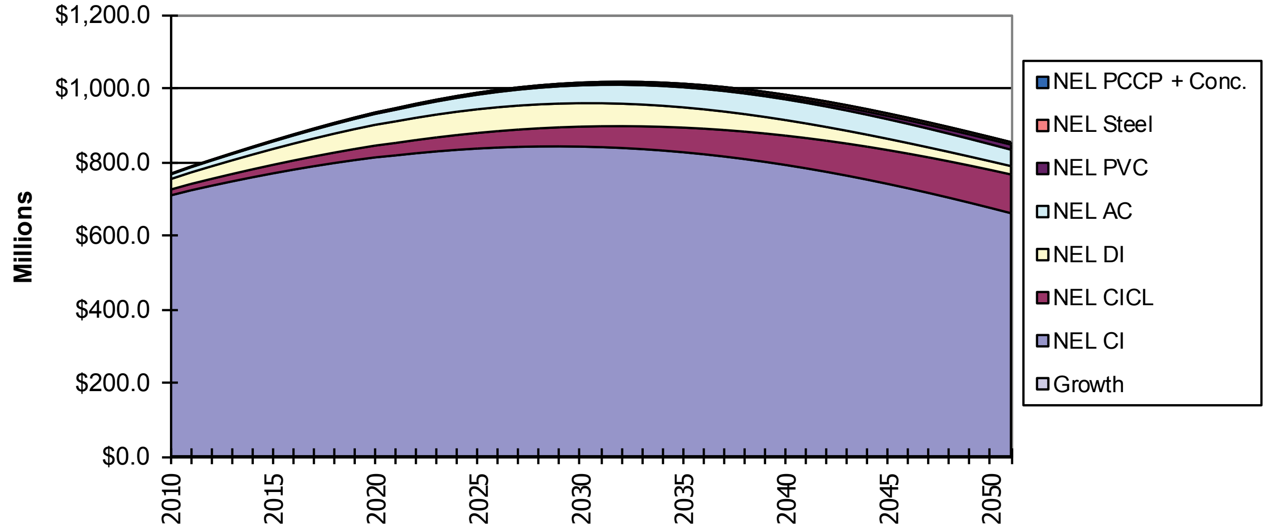


Proportion of Current System Built by Decade: South



Investment for Replacement & Growth

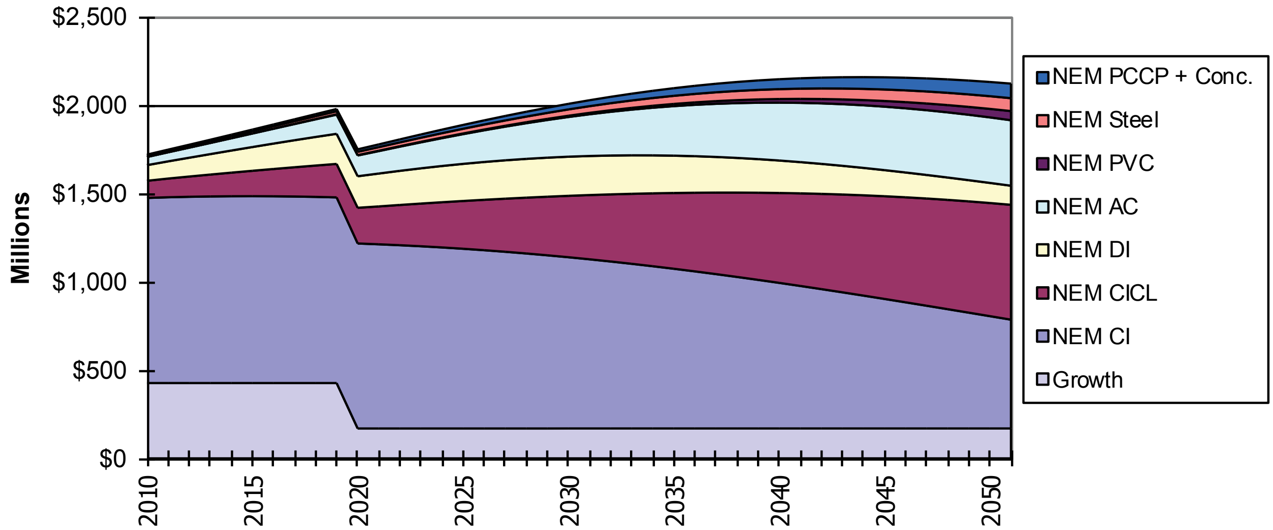
Northeast Large



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

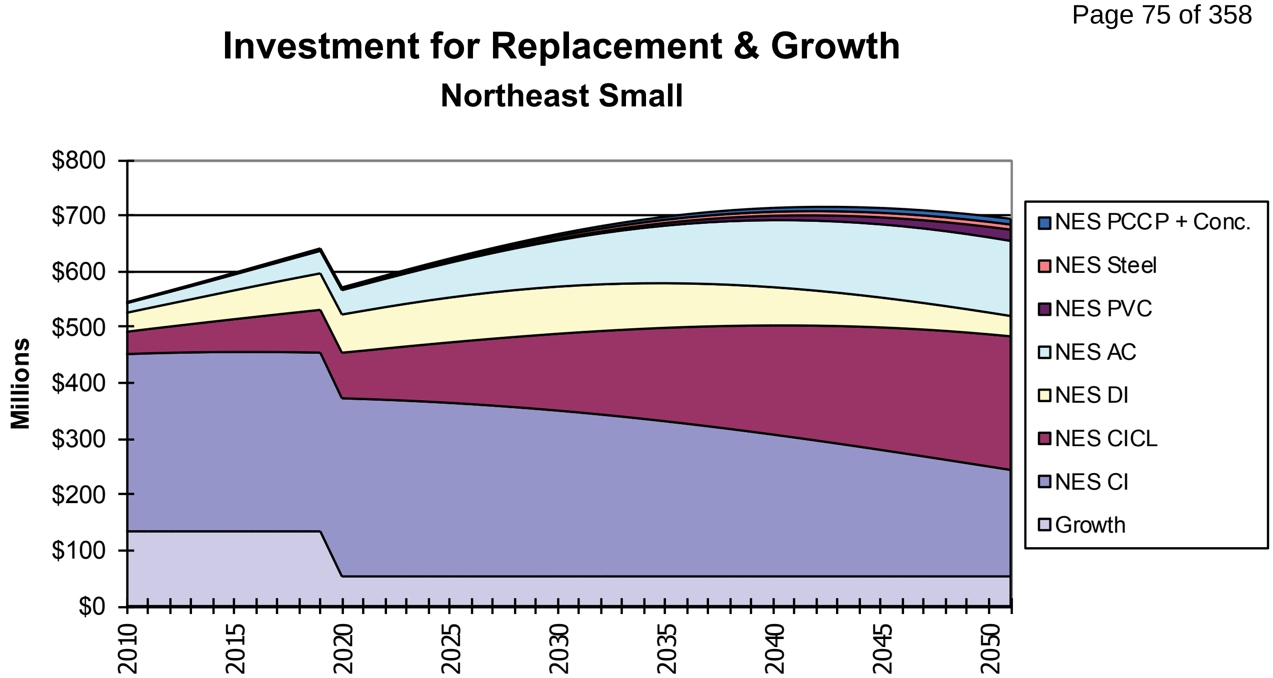
Investment for Replacement & Growth

Northeast Medium



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

The charts show needs for replacement of particular types of pipe and for growth (see the keys below and to the right of the chart). An artifact of the model and US Census data result in an apparent upward or downward "spike" in growth-related needs between certain decades. In reality, the apparent sudden shift in growth-related needs will be spread more evenly over the years bridging each decade to the next.



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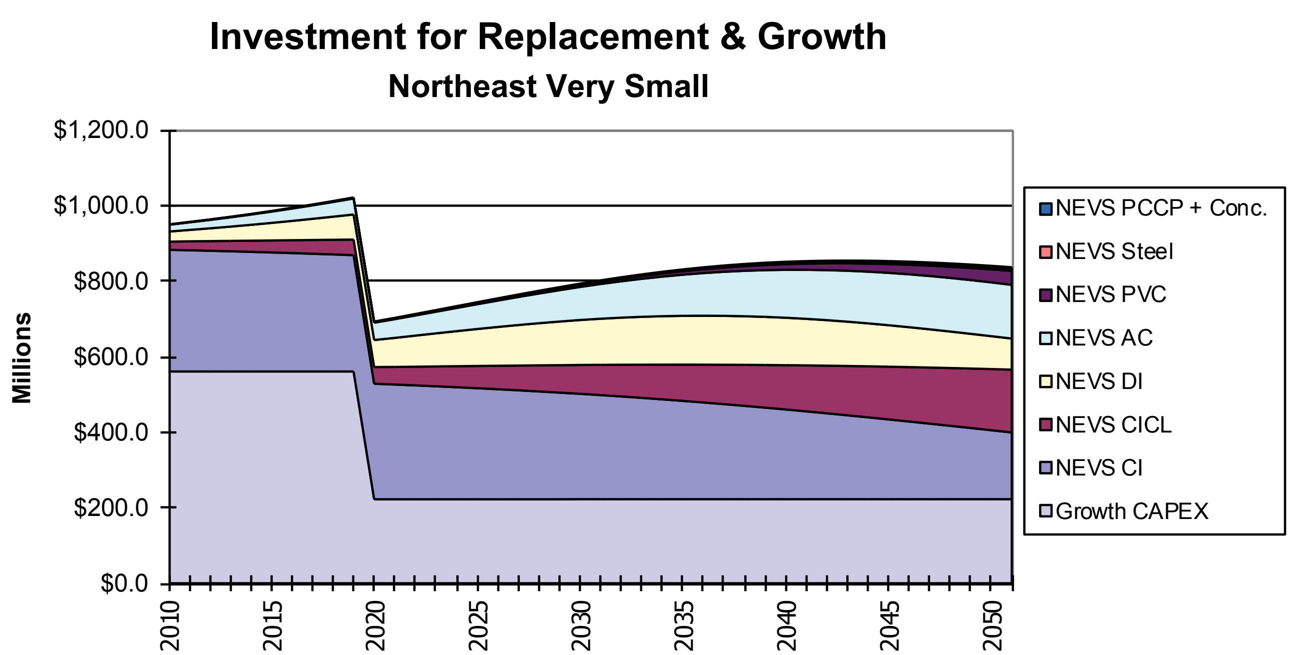

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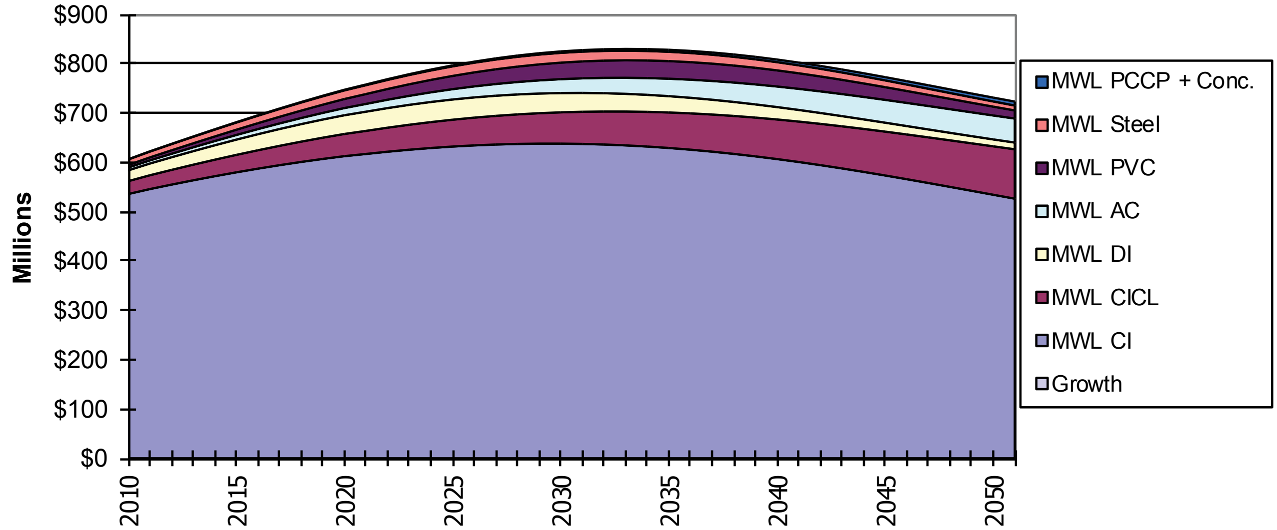
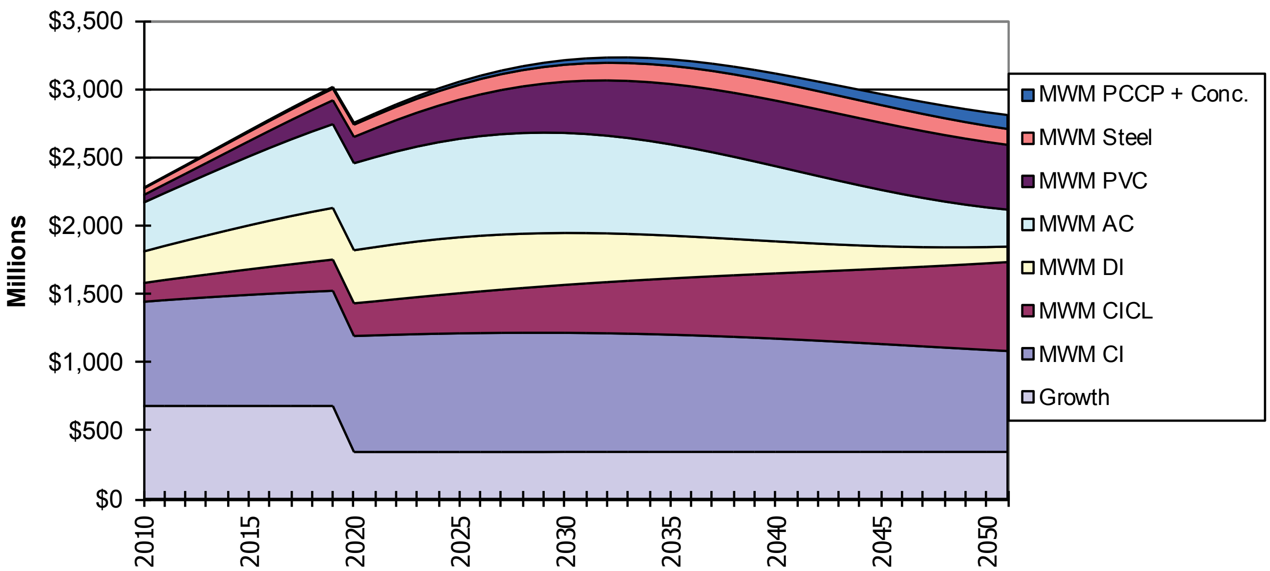
Investment for Replacement & Growth
Midwest Large



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

Investment for Replacement & Growth
Midwest Medium



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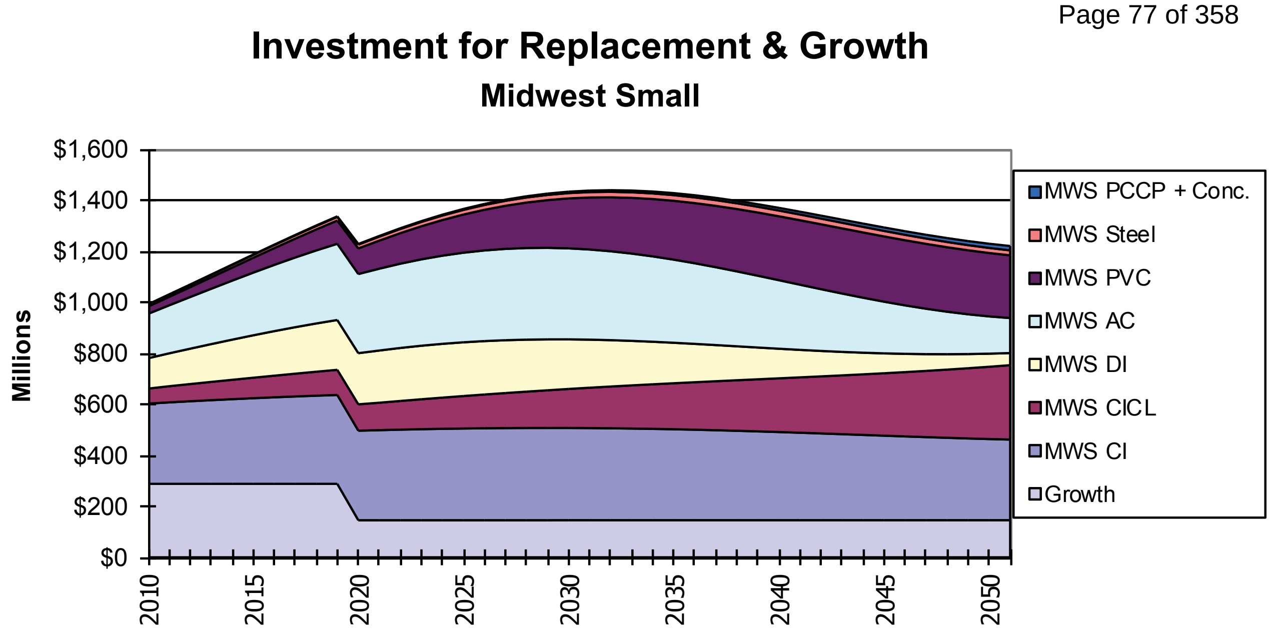
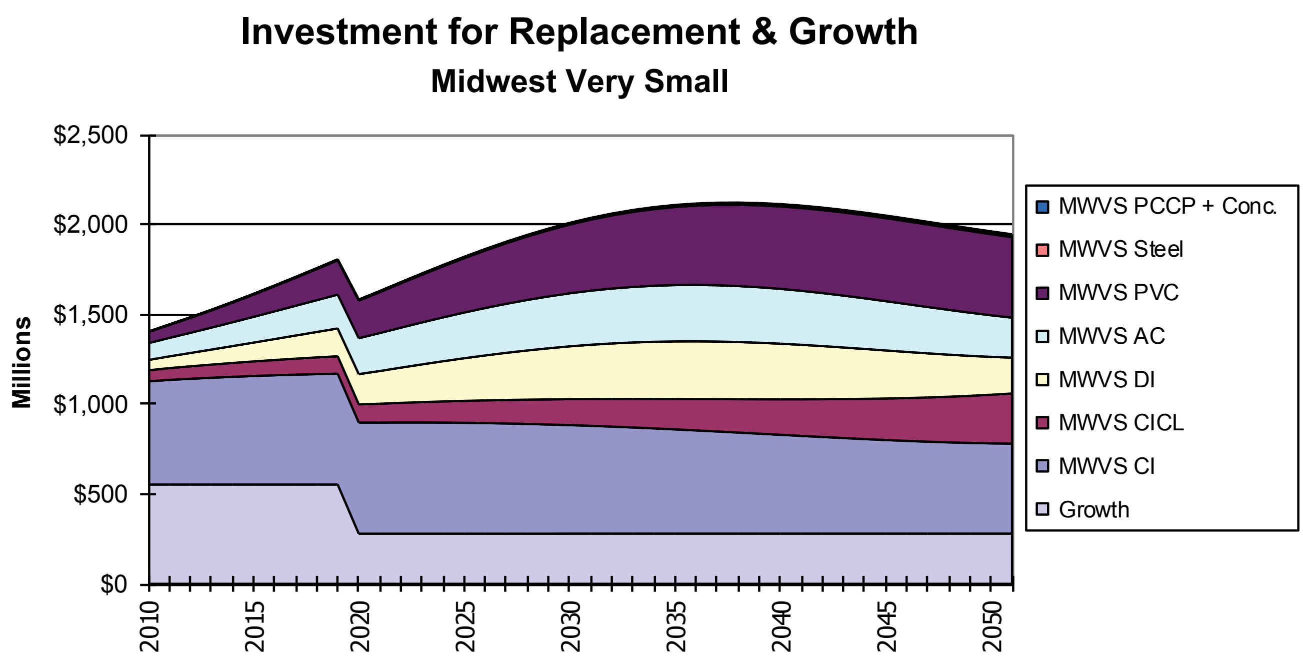
The charts show needs for replacement of particular types of pipe and for growth (see the keys below and to the right of the chart). An artifact of the model and US Census data result in an apparent upward or downward "spike" in growth-related needs between certain decades. In reality, the apparent sudden shift in growth-related needs will be spread more evenly over the years bridging each decade to the next.



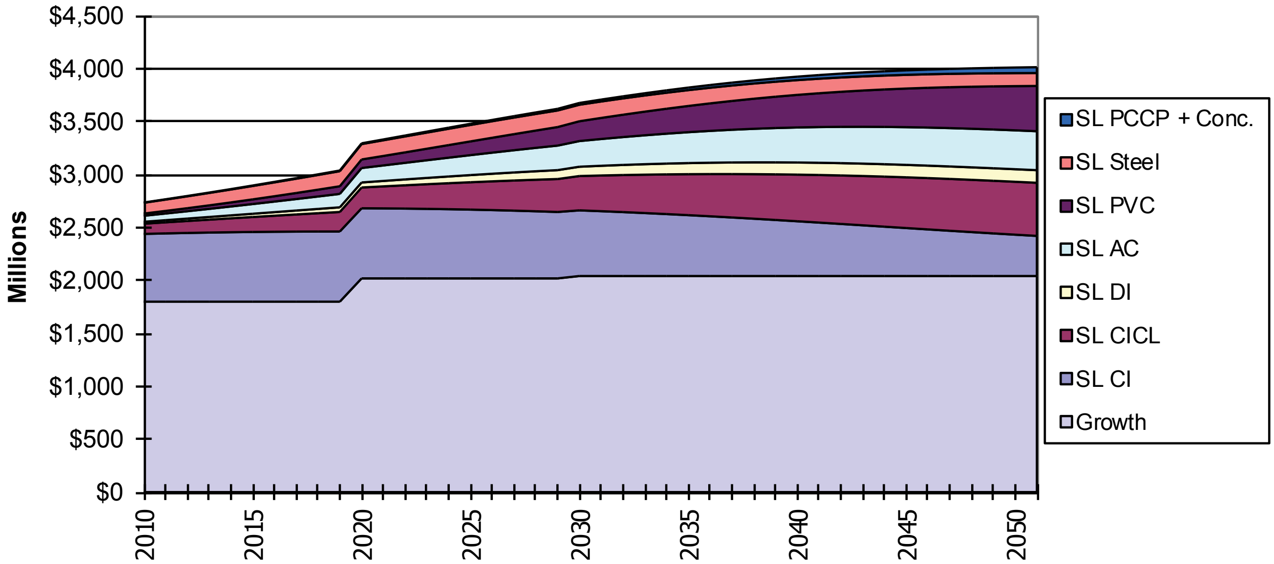
CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

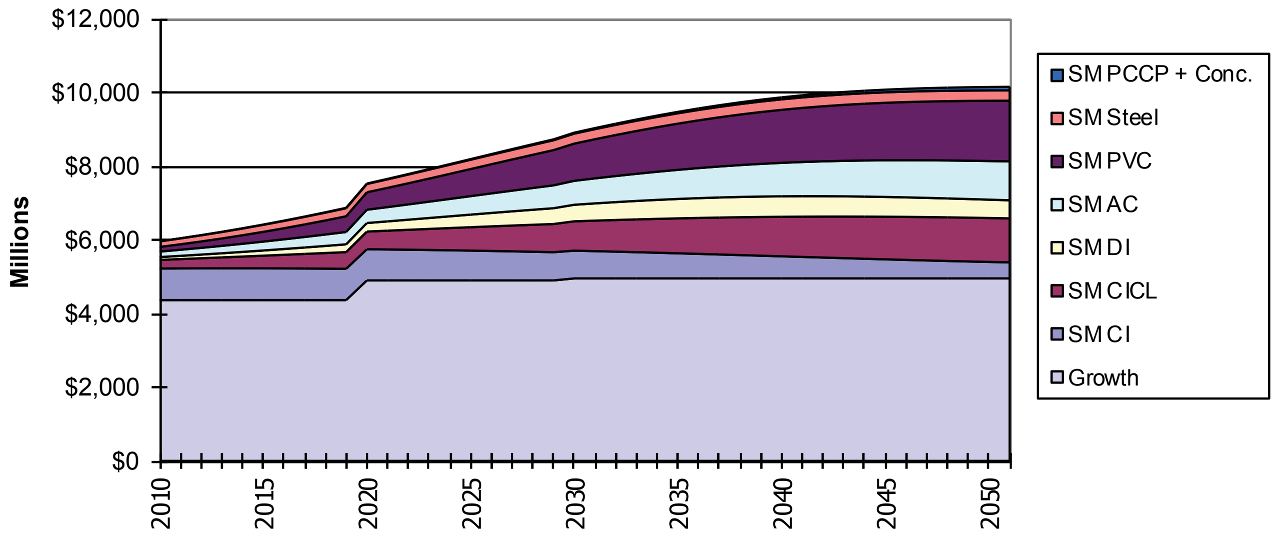
The charts show needs for replacement of particular types of pipe and for growth (see the keys below and to the right of the chart). An artifact of the model and US Census data result in an apparent upward or downward "spike" in growth-related needs between certain decades. In reality, the apparent sudden shift in growth-related needs will be spread more evenly over the years bridging each decade to the next.

Investment for Replacement & Growth
South Large



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

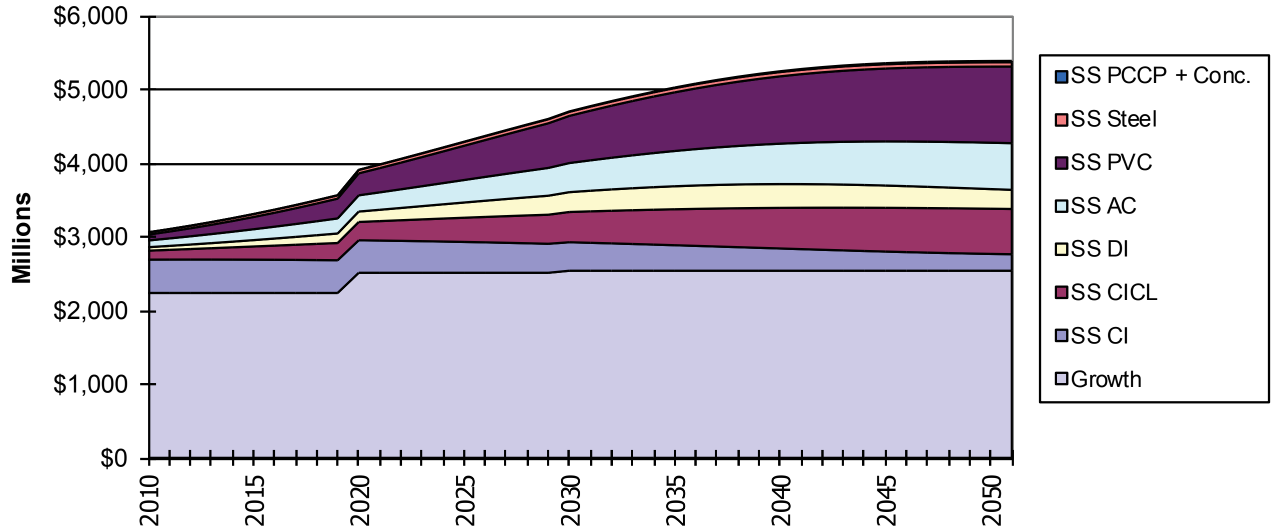
Investment for Replacement & Growth
South Medium



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

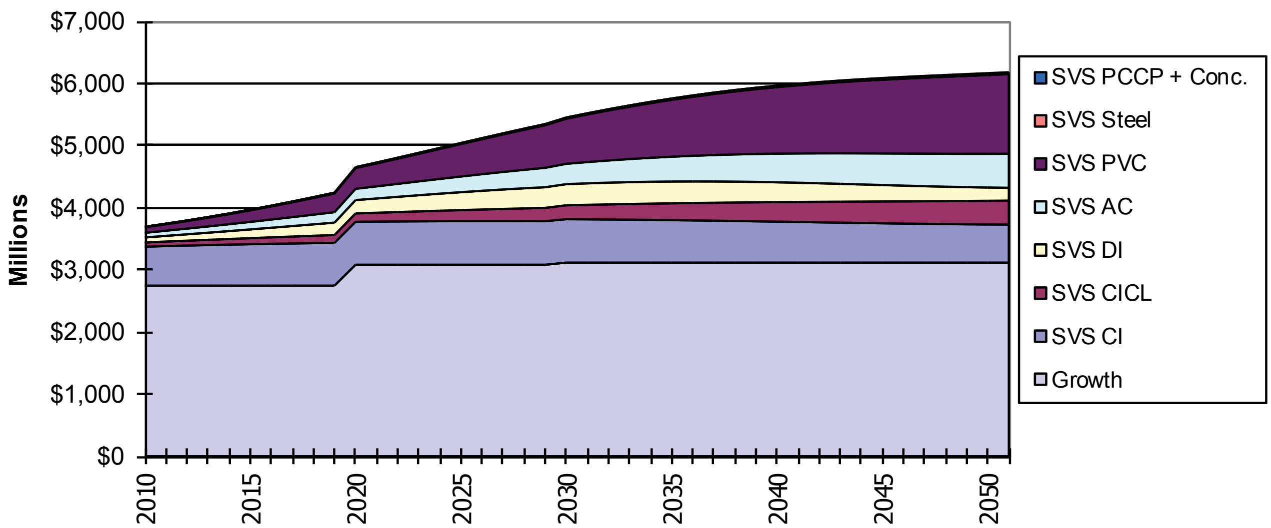
The charts show needs for replacement of particular types of pipe and for growth (see the keys below and to the right of the chart). An artifact of the model and US Census data result in an apparent upward or downward "spike" in growth-related needs between certain decades. In reality, the apparent sudden shift in growth-related needs will be spread more evenly over the years bridging each decade to the next.

Investment for Replacement & Growth
South Small



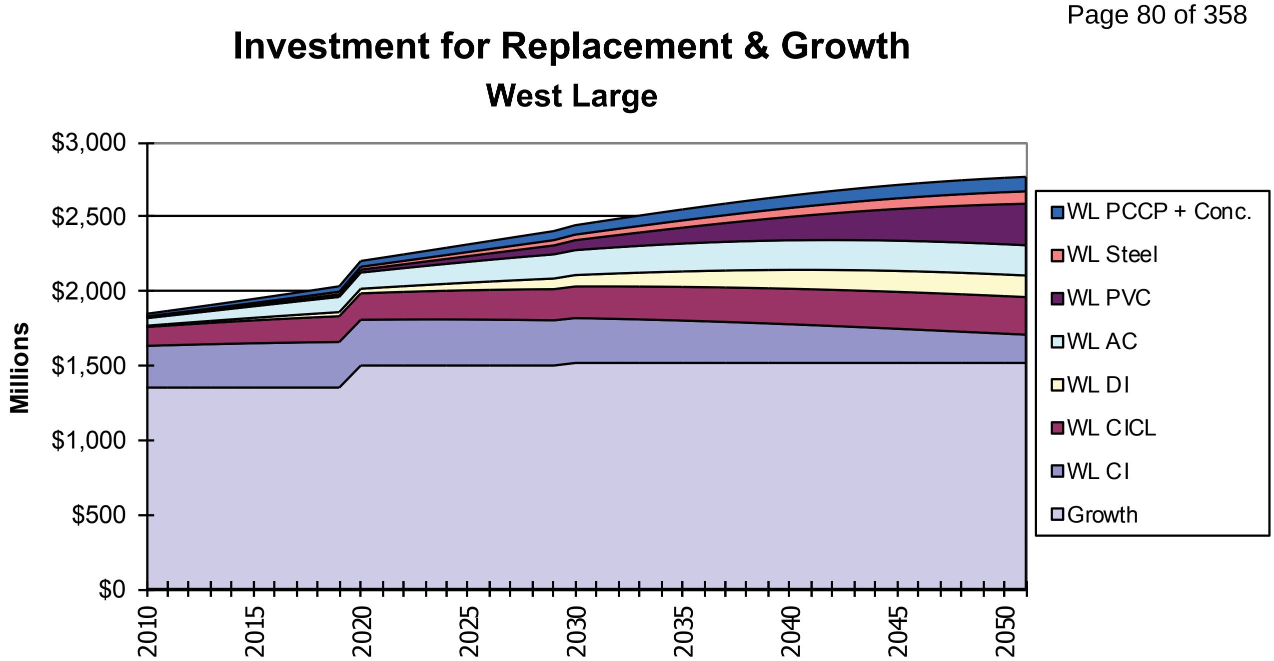
CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

Investment for Replacement & Growth
South Very Small



CI: cast iron; CICL: cast iron cement lined; DI: ductile iron; AC: asbestos cement; PV: polyvinyl chloride; PCCP: prestressed concrete cylinder pipe

The charts show needs for replacement of particular types of pipe and for growth (see the keys below and to the right of the chart). An artifact of the model and US Census data result in an apparent upward or downward "spike" in growth-related needs between certain decades. In reality, the apparent sudden shift in growth-related needs will be spread more evenly over the years bridging each decade to the next.



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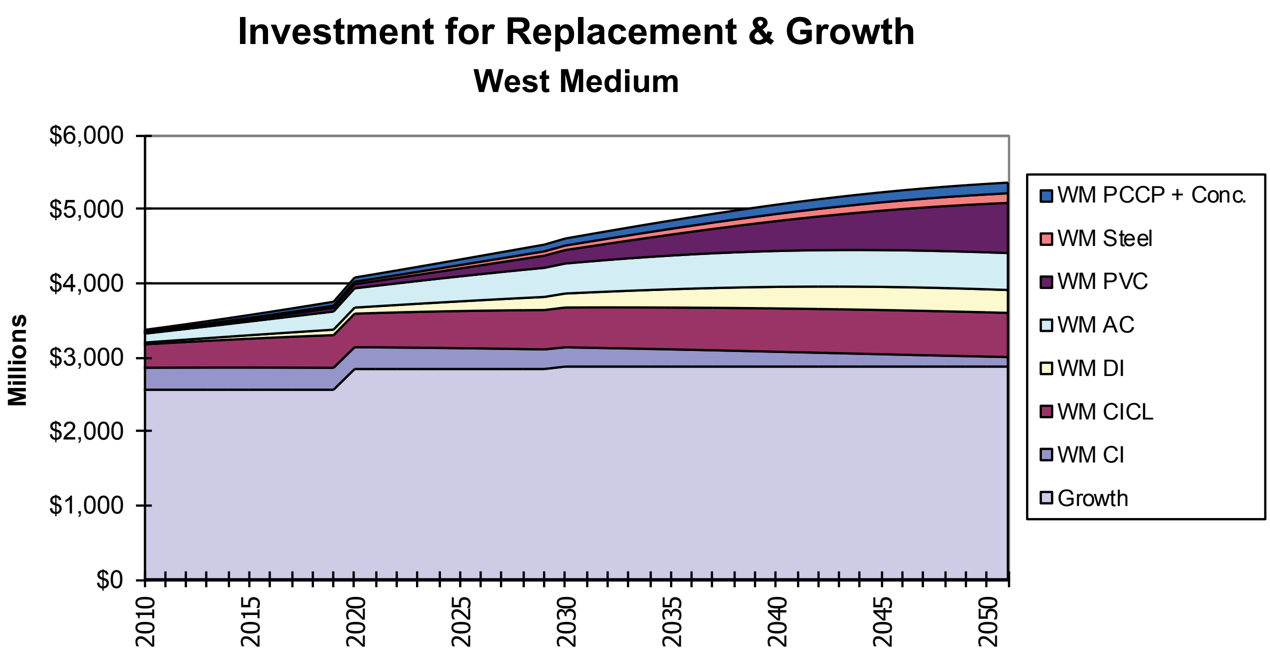

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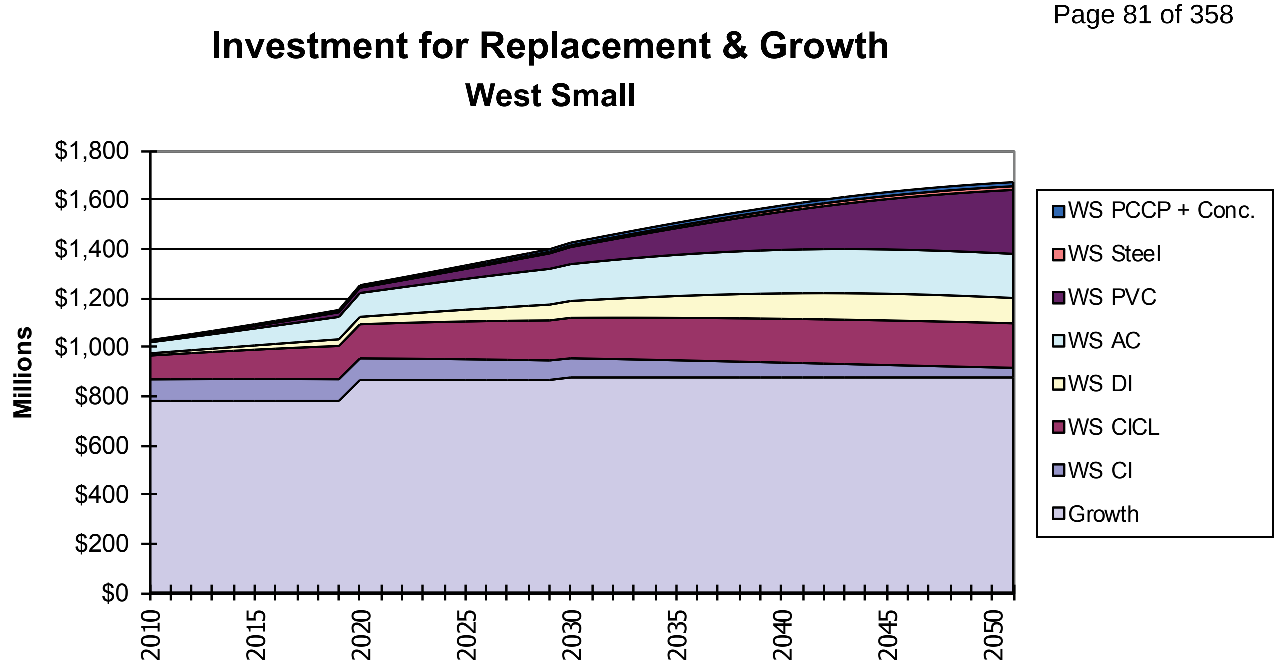

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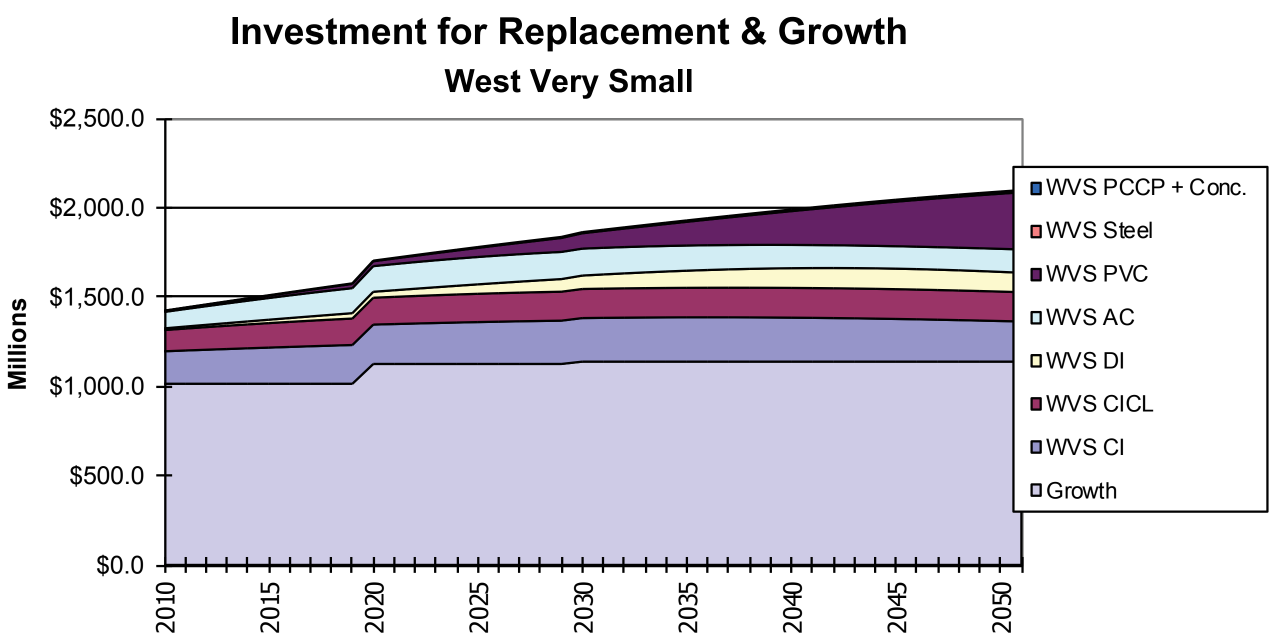

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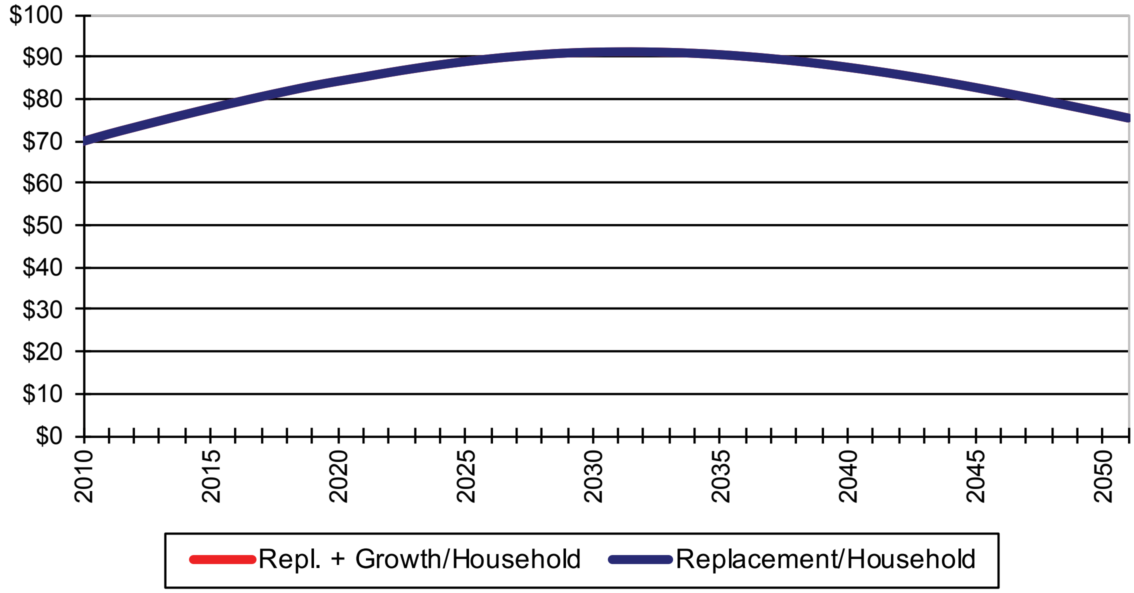
Household Cost of Needed Investment for Replacement Plus Growth*

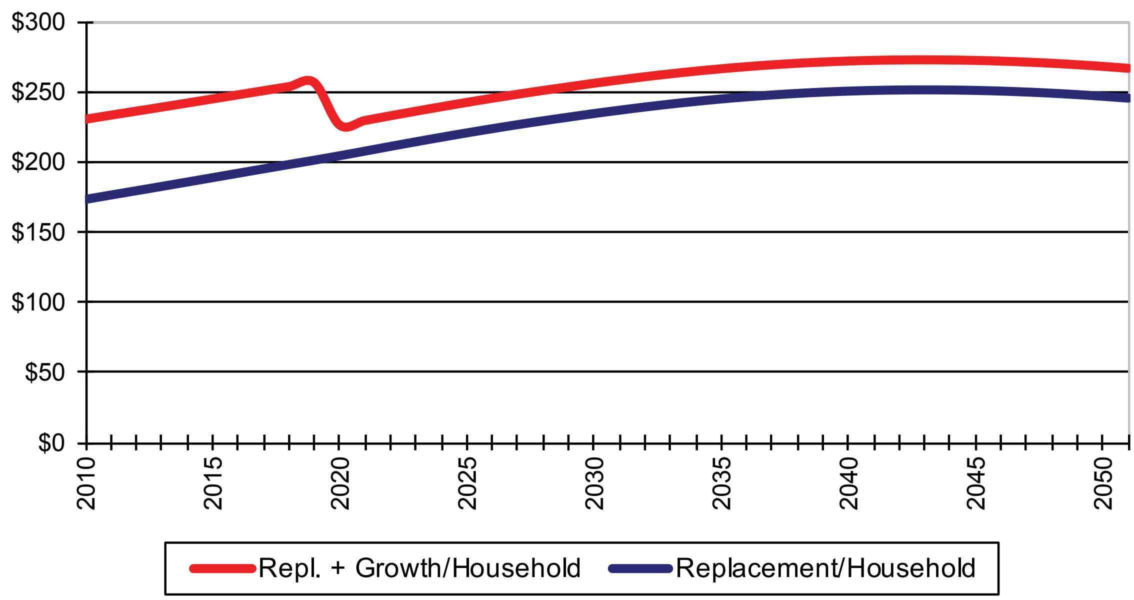
Northeast Large



**This assumes costs are spread evenly across households of 2.6 persons each, based on data from the US Census.*

Household Cost of Needed Investment for Replacement Plus Growth*

Northeast Medium



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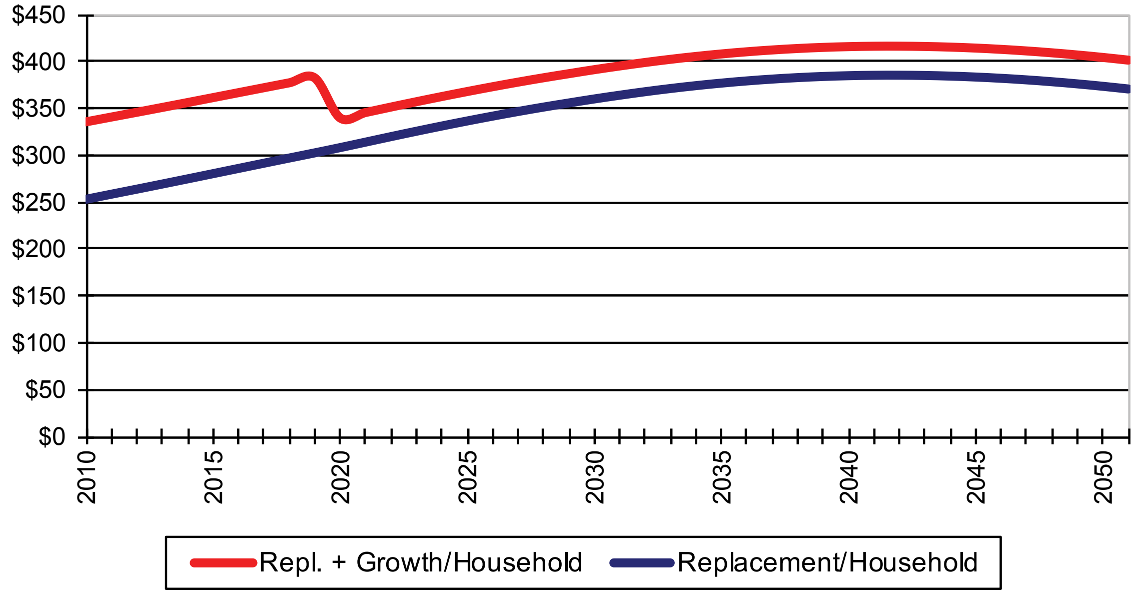
Household Cost of Needed Investment for Replacement Plus Growth*

Northeast Small



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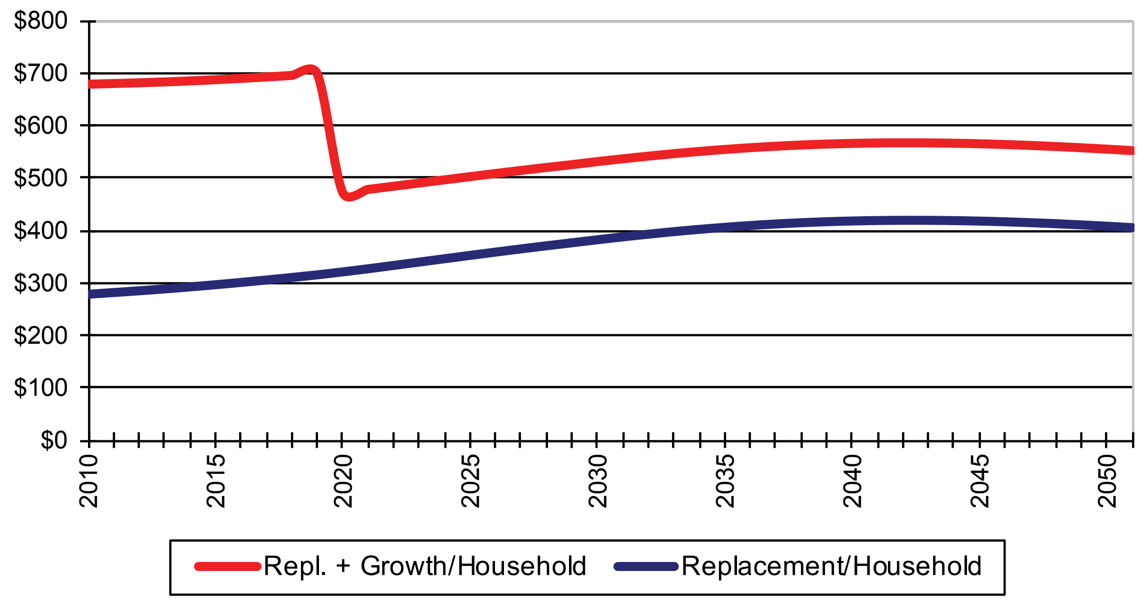
Household Cost of Needed Investment for Replacement Plus Growth*

Northeast Very Small



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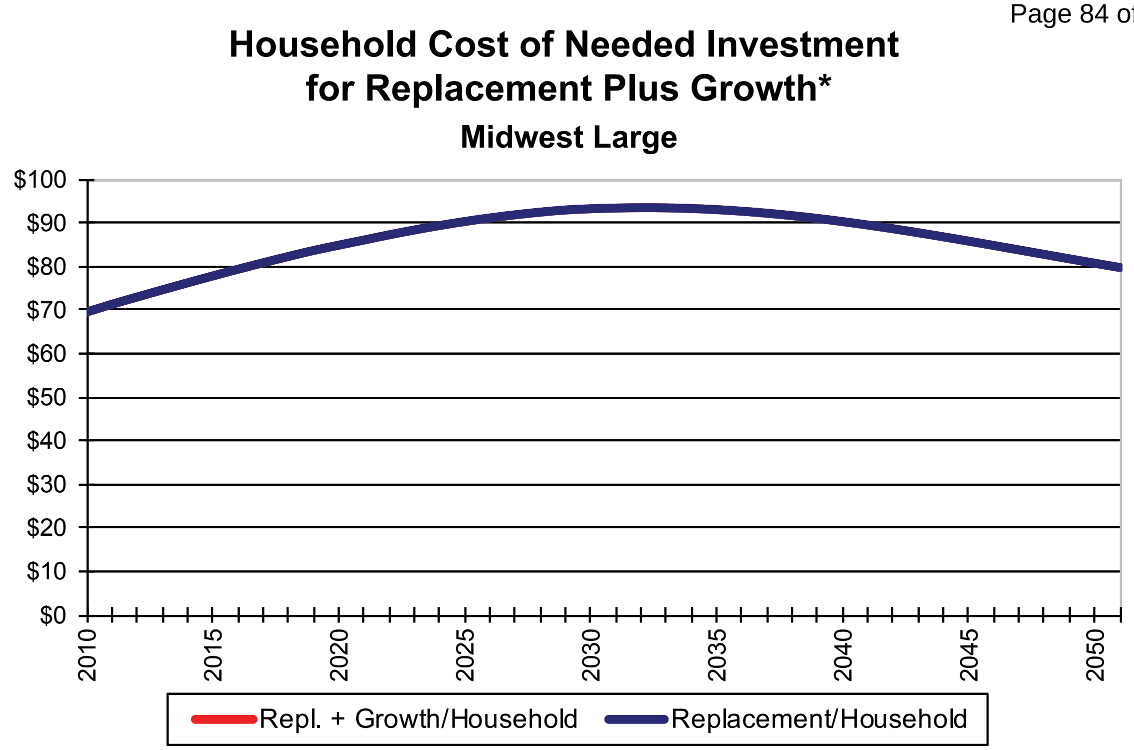

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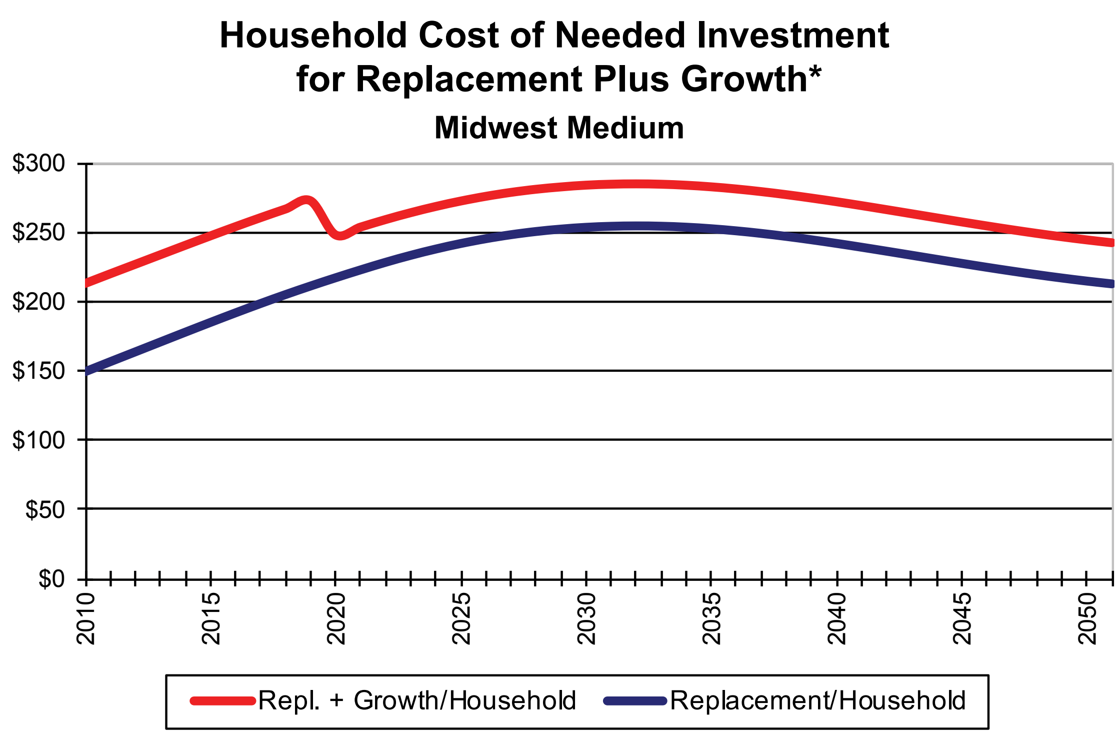

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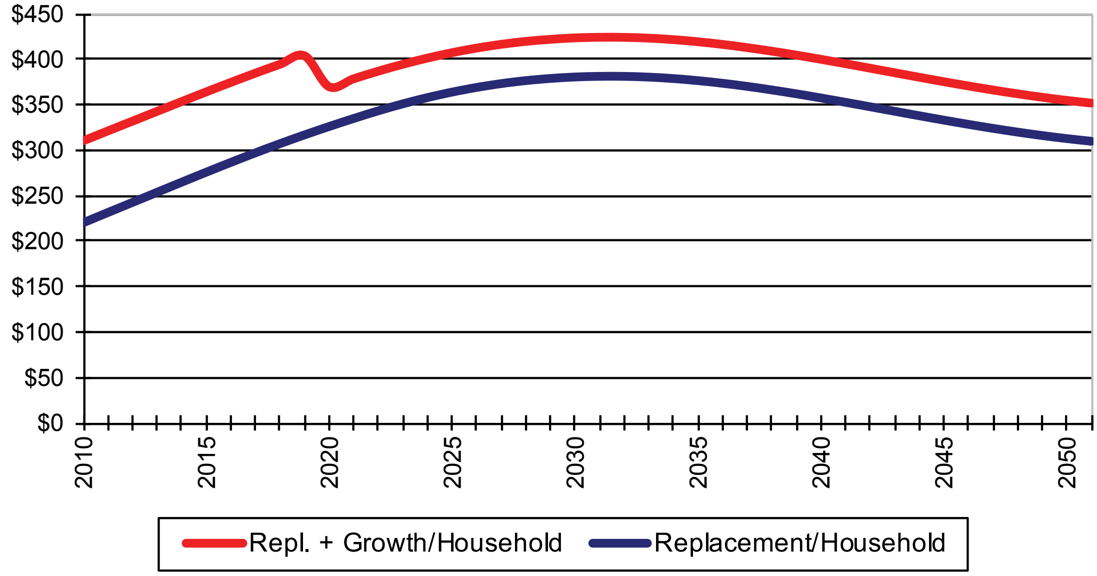
Household Cost of Needed Investment for Replacement Plus Growth*

Midwest Small



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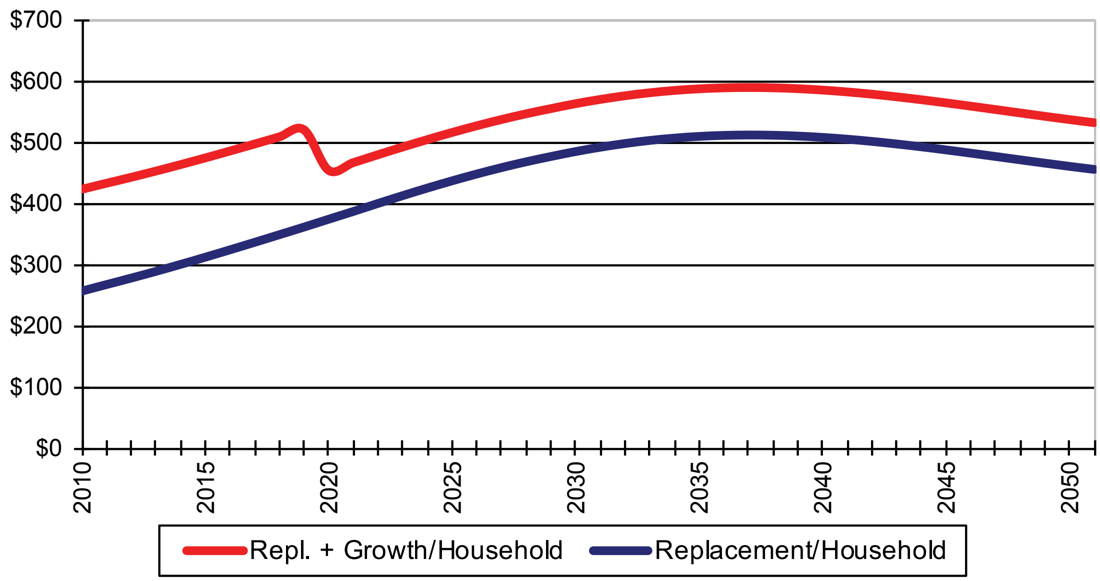
Household Cost of Needed Investment for Replacement Plus Growth*

Midwest Very Small



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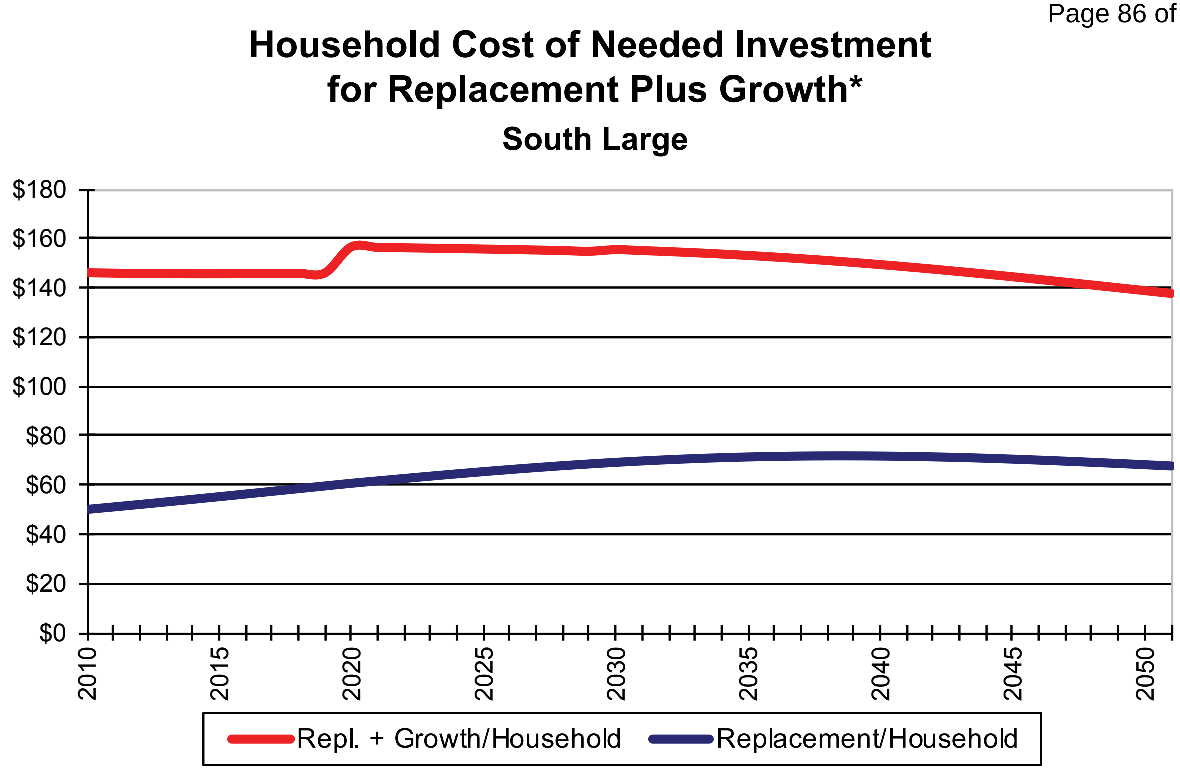

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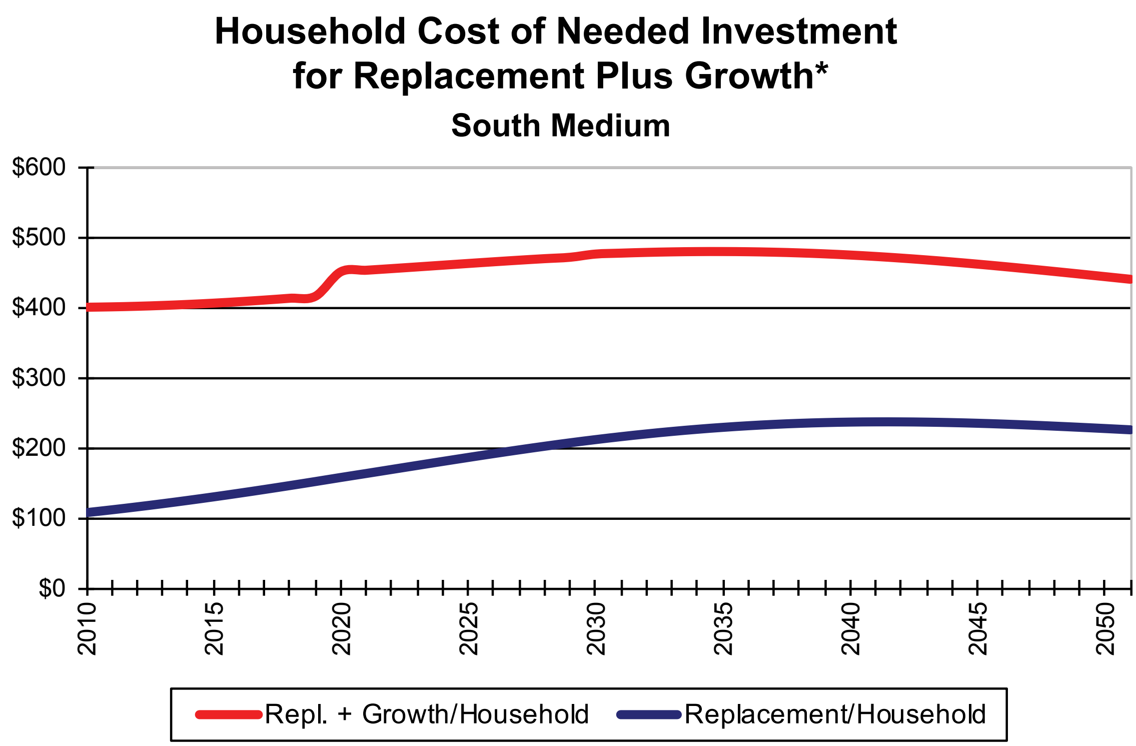

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Household Cost of Needed Investment for Replacement Plus Growth*

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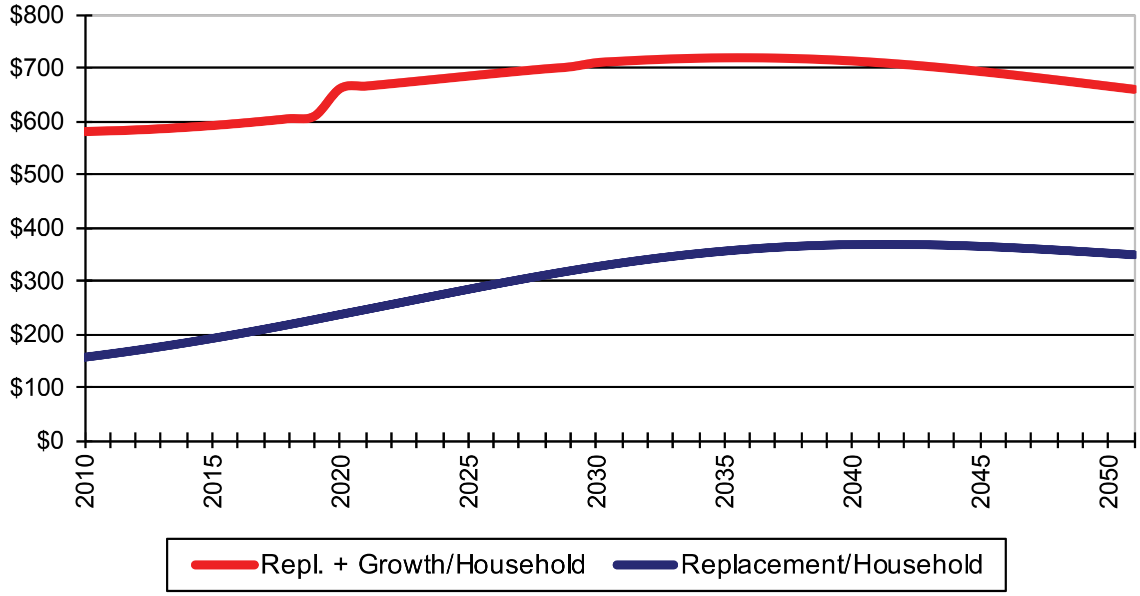

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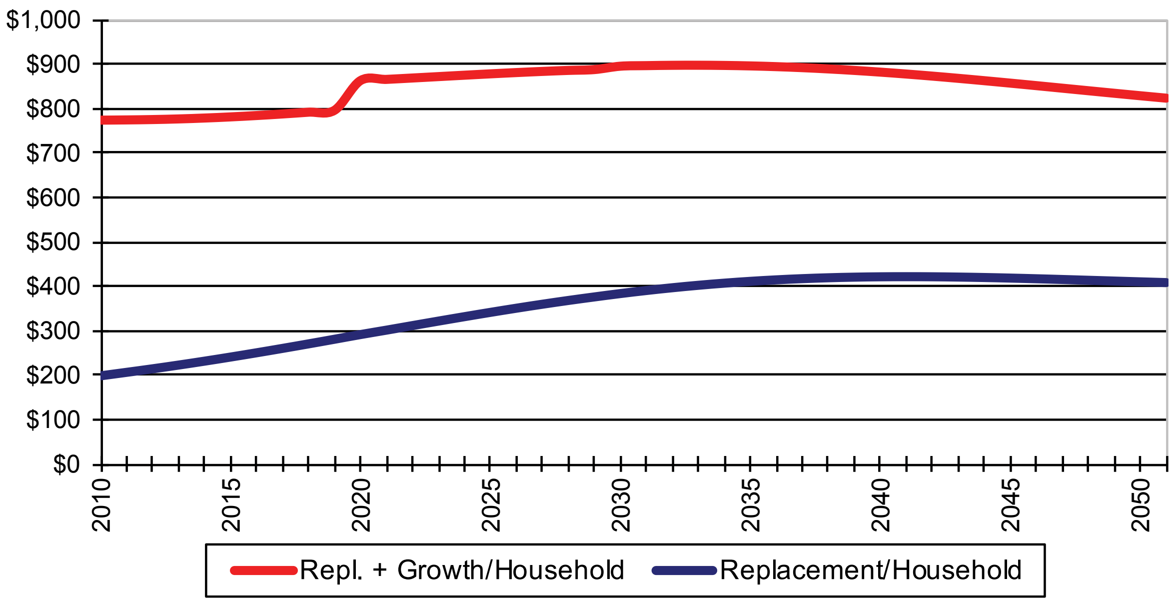
South Very Small



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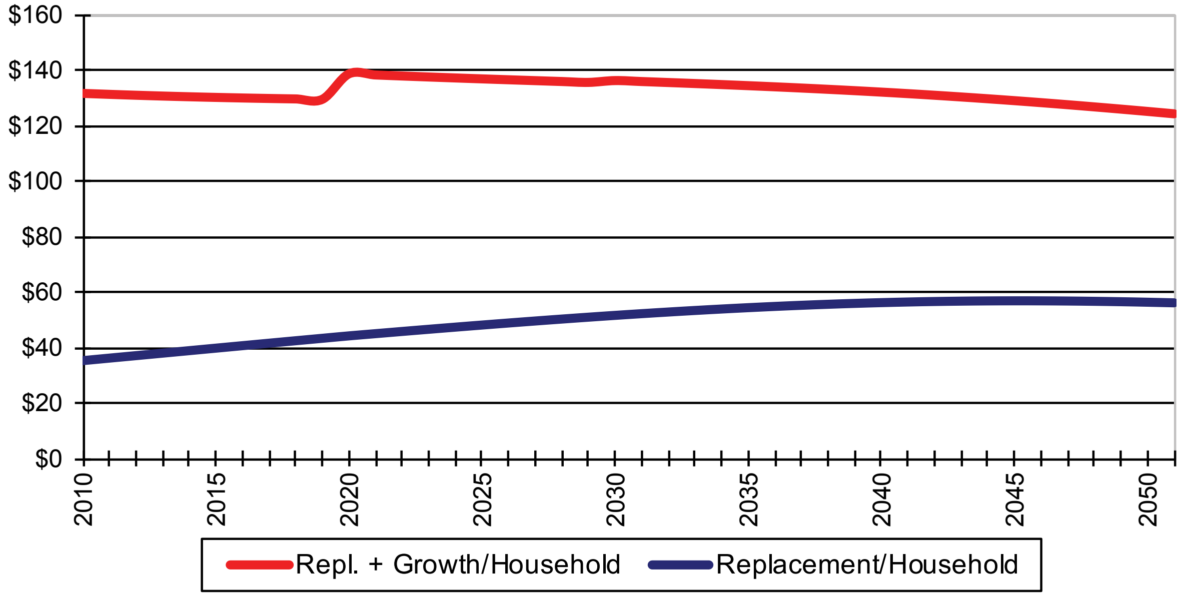

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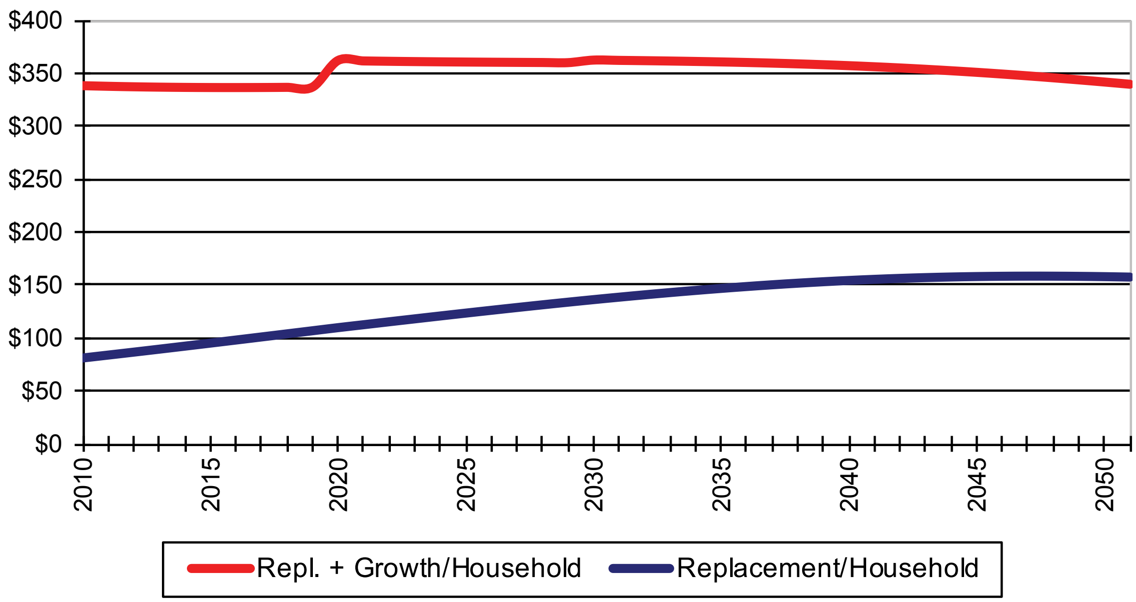

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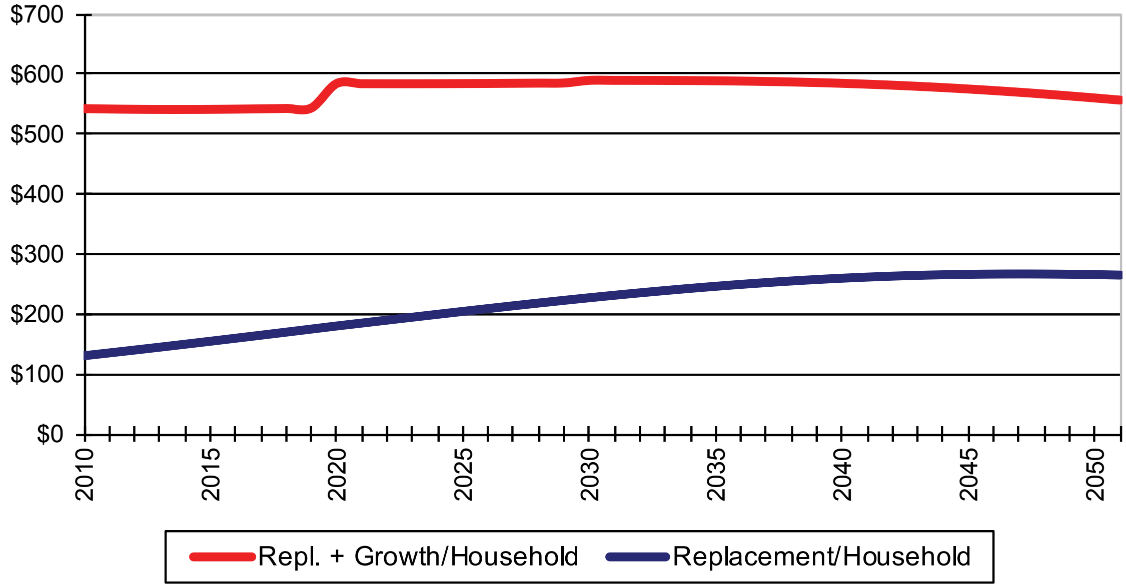

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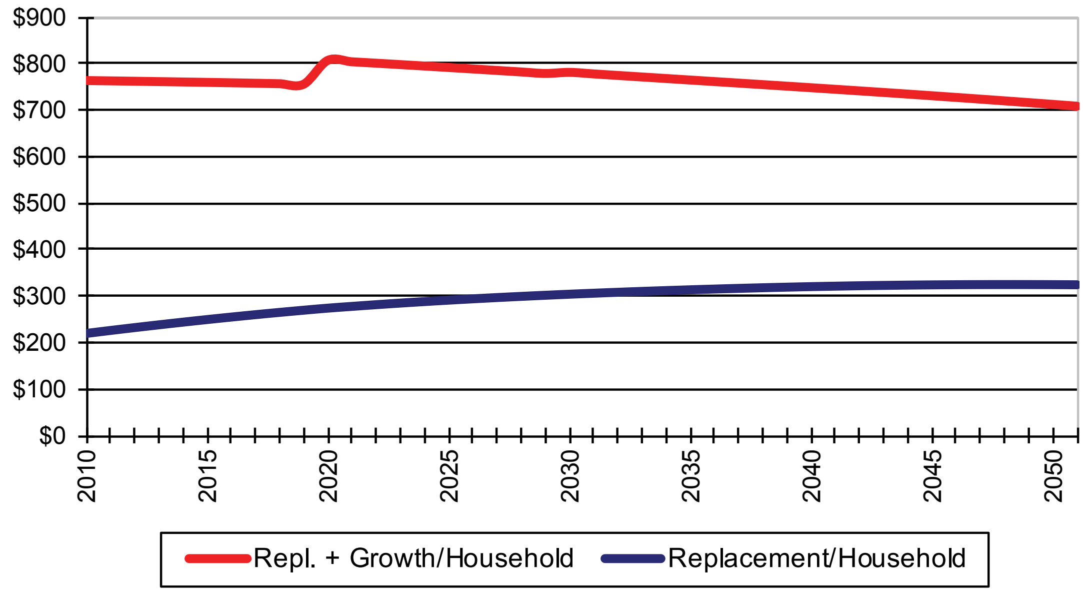

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Footnote 5 Document

American Society of Civil Engineers, *"Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future"* (2016),

FAILURE TO ACT

THE IMPACT OF CURRENT INFRASTRUCTURE INVESTMENT ON AMERICA'S ECONOMIC FUTURE ★★★★

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

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FAILURE TO ACT

THE IMPACT OF CURRENT INFRASTRUCTURE INVESTMENT ON AMERICA'S ECONOMIC FUTURE ★★★★

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Every four years, the American Society of Civil Engineers (ASCE) publishes *The Report Card for America's Infrastructure*, which grades the current state of the nation's infrastructure categories on a scale of A through F. In 2009, the U.S. infrastructure earned just a D average. When the next Report Card is released in 2013, it will provide an updated look at the state of U.S. infrastructure conditions, but there is also a larger question at stake: **How does a D for infrastructure affect America's economic future?**

This *Failure to Act* report answers the key question of how the conditions of the United States' infrastructure systems affect the nation's economic performance. The *Failure to Act* report provides this economic analysis by addressing 9 of ASCE's 16 infrastructure categories that are addressed in the 2013 *Report Card* (see table 1). Today, perhaps more than ever, economic performance is critical to the nation's future.

The purpose of the *Failure to Act* report series is to provide an analysis of the economic implications for the United States of continuing its current investment trends in infrastructure. The *Failure to Act* series analyzes two types of infrastructure needs:

- ★ Building new infrastructure to service increasing populations and expanded economic activity; and
- ★ Maintaining or rebuilding existing infrastructure that needs repair or replacement.

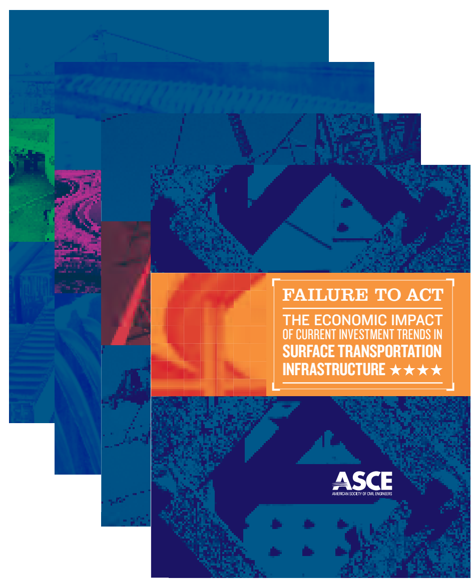
The four preceding reports in this series assess the implications of present trends in infrastructure investment for the productivity of industries, for national competitiveness, and for costs to households.

TABLE 1 ★ Comparison of 2009 Report Card and Failure to Act Series

2009 REPORT CARD	INCLUDED IN FAILURE TO ACT SERIES
Dams	
Drinking Water	★
Hazardous Waste	
Levees	
Solid Waste	
Wastewater	★
Aviation	★
Bridges	★
Inland Waterways	★
Rail	★
Roads	★
Transit	★
Parks and Recreation	
Schools	
Energy	★
Marine Ports	★

NOTE Marine ports were not evaluated in the 2009 *Report Card*, but were part of the *Failure to Act* series and will be included in the 2013 *Report Card*.

2009 REPORT CARD



FAILURE TO ACT SERIES

1 INTRODUCTION

Infrastructure is the physical framework upon which the U.S. economy operates and the nation's standard of living depends. Everything depends on this framework, including transporting goods, powering factories, heating and cooling office buildings, and enjoying a glass of clean water.

The preceding four *Failure to Act* reports compared current and projected needs for infrastructure investment against the current funding trends in surface transportation; water and wastewater; electricity; and airports, inland waterways, and marine ports. Our projections included both the cost of building new infrastructure to service increasing populations and the cost of expanded economic activity; and for maintaining or rebuilding existing infrastructure that needs repair or replacement. The total documented cumulative gap between projected needs and likely investment in these critical systems will be $1.1 trillion by 2020. The subsequent analyses focused on the long-term effects associated with infrastructure investments and did not consider the immediate benefits associated with the construction process. The results show that deteriorating infrastructure, long known to be a public safety issue, has a cascading impact on the nation's economy, negatively affecting business productivity, gross domestic product (GDP), employment, personal income, and international competitiveness.

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The categories of infrastructure systems analyzed in the preceding *Failure to Act* reports were reviewed in isolation by each study.[1] However, it is clear that there is an interactive effect between different infrastructure sectors and a cumulative impact of an ongoing investment gap in multiple infrastructure systems. For example, regardless of how quickly goods can be offloaded at the nation's ports, if highway and rail infrastructure needed to transport these goods to market is congested, traffic will slow and costs to business will rise, creating a drag on the U.S. economy that is ultimately reflected in a lower GDP.

This fifth and final report analyzes the interactive effect between investment gaps in the infrastructure sectors addressed in each of the preceding studies. It presents an overall picture of the national economic opportunity associated with infrastructure investment and the consequences of failing to fill the investment gap.

The overall impact of deficient infrastructure associated with a general failure to invest cannot be estimated by simply adding the impacts found in each report because the degradation of surface transportation, water delivery and wastewater treatment, electricity, inland waterways, and marine ports each affect business productivity differently. Shifts to other production methods or modes of infrastructure may be possible given a decline in one system, which could mitigate the economic impacts of failing to invest in that system. For example, rail, inland waterways, and trucks are used to get goods to retail shelves—deteriorating conditions in one sector tend to make the other sectors more competitive. However, a general decline in infrastructure conditions across multiple sectors would preclude such strategies.

In addition, the consequences of infrastructure shortfalls differ by each system. With degrading surface transportation, trips can still be made, but they would take longer and be less reliable, and travel could be less safe. Declining airport and marine port infrastructure directly impacts the nation's ability to import and export goods efficiently, driving up costs to U.S. consumers.

Overall, if the investment gap is not addressed throughout the nation's infrastructure sectors, by 2020, the economy is expected to lose almost $1 trillion in business sales, resulting in a loss of 3.5 million jobs. Moreover, if current trends are not reversed, the cumulative cost to the U.S. economy from 2012–2020 will be more than $3.1 trillion in GDP and $1.1 trillion in total trade.[2]

Often, estimates of economic activity and job creation focus on the design and construction period for infrastructure projects, such as a project to rebuild an aging bridge. However, this study focuses on the incremental and gradual decline of infrastructure systems under current investment scenarios, and it shows that the negative impacts on the nation's economy are exacerbated over time as needed investments are deferred. Conversely, this study demonstrates that the economic benefits of infrastructure investment reverberate through every sector of the economy over time.

2 | ECONOMIC IMPACTS OF FAILING TO INVEST ACROSS INFRASTRUCTURE SYSTEMS

In combination with current investment trends, cumulative infrastructure investment needs will be approximately $2.7 trillion by 2020 and will rise to $10 trillion by 2040. It is expected that funding will be available to cover only 60% (approximately $1.7 trillion) of these needs through 2020, and that will drop to 53% by 2040. Thus, the investment gaps will total $1.1 trillion by 2020, and will grow to $4.7 trillion by 2040.

As shown in table 2, the bulk of the gap is due to surface transportation needs, including roads, bridges, and transit systems. In addition, figure 1 shows the percentage of needs for each infrastructure type and the remaining unfunded investment gap.

The previous studies in the *Failure to Act* series found that underinvesting in infrastructure will result in higher costs to businesses and households as a consequence of less efficient and more costly infrastructure services. For example, travel times will lengthen with inefficient roadways and congested air service, and out-of-pocket expenditures to households and business costs will rise if the electricity grid or water delivery systems fail to keep up with demand. Goods will be more expensive to produce and more expensive to transport to retail shelves for households or to business customers. Business related travel, as well as commuting and personal travel, will also become more expensive. As a consequence, U.S. businesses will become less efficient. As costs rise, business productivity falls, causing GDP to drop, cutting employment and ultimately reducing personal income. Higher costs will also render U.S. goods and services less competitive internationally, reducing exports and decreasing dollars earned and brought into the U.S. from sales to international customers. Impacts will be spread throughout the economy, but will fall disproportionately on the technology and knowledge-based industries that drive innovation and economic development.

Although the U.S. economy will still be producing goods and services, it will do so at a reduced scale, and the lower wages will lead to less consumer spending. Impacts ultimately will fall hardest on households that will pay more for services—including transportation, water and wastewater, and electricity—and absorb the brunt of fewer

TABLE 2 ★ Cumulative Infrastructure Needs by System Based on Current Trends Extended to 2020 and 2040 *(Dollars in $2010 billions)*

INFRASTRUCTURE SYSTEMS	2020 TOTAL NEEDS	2020 EXPECTED FUNDING	2020 FUNDING GAP	2040 TOTAL NEEDS	2040 EXPECTED FUNDING	2040 FUNDING GAP
Surface Transportation	$1,723	$877	$846	$6,751	$3,087	$3,664
Water/Wastewater	$126	$42	$84	$195	$52	$144
Electricity	$736	$629	$107	$2,619	$1,887	$732
Airports*	$134	$95	$39	$404	$309	$95
Inland Waterways & Marine Ports	$30	$14	$16	$92	$46	$46
TOTALS	**$2,749**	**$1,657**	**$1,092**	**$10,061**	**$5,381**	**$4,681**

*Airport needs and gaps include anticipated cost of NextGen: $20 billion by 2020 and $40 billion by 2040.

jobs, lower incomes, and higher prices for both domestically produced and imported goods.

The reduction in business sales due to the drop in exports, personal income and consumer spending will eventually reduce national GDP, which a primary indicator of national economic productivity.

Aggregate Economic Impacts

Businesses and households face higher costs due to several factors, including unreliable transportation services, less reliable water and electricity services, and unmet maintenance needs and outdated facilities for airports, marine ports, and inland waterways. These costs absorb funds from businesses that would otherwise be directed to investment or research and development, and funds from households that would go toward discretionary consumer purchases. The costs are expected to total over $1.8 trillion by 2020, as shown in table 3. Thus, not only will business and personal income be lower but more of that income will need to be diverted to infrastructure-related costs. This dynamic creates lower demand in key economic sectors associated with business investments for expansion and research and development, and in consumer sectors.

Compared with baseline forecasts for the years 2012–20, the cumulative impact of deficient infrastructure due to continued underinvestment in the transportation, water, energy, and port sectors is predicted to result in an aggregated loss of $3.1 trillion in GDP from the U.S. economy. Losses are expected to include $484 billion in exports and almost $1.1 trillion in total trade. As a result of this underperformance, job losses will mount annually, and by 2020 it is predicted that there will be 3.5 million fewer jobs throughout the country.

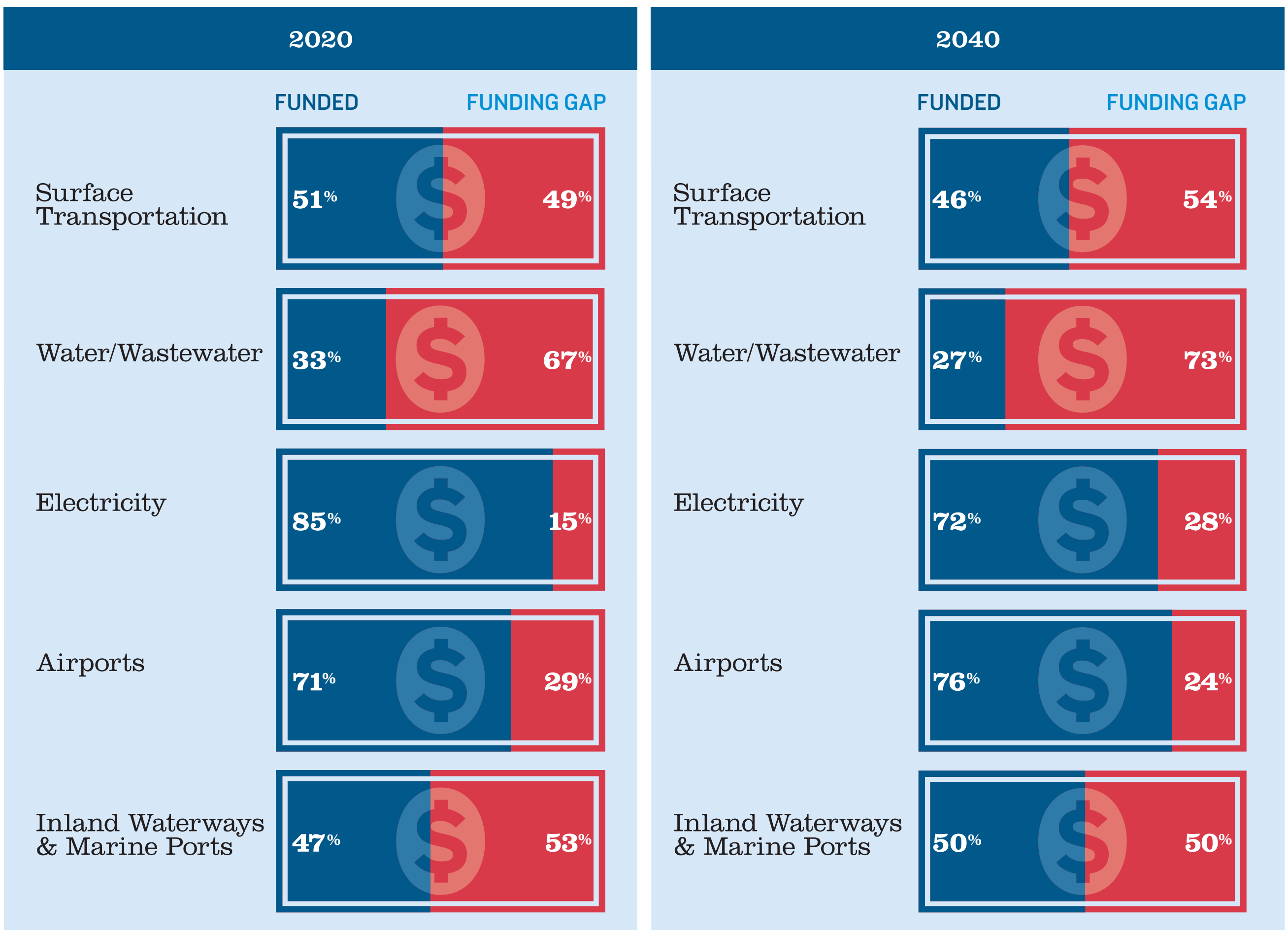
The expected impact for every household in the U.S. will be an average loss of more than $3,000 per year through 2020 in disposable personal income, amounting to $28,000 per household over nine years, as shown in table 4. These losses will be due to job cutbacks and declining business productivity (which includes less sales and lower GDP), which will result in lower household incomes. By 2040, these effects will be more pronounced. Based on extending identified needs and finding trends, by the year 2040, the impacts of a cumulative $4.7 trillion gap in transportation, water, energy, and ports (including the investments through 2020) includes losses of almost 7 million jobs from the national economy. In terms of dollar losses from expected levels in 2040 are $2.5 trillion in business sales, including $473 billion in exports ($712 billion in total trade), $1.3 trillion in national GDP, and $1.2 trillion in disposable personal income that would be lost to U.S. households.

Per household, the expected loss of disposable personal income is estimated to exceed $6,000 annually from 2021 to 2040, which adds to $126,000 over the 20-year time frame. On average, the cost of deficient infrastructure is expected to reach $5,400 per year for each household in the nation from 2012 to 2040, as shown in table 4.

From 2012 until 2020, consumer spending will drop by almost $2.4 trillion as a consequence of the declines in disposable income. Although consumer spending is calculated to decline in each of the preceding *Failure to Act* studies, the effect is particularly pronounced when examining impacts on all the infrastructure systems together.

Nationally, the cumulative loss in national business sales[3] will be almost $6 trillion over the years 2012-2020. Nearly $34 trillion more

FIGURE 1 ★ **Investment Gap by Infrastructure Category as a Percentage of Total Needs in the Years 2020 and 2040**



SOURCE Data taken from previous *Failure to Act* studies.

TABLE 3 ★ Costs to Businesses and Households of Degrading Infrastructure

CUMULATIVE TO 2020

INFRASTRUCTURE SYSTEMS	HOUSEHOLDS	BUSINESSES	TOTAL
Surface Transportation	$481	$430	$911
Water/Wastewater	$59	$147	$206
Electricity	$71	$126	$197
Airports	N/A	$258	$258
Inland Waterways & Marine Ports	N/A	$258	$258
TOTALS	**$611**	**$1,219**	**$1,830**

NOTE Dollars in $2010 Billions. Costs do not include personal income or value of time other than business travel.

CUMULATIVE TO 2040

INFRASTRUCTURE SYSTEMS	HOUSEHOLDS	BUSINESSES	TOTAL
Surface Transportation	$1,880	$1,092	$2,972
Water/Wastewater	$616	$1,634	$2,250
Electricity	$354	$640	$994
Airports	N/A	$1,212	$1,212
Inland Waterways & Marine Ports	N/A	$1,233	$1,233
TOTALS	**$2,850**	**$5,811**	**$8,661**

NOTE Dollars in $2010 Billions. Costs do not include personal income or value of time other than business travel.

TABLE 4 ★ Impacts of Infrastructure Investment Gap Per Household

	2012-2020	2021-2040	2012-2040
Average Annual Disposal Income Per Household	–$3,100	–$6,300	–$5,400
Total Disposal Income Per Household	**–$28,300**	**–$126,300**	**–$157,200**

NOTE Dollars rounded to nearest $100. Totals may not multiply due to rounding.

SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

TABLE 5 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Business Sales in the Years 2020 and 2040

(Dollars in $2010 billions)

2020		2040	
SECTOR	**BUSINESS SALES/OUTPUT**	**SECTOR**	**BUSINESS SALES/OUTPUT**
Retail trade	–$95	Finance & insurance	–$204
Water and sanitary services	–$76	Retail trade	–$172
Restaurants and bars	–$55	Real estate and royalties	–$159
Finance & insurance	–$51	Wholesale trade	–$132
Electric utilities	–$46	Owner-occupied housing	–$115
Hotels	–$36	Professional services	–$100
Medical Services	–$35	Other business services	–$94
Advertising	–$34	Medical Services	–$94
Personal & repair services*	–$25	Computer & data processing	–$82
Gas utilities	–$23	Air transport	–$62
Computer & data processing	–$21	Restaurants and bars	–$59
Wholesale trade	–$21	Maintenance & repair	–$59
Other instruments	–$19	Aerospace	–$58
Other business services	–$18	Agriculture, forestry, fisheries	–$54
Agriculture, forestry, fisheries	–$17	Movies and amusements	–$50
Other Sectors	–$386	Other Sectors	–$1,037
Total	**–$958**	**Total**	**–$2,529**

SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

*Excludes auto repair services.

TABLE 6 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Jobs in the Years 2020 and 2040

(Dollars in $2010 billions)

2020		2040	
SECTOR	**JOBS**	**SECTOR**	**JOBS**
Retail trade	–786,000	Retail trade	–1,198,000
New construction	–394,000	New construction	–753,000
Medical Services	–298,000	Medical Services	–638,000
Other business services	–294,000	Wholesale trade	–601,000
Restaurants and bars	–272,000	Restaurants and bars	–558,000
Finance & insurance	–245,000	Other business services	–549,000
Wholesale trade	–228,000	Education, social services, NPO	–437,000
Education, social services, NPO	–213,000	Finance & insurance	–358,000
Professional services	–154,000	Professional services	–298,000
Movies and amusements	–102,000	Movies and amusements	–249,000
Printing & publishing	–67,000	Air transport	–191,000
Air transport	–63,000	Printing & publishing	–126,000
Automobile services	–58,000	Computer & data processing	–109,000
Real estate and royalties	–57,000	Real estate and royalties	–107,000
Computer & data processing	–54,000	Personal & repair services, ex. auto	–89,000
Other Sectors	–178,000	Other Sectors	–598,000
Total	**–3,463,000**	**Total**	**–6,859,000**

SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

in sales are predicted to be lost from 2021-2040. The aggregate loss of GDP from the U.S. economy is expected to be $3.1 trillion cumulatively over the years 2012-2020, and an additional $18 trillion from 2021 through 2040.

By 2020, the economy is expected to lose almost 3.5 million jobs, and mounting impacts from underinvestment in infrastructure will result in nearly 7 million jobs lost by 2040.[4] Tables 5 and 6 show that the economic benefits of infrastructure investment reverberate through every sector of the economy and are exacerbated over time as needed investments are deferred.[5]

Tables 5 and 6 show that the impacts by sector will shift by 2040, as the gaps between infrastructure needs and investment widens and the economy has time to adjust to lower levels of services. Large, labor-intensive industries such as retail, medical services, and restaurants will be particularly hard hit by 2040. This is the long-term result of households earning less disposable income and reducing purchases (restaurant meals, home improvements, consumer electronics, new furniture for examples), deferring services (medical care), and the long-term reduction in business sales that will particularly affect construction spending.

By 2040, the key sectors related to America's innovation and knowledge base—including aerospace, air transportation, business services, professional services, and finance—will all be among the hardest-hit in terms of sales and industry sales.

Primarily, these impacts are due to: (1) fewer purchases for higher priced goods and services by both households and businesses in adjusting to declining business sales and lower disposable personal income; (2) higher production costs, transportation costs and a less efficient supply chain reduces the competitiveness of U.S. produced exports; (3) supply-chain impediments, including the costs of transportation, inefficiencies at ports that increase the costs of products; and (4) a redistribution of business revenues from R&D, major purchases and higher priced business services in order to pay for higher costs of transportation, water and energy.

Even though net job impacts are counted in millions of jobs lost from the U.S. due to insufficient infrastructure investment, overall economic impacts in dollars lost in the economy, measured by business sales and GDP will be more dramatic than impacts on overall number of jobs. Job losses in part will be mitigated by more people working for less money. Many of these jobs will replace technology-based and education industry jobs that are the basis of long-term economic development.

In 2020, the United States population is predicted to exceed 340 million people and the national population is expected to grow to more than 400 million by 2040. Workers will still be needed to provide basic and a reduced level of luxury products and services to this population.

The impact of declining business productivity due to inefficient infrastructure may add some jobs to the economy even as income is declining. As an example, in 2020 and 2040, deficient infrastructure is expected to negatively affect the value of agriculture sales and exports as shipping costs rise. However, even though this sector's sales and exports will fall, more workers will be needed in 2020 to produce and supply its products, as shown in table 7. Other sectors that will increase job shares by 2020 are automobile repair services, truck driving, and highway passenger services. These findings are consistent with those of the previous *Failure to Act* study on surface transportation, because poor pavement conditions and deficient roads will cause more damage to vehicles, slower travel times will require more drivers and crews, and a degrading inland waterway system and congested air space will lead more people to travel by car and more goods to be shipped by truck.

Table 7 presents data on those industries that will be most affected by a decline in exports in 2020 and 2040. These industries include a cross-section of critical sectors of the national economy, including finance, aerospace, instruments, and communications. These industries also represent basic manufacturing and services, including wholesale trading, equipment, and agricultural products.

TABLE 7 ★ The Sectors Most Negatively Affected by Degrading Infrastructure in Terms of Value of Exports in 2020 and 2040

(Dollars in $2010 billions)

2020

SECTOR	VALUE
Finance & insurance	–$9
Wholesale trade	–$7
Aerospace	–$6
Agriculture, forestry & fisheries	–$5
Air transport	–$4
Other chemicals	–$3
Professional services	–$2
Other instruments	–$2
Petroleum refining	–$2
Ag., const. & material handling equipment	–$2
Drugs	–$2
Meat products	–$2
General & misc. industrial equipment	–$2
Communications equipment	–$2
Motor vehicle parts	–$2
Other Sectors	–$41
Total	**–$106**

2040

SECTOR	VALUE
Finance & insurance	–$50
Aerospace	–$47
Wholesale trade	–$35
Air transport	–$31
Agriculture, forestry & fisheries	–$18
Communications equipment	–$15
Professional services	–$13
Other instruments	–$13
Other chemicals	–$13
Meat products	–$10
Electronic components	–$9
Ag., const. & material handling equipment	–$8
Computer & data processing	–$7
Plastics & synthetics	–$7
Medical instruments & supplies	–$7
Other Sectors	–$188
Total	**–$517**

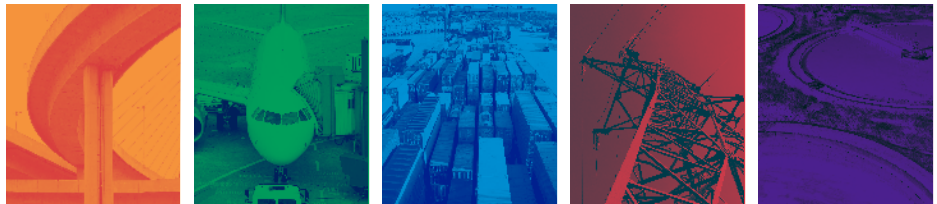
SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

3 REVIEW OF INFRASTRUCTURE SECTORS

Each of the specific infrastructure studies that were conducted in the *Failure to Act* series was based on assuming extending current needs through 2040, recent funding trends, and trends in how infrastructure is being used.

The projected needs for investments in infrastructure systems, and the consequent costs to industries and households of not making these investments, are documented by models used by federal infrastructure agencies; databases; reports published by federal agencies and by industry groups that represent local, regional, and private sector infrastructure providers; academic and professional literature; and interviews with industry experts. Economic impacts were calculated using the LIFT model (Long-Term Interindustry Forecasting Tool) of the Inforum Interindustry Forecasting Project at the University of Maryland.

TABLE 8 ★ Cumulative Impacts to the National Economy by Category
(Dollars are in $2010 billions)



	Surface Transportation	Airports	Inland Waterways & Marine Ports	Electricity	Water / Wastewater
Business Sales					
Through 2020	$1,700	$580	$1,335	$847	$734
2021–2040	$7,062	$2,682	$6,496	$3,590	$6,791
GDP					
Through 2020	$897	$313	$697	$496	$416
2021–2040	$1,765	$1,209	$3,278	$1,954	$3,702
Jobs					
2020	877,000	350,000	738,000	529,000	669,000
2040	410,000	358,000	1,384,000	366,000	1,377,000
Disposable Income					
Through 2020	$930	$361	$872	$656	$541
2021–2040	$2,205	$1,128	$3,662	$2,294	$4,440
Value of Exports					
Through 2020	$114	$54	$270	$51	$20
2021–2040	$1,093	$708	$1,712	$630	$807

SOURCES LIFT/Inforum Model of the University of Maryland, and EDR Group.

NOTE This Table reflects the research conducted in 2011 and 2012 and findings of the four infrastructure sector studies that preceded this report. Jobs rounded to the nearest thousand.

Summary of Findings from Previous Studies

The projected annual impacts of the infrastructure systems reviewed are shown for 2020 and 2040 in table 8. It is important to note that in some cases the national economy is expected to adjust from the degradation of infrastructure. In particular, annual losses in GDP and income will be similar in 2020 and 2040 because inadequate investment in surface transportation and job impacts are expected to be cut in half between these two years. These numbers, however, mask the dynamic that job increases will be in those industries that address poor roadway conditions and that job losses will continue to be seen in the U.S. knowledge-based and innovation industries that drive economic development.

The studies did not presume new technologies, or expanded technologies not currently scheduled for implementation. Examples of such technologies not considered in these reports are high-speed rail or maglev systems in surface transportation and a radical expansion of renewable energy for electricity generation. The electricity study assumed that technologies in place or planned for power generation by region would be in place through 2040. For aviation, the costs of the Next Generation Air Transportation System's (NextGen's) technologies were considered as part of the gap, and likely air congestion without NextGen was part of the basis for estimating future economic impacts.

Surface Transportation

The nation's surface transportation infrastructure includes the critical highways, bridges, railroads, and transit systems that enable people and goods to access the markets, services, and inputs of production that are essential to America's economic vitality. For many years, the nation's surface transportation infrastructure has been deteriorating. However, because this deterioration has been diffused throughout the nation, and has occurred gradually over time, its true costs and economic impacts have not always been immediately apparent. In practice, the transportation funding that is appropriated is spent on a mixture of system expansion and preservation projects. Although these allocations have often been sufficient to avoid the imminent failure of key facilities, the continued deterioration leaves a significant and mounting burden on the U.S. economy.

Across the U.S., regions are affected differently by deficient and deteriorating infrastructure. The most affected regions are those with the largest concentrations of urban areas, because urban highways, bridges, and transit systems are generally in worse condition today than rural facilities. Peak commuting patterns also place larger burdens on the capacities of urban areas. However, because the nation is so dependent on the Interstate Highway System, impacts on interstate performance in some regions or areas are felt throughout the nation.

Nationally, for highways and transit, 630 million vehicle hours traveled were lost due to congestion in 2010. This total is expected to triple to 1.8 billion hours by 2020 and further increase to 6.2 billion hours in 2040. These vehicle hours understate person hours and underscore the severity of the loss in productivity.

Deteriorating conditions and performance impose costs on American households and

By 2020, America's projected surface transportation infrastructure deficiencies are expected to cost the national economy cumulatively almost $900 billion in GDP, rising to $2.7 billion through 2040.

businesses in a number of ways. Facilities in poor condition lead to increases in operating costs for trucks, cars, and rail vehicles. Additional costs include damage to vehicles from deteriorated roadway surfaces, the imposition of both additional miles traveled, time expended to avoid unusable or heavily congested roadways or due to the breakdown of transit vehicles, and the added cost of repairing facilities after they have deteriorated, as opposed to preserving them in good condition. In addition, increased congestion decreases the reliability of transportation facilities, meaning that travelers are forced to allot more time for trips to assure on-time arrivals (and for freight vehicles, on-time delivery). Moreover, congestion increases environmental and safety costs by exposing more travelers to substandard conditions and requiring vehicles to operate at less efficient levels as conditions continue to deteriorate.

Surface transportation costs are imposed primarily by pavement and bridge conditions, highway congestion, and transit and train vehicle conditions that are operating well below minimum tolerable levels for the level of traffic they carry. In 2010, it was estimated that deficiencies in America's surface transportation systems cost households and businesses nearly $130 billion. This included approximately $97 billion in vehicle operating costs, $32 billion in travel time delays, $1.2 billion in safety costs, and $590 million in environmental costs. If present trends continue, by 2020 the annual costs imposed on the U.S. economy from deteriorating surface transportation infrastructure will increase to $210 billion, and by 2040 to $520 billion—with cumulative costs mounting to $912 billion and $2.9 trillion by 2020 and 2040, respectively.

By 2020, America's projected surface transportation infrastructure deficiencies—in a scenario of extended trends—are expected to cost the national economy cumulatively almost $900 billion in GDP, rising to $2.7 trillion through 2040. In 2020, nearly 900,000 jobs are expected to be lost. By 2040, these gross job losses will be mitigated to slightly more than 400,000 jobs, but a greater proportion of this apparent job rebound will be due to the need to expand industries associated with automotive repairs. Moreover, as productivity deteriorates along with infrastructure degradation, more resources will be wasted in each sector. In other words, it may take two jobs to complete the tasks that one job could handle without delays due to worsening surface transportation. By 2040, approximately 1.3 million more jobs could exist in key knowledge-based and technology-related economic sectors if sufficient transportation infrastructure were maintained. These losses would be balanced against almost 900,000 additional jobs projected in traditionally lower-paying service sectors of the economy that would benefit from deficient transportation (such as auto repair services) or from declining productivity in domestic service-related sectors (such as truck driving and retail trade).

The most significant economic threat concerning aviation is air and ground congestion at major airports and regions.

Airports

Among the 3,300 airports in the United States that are designated by the Federal Aviation Administration (FAA) as important to the national aviation system, 35 airports with the nation's top 15 markets account for 80 percent of U.S. passenger origin and destination movements, totaling 343 million trips. The FAA forecasts that enplanements in these 15 markets will increase 30% by 2020 and 121% by 2040.[6] These projections exceed enplanements forecasted at other commercial airports, which are predicted to increase 25% by 2020 and 93% by 2040. More important from the perspective of air traffic projections, commercial aircraft operations are projected to grow by 17% through 2020 and 62% by 2040, including increases in the 15 major markets of 23% by 2020 and 86% by 2040. Similar to passenger travel, freight shipments are concentrated in major metro areas. By tonnage, 92% of international air freight tonnage is imported or exported through the 15 leading U.S. customs districts, and 70% of domestic air tonnage originates at key metro markets.

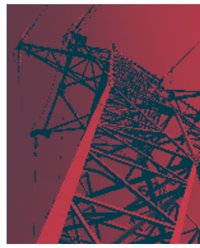
The most significant economic threat concerning aviation is air and ground congestion at major airports and regions. Extending the trends of needs and spending documented by the FAA and Airports Council International shows an annual capital gap of about $2 billion through 2020 (roughly $13 billion in need and $11 billion in expenditures per year) and $1 billion annually from 2021 to 2040 ($12 billion in need and $11 billion in expenditures, assuming that spending through 2020 does not fall lower than recent trends). In addition to construction needs, congestion relief is being proposed through NextGen, which is expected to transform the management and operation of the air transportation system in the United States, moving from the current ground-based radar system to a satellite-based system. At present the most widely accepted cost of NextGen is $31 billion, in addition to approximately $9 billion that has already been invested between 2003 and 2011.

The implications of these investment needs are expected to result in a cumulative impact on the U.S. economy. Anticipated growth of aircraft operations and passengers at major airports will lead to delays for cargo movement and business travel, assuming that capital spending remains consistent through 2040 as it has been from 2001 (about $10 billion annually in 2010 value). The broad impacts on the U.S. economy would represent a cumulative loss of GDP amounting to $313 billion by 2020 and $1.52 trillion by 2040. Overall, the U.S. economy will end up with an average of 350,000 fewer jobs than it would otherwise have by 2020 and 358,000 fewer jobs in 2040.

Inland Waterways & Marine Ports

The U.S. inland waterway system consists of over 12,000 miles of inland and intracoastal waterways, with over 240 lock chambers, along with over 300 commercial harbors. Domestically, this system accounts for 10% of all tonnage moved in the United States and almost 20 percent of the total value of all freight transported over the entire U.S. transportation system. This includes approximately 56% of all crude petroleum, 15% of all coal, and 24% of other fuel oils, which alone affect the efficiency of all economic sectors that rely on energy. In addition, 70% of U.S. imports arrive by water, including 86% of crude petroleum imports, as well as approximately 76% of U.S. exports (by tonnage), accounting for approximately 35% of total exports by value.

If America's current level of investment in its inland waterways and marine ports continues, the losses to its economy will increase shipping costs. The toll of these impacts will be seen in GDP losses that will accumulate every year—from a loss of almost $95 billion in 2020 to over $255 billion by 2040. The cumulative loss in national GDP through 2040 will be over $4.0 trillion—driven by the rising costs to import and export goods and declining competitiveness. In turn, these effects will result in over 738,000 fewer jobs in 2020. By 2040, the job losses will grow to over 1.3 million—jobs that will be lost by the nation's lack of competitiveness in global trade and because households and businesses will be spending more for commodities that move within the U.S. on inland waterways and for goods that are imported.



Electricity

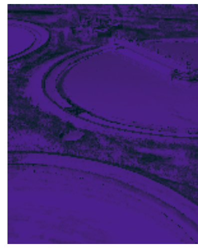
Electricity relies on an interconnected system that is composed of three distinct elements:[7]

1. Generation facilities—including approximately 5,800 major power plants and numerous other smaller generation facilities;
2. High-voltage transmission lines—a network of over 450,000 miles that connects generation facilities with major population centers; and
3. Local distribution systems that bring electric power into homes and businesses via overhead lines or underground cables.

The United States' system of generation, transmission, and distribution facilities was built over the course of a century. Centralized electric generating plants with local distribution networks were started in the 1880s, and the grid of interconnected transmission lines was started in the 1920s. Today, the U.S. system is a complex patchwork system of regional and local power plants, power lines, and transformers that have widely varying ages, conditions, and capacities.

Nationally, extending current trends leads to funding gaps in electric generation, transmission, and distribution that are projected to grow over time to a level of $107 billion by 2020, about $11 billion per year, and almost $732 billion by 2040. By 2020, distribution and transmission infrastructure are expected to account for more than 88% of the investment gap and generation infrastructure to represent roughly 11.5%. By 2040, however, generation infrastructure will potentially be the most costly element of the gap, accounting for 55% of the total, with transmission accounting for 15%, and distribution accounting for 30%. This would be a reversal from 2020, when generation is seen as the best-funded element of electricity infrastructure due to investments made during the preceding decade. The projected investment gap will be due to some combination of aging equipment and capacity bottlenecks that lead to the same general outcome—a greater incidence of electricity interruptions. The interruptions may occur in the form of equipment failures, intermittent voltage surges, power quality irregularities due to equipment insufficiency, and blackouts or brownouts as demand exceeds capacity for periods of time. These periods could be unpredictable in frequency and length, but the end result would be a loss of reliability in electricity supply that imposes direct costs to households and businesses. A failure to meet the projected gap would cost households $6 billion in 2012, $71 billion by 2020, and $354 billion by 2040. It would cost businesses $10 billion in 2012, $126 billion by 2020, and $641 billion by 2040.

If future investment needs are not addressed to upgrade the nation's electric generation, transmission, and distribution systems, the economy will suffer. Costs may occur in the form of higher costs for electric power, costs incurred because of power unreliability, or costs associated with adopting more expensive industrial processes. Ultimately, these costs all lead to the same economic impact: the diversion of household income from other planned expenditures to cover these increased costs. As costs to household and businesses associated with service interruptions rise, GDP will fall by a total of $496 billion by 2020. The U.S. economy will end up with an average of 529,000 fewer jobs than it would otherwise have by 2020. Even with economic adjustments occurring later on, with catch-up investments, the result would still be 366,000 fewer jobs in 2040.



Water / Wastewater

Of all the infrastructure types, water is the most fundamental to life, and is irreplaceable for drinking, cooking, and bathing. Farms in many regions cannot grow crops without irrigation. Government offices, hospitals, restaurants, hotels, and other commercial establishments cannot operate without clean water. Moreover, many industries—for example, food and chemical manufacturing and power plants—could not operate without the clean water that is a component of finished products or that is used for industrial processes or cooling. Drinking-water systems collect source water from rivers and lakes, remove pollutants, and distribute safe water. Wastewater systems collect used water and sewage, remove contaminants, and discharge clean water back into the nation's rivers and lakes for future use. Wet weather investments, such as sanitary sewer overflows, prevent various types of pollutants like sewage, heavy metals, and fertilizer from lawns from ever reaching the waterways.

Delivery of water and wastewater services in the United States is decentralized and strained. Approximately 54,000 drinking water systems collectively serve more than 264 million people (more than half the nation's public drinking-water systems serve fewer than 500 people). In addition, almost 15,000 wastewater treatment facilities and 20,000 wastewater pipe systems are spread across the U.S. as of 2008.

Although access to centralized treatment systems is widespread, the condition of many of these systems is also poor, with aging pipes and inadequate capacity leading to the discharge of an estimated 900 billion gallons of untreated sewage each year. As the U.S. population has increased, the percentage served by public water systems has also increased. Each year new water lines are constructed to connect more distant

Water-related infrastructure in the United States is clearly aging, and investment is not able to keep up with the need. If current trends continue, the investment required will amount to $126 billion by 2020, and the anticipated capital funding gap will be $84 billion.

dwellers to centralized systems, continuing to add users to aging systems. Although new pipes are being added to expand service areas, drinking-water systems degrade over time, with the useful life of component parts ranging from 15 to 95 years. Failures in drinking-water infrastructure can result in water disruptions, impediments to emergency response, and damage to other types of essential infrastructure. In extreme situations caused by failing infrastructure or drought, water shortages may result in unsanitary conditions, increasing the likelihood of public health issues.

The U.S. Environmental Protection Agency estimated the cost of the capital investment that is required to maintain and upgrade drinking-water and wastewater treatment systems across the U.S. in 2010 as $91 billion. However, only $36 billion of this $91 billion was funded, leaving a capital funding gap of nearly $55 billion. Water-related infrastructure in the United States is clearly aging, and investment is not able to keep up with the need. If current trends continue, the investment required will amount to $126 billion by 2020, and the anticipated capital funding gap will be $84 billion. Moreover, by 2040, the needs for capital investment will amount to $195 billion and the funding gap will have escalated to $144 billion, unless strategies to address the gap are implemented in the intervening years to alter these needs.

By 2020, the predicted deficit for sustaining water delivery and wastewater treatment infrastructure will be $84 billion. This may lead to $206 billion in increased costs for businesses and households between now and 2020. In a worst case scenario, the U.S. will lose nearly 700,000 jobs by 2020. Unless the infrastructure deficit is addressed by 2040, 1.4 million jobs will be at risk in addition to what is otherwise anticipated for that year.

The impacts on jobs are a result of costs to businesses and households managing unreliable water delivery and wastewater treatment services, and will be spread throughout the economy. Moreover, the situation is expected to worsen as the gap between needs and investment continues to grow over time. In 2020, almost 700,000 jobs will be threatened, which will grow to 1.4 million jobs by 2040. By 2020, the nation will have lost over $400 billion in GDP, while the cumulative impact through 2040 is expected to be almost $4 trillion.

4 CONCLUSIONS

The U.S. economy relies on low transportation costs and the reliable delivery of clean water and electricity to businesses and households to offset higher wage levels and costs of production when compared with many of America's competitors. However, this report series shows that business costs and therefore prices will increase if surface transportation systems worsen; ports and inland waterways become outdated or congested; and if water, wastewater, and electricity infrastructure systems deteriorate or fail to keep up with changing demand. Greater costs to transport the wide array of imported goods that supply U.S. domestic manufacturers and rising costs for exports will affect the nation's ability to compete in global markets for goods produced in the U.S., while irregular delivery of water and wastewater services and electricity will make production processes more expensive and divert household disposable income to these basic necessities.

Higher business costs will be incurred due to deteriorating infrastructure in terms of charges for services and efficiency, which will lead to higher costs incurred by households for goods and services due to the rising prices passed on by businesses. The result of these effects will be a reduction in disposable income and reduced spending for consumer goods and services, which will further exacerbate business impacts. Moreover, over time, these impacts will affect the means for businesses to provide well-paying jobs, further reducing incomes.

The results of this final study underscore the findings of the preceding reports in the *Failure to Act* series. Often, estimates of economic activity and job creation focus on the design and construction period for infrastructure projects. Generally, in these type of analyses, the construction impacts rise with the magnitude of infrastructure investment. However, these studies demonstrate that the economic benefits of infrastructure investment reverberate through every sector of the economy and are exacerbated over time as needed investments are deferred, in addition to the economic "shock value" of construction spending.

The analyses presented in the previous studies show that deteriorating infrastructure affects businesses and households in various ways, leading to reductions in business efficiencies, increasing business costs, and increasing costs of goods and services to households. The findings of this final report show that the weakening of multiple infrastructure systems will have a greater effect overall than a simple adding up of the impacts for the individual infrastructure studies.

Several core reasons explain this effect. First, if one transportation system fails, another system can be used in some cases. For example, if airports are too congested, passengers can drive or use trains, and cargo can be shipped by truck, rail, or inland waterways. However, this substitution is not possible if multiple systems deteriorate. Moreover, every trip to and from an airport, marine port, and an inland port is by some form of surface transportation. Second, the efficient operations of different infrastructure systems depend on each other. For example, power plants use water to generate electricity (for boiling water to create steam and for cooling).[8] Thus, electricity and water are needed to manufacture parts for transportation vehicle repairs and materials for road repairs. Transportation of all modes is required to deliver parts and equipment to all types of infrastructure systems, including transportation facilities.

Sustainable policies and personal choices will not fix America's infrastructure, but they can reduce wear and tear, and thereby extend the useful lives of the nation's infrastructure systems. In turn, this could extend the time frame for the full levels of investments suggested in these studies and may mitigate some of the economic consequences of not funding investment. More research on tying sustainable practices to infrastructure investment would be a valuable contribution for understanding the trade-offs that must be faced both nationally and regionally.

The five reports in the *Failure to Act* series are analytical and do not offer policy or funding prescriptions. Each report suggests that more research is needed to document the demand response—that is, how businesses and households will adjust demand based on changes in the efficiencies and costs of infrastructure services, which may affect the level of investment funding from each of these traditional sources. Regardless of the policy solutions, the *Failure to Act* series demonstrates that maintaining and modernizing out nation's infrastructure has long-term economic implications.

★ ENDNOTES

1. The single exception is that the logic of the airports, inland waterways, and marine ports study is that ports require ground access to and from these facilities.

2. Note that these are single-year impacts for 2020 and 2040, not cumulative totals.

3. Output is primarily business sales but also includes spoilage/breakage and unsold inventory.

4. Note that these are single-year impacts for 2020 and 2040, not cumulative totals.

5. Although the data shown in table 5 are net impacts to the economy, it should be noted that economic sectors will gain jobs and/or business sales above projected levels in order to serve needs caused by declining infrastructure performance.

6. An "enplanement is a passenger boarding. The FAA uses revenue passenger boardings (enplanements) and cargo data to calculate the apportionments that determine apportionment formula for the Airport Improvement Program.

7. The first two elements are usually referred to as the bulk power system.

8. See P. Torcellini et al., *Consumptive Water Use for U.S. Power Production* (Washington: National Renewable Energy Laboratory, U.S. Department of Energy, 2003).

ABOUT EDR GROUP

Economic Development Research Group, Inc. (EDR Group) focuses specifically on applying state-of-the-art tools and techniques for evaluating economic development performance, impacts and opportunities. The firm was started in 1996 by a core group of economists and planners who are specialists in evaluating impacts of infrastructure services and technology on economic development opportunities.

The firm provides consulting and analysis services to private and public-sector clients across the U.S., Canada and overseas. This includes benefit-cost, economic impact, and cost-effectiveness studies for projects, programs and policies. These efforts support economic development strategies, planning processes and public investment decision-making. In addition, EDR Group provides software tools to assist others in conducting economic analysis, including tools for assessing transportation, energy and economic development investments. EDR Group provides a large collection of its economic impact analysis studies and information on analysis tools, which can be found at www.edrgroup.com.

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Footnote 6 Document

Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth, and Competitiveness, Section 2.4 Water Utilities, p.69-73 (Sep. 16, 2015)

2.2 Business

American businesses can drive significant improvements to U.S. energy productivity, and they stand to benefit significantly from increasing energy productivity within their own operations. Although the importance of energy use may vary by type of business, improving energy productivity can be a universal source of enhancing competitiveness by increasing the amount of goods and services produced for a given amount of energy used. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers. Notable contributions were provided by Raleigh regional dialogue participants for energy productivity in buildings and by St. Paul regional dialogue participants for advanced and smart manufacturing.

Lack of funding is a common barrier to reducing energy costs in businesses; the most significant financial barriers are insufficient internal capital budgets and competition with other capital investments.[90] To more clearly target recommended strategies, the *Roadmap* separates businesses into commercial (i.e., businesses that provide services and have lower energy intensities) and industrial groups (i.e., businesses that produce physical goods and have higher energy intensities). Both groups have the opportunity to encourage gains in energy productivity for their customers while offering them innovative products and services. Actions by businesses contribute to all six energy productivity wedges.

2.2.1 COMMERCIAL BUSINESSES

2.2.1.1 New Financing Models

The investments needed across all sectors of the economy to increase energy productivity will require both existing and new innovations in financing mechanisms. Financing of investments is a barrier to increasing energy productivity for households, industrial businesses, and commercial businesses.[91] Together with strategies implemented by government

90 Johnson Controls, *Energy Efficiency Indicator: 2013 U.S. Results*, accessed July 2015, http://www.institutebe.com/InstituteBE/media/Library/Resources/Energy%20Efficiency%20Indicator/061213-IBE-Global-Forum-Booklet_I-FINAL.pdf.

91 Johnson Controls, *Energy Efficiency Indicator*: 2013 U.S. Results.

on the federal, state, and local levels, improved financing can facilitate the adoption of existing energy productivity technology and pave the way for new markets for yet-to-be commercialized technologies.

Small commercial buildings are an untapped source of energy productivity improvements, as is apparent in the potential investment value and energy savings for them; the investment value of the market for small building energy retrofits is estimated at $36.5 billion, with associated potential energy and utility bill savings of 420 trillion Btu and $138 billion, respectively.[92] The approaches required for tapping this potential differ from large enterprises and large commercial buildings, but public-private partnerships such as PACE financing and on-bill financing are examples of strategies to overcome the barriers for this market segment. As of January 2014, on-bill financing programs were operating or preparing to launch at least 25 U.S. states as well as in Canada and the United Kingdom. In aggregate, the 30 programs reviewed for a study done through SEE Action have delivered over $1.8 billion of financing to consumers for energy improvements.[93] Specific improvements for financing of small building energy efficiency projects include developing turnkey solutions, expanding contractor-led programs, and improving underwriting and program execution.[94]

2.2.1.2 Workforce Training

Increasing the energy efficiency of buildings is essential to meeting the energy productivity goal, yet building and construction contractors, and building trades professionals often lack awareness of the potential growth of the energy efficiency services sector, and more workers with energy efficiency qualifications are needed.[95] An instrumental strategy for overcoming this barrier is to incorporate energy efficiency into existing union and trade organization training programs, especially in ways that teach whole-building approaches to efficiency.[96] These organizations can also team with community and technical colleges, universities, and public utility commissions to effectively address the efficiency workforce education and training needs. For example, Pulaski Technical College in Arkansas offers energy efficiency courses for continuing education credits to professionals in the building trades.[97]

92 National Institute of Building Sciences Council on Finance, Insurance and Real Estate, *Financing Small Commercial Building Energy Performance Upgrades: Challenges and Opportunities* (Washington, D.C.: National Institute of Building Sciences, 2015), accessed July 2015, http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/CC/CFIRE_CommBldgFinance-Final.pdf.

93 State and Local Energy Efficiency Action Network, *Financing Energy Improvements on Utility Bills: Market Updates and Key Program Design Considerations for Policymakers and Administrators* (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2014), accessed July 2015, https://www4.eere.energy.gov/seeaction/system/files/documents/publications/executive/onbill_financing_es.pdf.

94 National Institute of Building Sciences, *Financing Small Commercial Building Energy Performance Upgrades: Challenges and Opportunities* (Washington, D.C.: National Institute of Building Sciences, 2014), accessed July 2015, http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/CC/CFIRE_CommBldgFinance-Final.pdf.

95 Charles A. Goldman, Jane S. Peters, Nathaniel Albers, Elizabeth Stuart, and Merrian C. Fuller, *Energy Efficiency Services Sector: Workforce Education and Training Needs*, LBNL-3163E (Berkeley, CA: Lawrence Berkeley National Laboratory, 2010), accessed July 2015, http://emp.lbl.gov/publications/energy-efficiency-services-sector-workforce-education-and-training-needs.

96 Goldman et al. (2010).

97 "Continuing Education Credit Offerings," Pulaski Technical College, accessed July 2015, http://www.pulaskitech.edu/center_for_applied_building_sciences/continuing_education_credit_offerings.asp.

BUSINESS SUCCESS STORY

Lime Energy Tackles Barriers to Energy Efficiency in the Small and Mid-Sized Business (SMB) Segment

Lime Energy (Lime) is an energy services provider. One of its core strategies is to partner with utilities providing energy efficiency programs to small and mid-sized businesses (SMBs), a segment that represents the majority of commercial buildings in the United State. Since launching their innovative efficiency programs in 2011, Lime has delivered more than one billion kilowatt-hours of savings to over 100,000 SMBs, resulting in over $720 million of avoided energy costs while also adding 5,500 jobs to the U.S. economy. Lime Energy works directly for 12 of the top 25 utilities in the nation, having effectively brought energy savings performance contracting to their 1.4 million SMB customers.

Incentive programs targeting energy efficiency in commercial buildings have been implemented by utilities and program administrators for years, but they have struggled to gain participation from the SMB segment. These customers use nearly 50 percent of the energy consumed in the entire commercial building sector. Traditional barriers have included small business owners' lack of resources, their difficulty navigating technical energy efficiency concepts, and the high cost of acquiring these resources in the diverse SMB building sector. Lime Energy has spent the last four years attacking these problems head on. Below are examples of overcoming these barriers.

EXAMPLE: OVERCOMING THE SMB RESOURCE AVAILABILITY BARRIER

A south New York utility had run a commercial energy efficiency program for three years with little participation from customers with buildings under 10,000 square feet. The utility determined the low participation was because the program was too time-consuming and confusing for customers. Working with the utility, Lime Energy proposed an integrated program offering simplified customer participation. Lime installed a technology-driven delivery platform that enabled energy services representatives to take no more than 15 minutes to market the program, conduct an analysis, present financing options, and close the project. Given a small business owner's lack of availability, Lime's integrated approach and technology proved valuable to the utility, as it standardized and drastically shortened the time and customer involvement needed to initialize and implement the energy efficiency program.

EXAMPLE: OVERCOMING THE COST CONSTRAINT FOR SMBs

Utilities are often not adequately incentivized through state regulation to offer cost-effective energy efficiency programs to SMBs. One utility recognized the value of customer satisfaction and public goodwill that energy efficiency could bring to small businesses, but it needed help navigating tight budgetary constraints and a challenging policy landscape. Lime worked with the utility's program managers and with state policy advocates to design a program to fit this need. The program design was aimed at reducing energy efficiency program costs through technology and software innovation, increased staff effectiveness, marketing efficiency (through deep market segmentation and data analytics), and lowered project costs for consumers (through bulk procurement of efficiency measures with leading national distributors). Innovatively, Lime delivered these features to the utility in a guaranteed performance contract vehicle—similar to a power purchase agreement—easing concerns voiced by state regulators regarding runaway incentive budgets. This example shows how the "utility of the future" will deliver cost-effective, clean energy for their customers.

Through these tailored approaches, Lime Energy has directly financed over $9.2 million in efficiency projects, enabling 1,332 SMBs to participate in energy efficiency programs, and saving a collective 100,000 kWh in annual consumption in hard-to-reach markets such as restaurants, service stations, laundromats, and small retailers. Lime has influenced real customer behavior change, helping 1,747 small businesses make long-term investments of over $8.5 million in less than three years. Additionally, Lime's services increased customer satisfaction with utility energy efficiency programs to 96 percent, and overall satisfaction with the providing utility to 98 percent. Lime is helping utility clients move into the future, aligning their business goals with customer satisfaction while simultaneously reducing the emissions from the electricity they deliver. As regulations require increased delivery of energy efficiency resources, utilities have great potential in the SMB segment, for which Lime Energy's program delivery breakthroughs can be key. Lime's methods have made SMB energy efficiency delivery so cost effective that several utility clients are implementing these programs despite not having a regulatory requirement to do so.

For more information on Lime Energy's programs, their performance model, or the platform that powers it, see www.lime-energy.com.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.2.2 INDUSTRIAL BUSINESSES

Industrial businesses are critical participants in helping the United States meet the energy productivity goal because of their importance as energy users and engines of economic growth. These businesses also have the opportunity to provide new products and services that enable other businesses and sectors of the economy to improve their energy productivity. As a result, the industrial sector is well positioned to increase U.S. energy productivity through high-impact product innovation and the use of highly efficient manufacturing processes to streamline operations, improve productivity, and advance U.S. economic competitiveness.

In addition to increasing output using the same or less energy, energy productivity for industrial businesses can lead to substantial non-energy benefits or "co-benefits"[98] including reduced operations and maintenance costs, increased product quality, and improved worker health and safety. However, these co-benefits are often missing from the business case for projects that may increase a company's energy productivity. Getting funding for these projects may involve strategies such as having a separate capital account for proposed energy efficiency and energy productivity projects, or incorporating estimates of the value of energy productivity co-benefits.

The DOE's Better Plants Program (Better Plants) calls on its participants to demonstrate their commitment to increasing energy efficiency by voluntarily reducing their energy intensity by 25 percent over ten years. As of fall 2014, the 143 participants, representing nearly 11 percent of the total U.S. manufacturing footprint, reported cumulative savings of 320 trillion Btu and $1.7 billion in energy costs; this is enough energy to power the entire state of Vermont for over two years.[99] Building on the success of its participants, Better Plants started a pilot program to improve coordination of energy management practices between companies and their supply chains. For some manufacturers, much of the energy footprints of their products can be traced back to the materials and processes of their suppliers. Better Plants offers participating suppliers technical assistance, energy management training, and priority access to no-cost energy audits through DOE's IACs.[100] Johnson Controls, a Better Plants participant, achieved an annual energy intensity improvement of 8 percent,[101] and it is expanding its own supplier efficiency program by 60 suppliers by 2018. The company's program uses its own energy experts to train suppliers on identifying and implementing cost-effective energy efficiency investments. These efforts have helped suppliers achieve energy savings of 5-10 percent on investments with less than a two-year payback.[102]

98 International Energy Agency, *Capturing the Multiple Benefits of Energy Efficiency* (Paris: International Energy Agency, 2014).

99 U.S. Department of Energy Better Plants, "Progress Update: Fall 2014" DOE/EE-1140 (Washington, D.C.: U.S. Department of Energy, 2014), accessed July 2015, http://energy.gov/sites/prod/files/2014/09/f18/Better%20Plants%20Progress%20Update%202014.pdf.

100 U.S. Department of Energy Better Plants, "Overview: Supply Chain Pilot" (Washington, D.C.: U.S. Department of Energy, 2014), accessed July 2015, http://energy.gov/sites/prod/files/2014/07/f17/better_plants_supply_chain_pilot.pdf.

101 "Johnson Controls, Inc.," U.S. Department of Energy Better Buildings, accessed July 2015, http://betterbuildingssolutioncenter.energy.gov/energy-data/Johnson%20Controls,%20Inc.

102 Johnson Controls, Inc., "Johnson Controls teams up to scale energy efficiency in corporate supply chains," news release, June 11, 2015, http://www.prnewswire.com/news-releases/johnson-controls-teams-up-to-scale-energy-efficiency-in-corporate-supply-chains-300097486.html.

Small and medium enterprises that lack internal expertise in evaluating projects to increase energy productivity may find it beneficial to hire external assistance. Energy service companies can be a valuable partner in realizing reductions in energy use. They provide customers with guaranteed energy savings in return for payment from a portion of the achieved savings. Customers of energy service companies saved an estimated 33.7 terawatt-hours of electricity in 2012, equivalent to 2.5 percent of U.S. commercial electricity retail sales.[103]

2.2.2.1 Public-Private Partnerships

Partnerships between private business, government and universities for clean energy technologies are important enablers for meeting the energy productivity goal. Public-private partnerships can help increase access to capital, facilitate use of shared infrastructure, and lower technical risks. One notable example is the National Network of Manufacturing Innovation (NNMI), which focuses on R&D of foundational technologies that have potentially transformational technical and productivity impacts for the U.S. industrial sector. NNMI has established five institutes each of which focuses on a promising manufacturing approach or technology. For example, the institute Lightweight Innovations for Tomorrow (LIFT), which focuses on lightweight technology, has a project to reduce the wall thickness of ductile iron cast parts by 50 percent which could result in weight savings of 30–50 percent and associated energy efficiency benefits.[104] These institutes begin with federal support, but they are expected to operate with private-sector funding and without further federal funding after five years.

High-performance computing is another example where industry and public sector resources can join to increase energy productivity. Public-private partnerships in this space could further empower small and large businesses to harness the power of, as well as the modeling and simulation capabilities from, the national laboratory system—to improve R&D, reduce the time required to bring a product to market, and optimize production and supply processes.[105]

The Oak Ridge National Laboratory Manufacturing Demonstration Facility offers shared RD&D infrastructure for additive manufacturing and low-cost carbon fiber, which could be significant enablers of energy productivity, particularly in transportation applications and other technology areas.[106] The facility provides industries with the types of technical expertise and state-of-the-art technology that reduce risk and accelerate the commercialization of innovative new processes and products.

103 Juan Pablo Carvallo, Peter H. Larsen, and Charles A. Goldman, *Estimating customer electricity savings from projects installed by the U.S. ESCO industry*, LBNL-6877E (Berkeley, CA: Lawrence Berkeley National Laboratory, 2014), accessed July 2015, http://emp.lbl.gov/sites/all/files/lbnl-6877e.pdf.

104 Lightweight Innovations for Tomorrow, “LIFT Announces First Technology Project will Focus on Iron Alloys in Thin-Wall Castings,” news release, July 16, 2015, http://lift.technology/lift-announces-first-technology-project-will-focus-on-iron-alloys-in-thin-wall-castings/.

105 Council on Competitiveness, *Strengthen: Dialogue 5* (Washington, D.C.: Council on Competitiveness, 2015), accessed July 2015, http://www.compete.org/storage/documents/CoC_AEMC_D5_Strengthen_FINALv2.pdf.

106 Oak Ridge National Laboratory, *Manufacturing Demonstration Facility*, ORNL 2013-G00529/aas (Oak Ridge, TN: Oak Ridge National Laboratory, 2013), accessed July 2015, http://web.ornl.gov/sci/manufacturing/docs/MDF-factSheet.pdf.

SMALL BUSINESS SUCCESS STORIES

Eck Industries, South Shore Millwork, and Mid-South Metallurgical

Eck Industries of Manitowoc, Wisconsin, is a small four-generation, family-owned aluminum foundry. Eck Industries took advantage of the resources made available through Wisconsin's Focus on Energy program, an initiative that provides technical and financial resources for energy efficiency projects. Eck Industries worked with the state program to implement a lighting retrofit project that would better illuminate its production facilities. The lighting efficiency improvements proved successful—the new energy-efficient bulbs reduced the energy intensity of the facility's lighting by 46 percent, the project paid for itself in approximately eight months, and the company realized annual operating savings of more than $55,500.[1]

South Shore Millwork is a small business providing fine architectural woodwork in Norton, Massachusetts. In an effort to improve the efficiency of their millwork shop, the company reached out to Mass Save, an energy efficiency initiative sponsored by Massachusetts utility and efficiency companies. Through the program, South Shore Millwork installed high-efficiency lighting systems and controls, occupancy sensors, and variable speed drives at a total project cost of $218,000. The project saved $30,500 annually (a payback period of 4.5 years), and it reduced carbon emissions reduction by more than two tons annually.[2]

Mid-South Metallurgical is a niche commercial heat-treating company in Murfreesboro, Tennessee. The Mid-South Metallurgical facility operates 24 hours a day and it must accommodate furnace temperatures ranging from 120°F to 2375°F. To address efficiency challenges, the Industrial Assessment Center sponsored by the DOE at the University of Tennessee conducted an evaluation in which they discovered several areas where the company could save energy, including through better furnace insulation. Also found were opportunities to lower peak energy demand through an electrical demand system,

1 http://www.energy.gov/sites/prod/files/2014/05/f16/eck_industries_case_study.pdf

2 http://www.masssave.com/~/media/Files/Business/Case-Study/EE5200_MassSave_SouthShore.pdf

energy-efficient furnace burner tubes, and improvements in the lighting system. By adopting these recommendations, Mid-South Metallurgical lowered its energy use by 22 percent and decreased its energy costs by 18 percent, helping the company remain competitive through the recession and earning DOE's Energy Champion Award.[3]

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

3 http://www.energy.gov/sites/prod/files/2014/05/f16/midsouth_metallurgical_casestudy.pdf

2.2.2.2 Energy Management System Certification

Establishing and certifying an energy management system that systematically tracks, measures, and continually improves energy performance can serve as the foundation for increasing the energy productivity of industrial businesses. For example, manufacturers may focus on the energy used in their processes, as 18 percent of the manufacturing sector's total electricity use is due to direct non-process uses such as facility lighting and space conditioning.[107] Participation in DOE's Superior Energy Performance program, which includes achieving certification under the International Organization for Standardization (ISO) 50001 standard and the American National Standards Institute (ANSI)/MS Standard 50021, yielded average energy savings of $500,000 per year, which is equivalent to a two-year payback period.[108] Additionally, program participants have noted that certification provided more awareness of and confidence in energy performance improvements, unlocking additional resources to fund further improvements.

2.2.2.3 Advanced Manufacturing

Advanced manufacturing is composed of "efficient, productive, highly integrated, tightly controlled processes across a spectrum of globally competitive U.S. manufacturers and suppliers."[109] Reinvigorating the U.S. industrial sector by fostering the growth of advanced manufacturing capabilities will also provide high-quality jobs, which can further improve the U.S. economy. However, in order to bring about the changes necessary for advanced manufacturing, private investment needs to be complemented by public investment.[110]

Information and communications technology (ICT), including sensors and controls that enable optimized energy consumption in plants and other buildings, can be important for enabling energy productivity gains for companies. These ICT-rich systems are also integral to improving product quality and communication technology that is now being deployed in the electric power sector, where it is often called the smart grid, where it is enabling better use of labor, materials, and capital inputs more efficiently, productively and cleanly, thus supporting economic efficiency and some forms of energy productivity improvements. Estimates of the market size for these technologies range from $43 billion in potential sales

107 "2010 MECS Survey Data," U.S. Energy Information Administration, accessed July 2015, http://www.eia.gov/consumption/manufacturing/data/2010/.

108 Peter Therkelsen, Ridah Sabouni, Aimee McKane, and Paul Scheihing, "Assessing the Costs and Benefits of the Superior Energy Performance Program" (paper presented at the ACEEE Summer Study on Energy Efficiency in Industry, Niagara Falls, NY, 2013), accessed July 2015, http://energy.gov/sites/prod/files/2014/07/f17/sep_costbenefits_paper13.pdf.

109 "Made in America: The Next-Generation of Innovation," National Institute of Standards and Technology Advanced Manufacturing National Program Office, accessed July 2015, http://www.manufacturing.gov/advanced_manufacturing.html.

110 President's Council of Advisors on Science and Technology, Report to the President on Ensuring American Leadership in Advanced Manufacturing (Washington, D.C.: The White House, 2011), accessed July 2015, https://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf.

for building automation technologies by 2018[111] to over $120 billion for manufacturing automation sales by 2020.[112] While acknowledging cyber security concerns, attendees at the *Roadmap* regional dialogues noted the value of a standard protocol for new ICT products to allow interoperability between new entrants in this market. This QER also identified this.[113] The next section discusses strategies to develop new business models around enabling customers' energy productivity.

2.2.2.4 Innovative Products to Enable Energy Savings

The most significant opportunity for industry to help the U.S. meet its energy productivity goal is to develop, manufacture, and sell products and services that enable energy productivity improvements for their customers. Developing new business models around enabling energy productivity improvements for customers requires a better understanding of where energy is used along a product's value chain or life cycle. Tools like life-cycle assessment allow companies to uncover and target which portion of their products' life-cycles use the most energy, as well as other resources like water. Depending on the product, the energy required by industry to produce a product may only be a small fraction of its total life-cycle energy.

Providing products (e.g., lighter weight materials) that reduce this energy use not only provide value to the customer, but also reduce overall energy use and potentially create new markets. Continued advances in solid state lighting technology (SSL), such as fully controllable color tuning, have resulted in new and growing applications for highly efficient lighting that are geared specifically for productivity improvements. A sampling of these applications include spectrally controlled lighting to make people more alert or to facilitate sleep; spectrally optimized lighting for crop growth and livestock rearing; and spectrally tuned lighting for visual inspection processes or other enhanced visibility functions.[114]

111 ABI, "Commercial Building Automation Market to Top $43 billion by 2018, Says ABI Research." Press Release, April 30, 2013. http://www.reuters.com/article/2013/04/30/ny-abi-research-idUSnBw306552a+100+BSW20130430. As cited in Rogers et al. Intelligent Efficiency: Opportunities, Barriers, and Solutions, Report number E13J (Washington, D.C.: American Council for an Energy-Efficient Economy, 2013), accessed July 2015, http://aceee.org/sites/default/files/publications/researchreports/e13j.pdf.

112 Cullien, Matt, Machine to Machine Technologies: Unlocking the Potential of a $1 Trillion Industry. The Carbon War Room (2013). As cited in Rogers et al. Intelligent Efficiency: Opportunities, Barriers, and Solutions, Report number E13J (Washington, D.C.: American Council for an Energy-Efficient Economy, 2013), accessed July 2015, http://aceee.org/sites/default/files/publications/researchreports/e13j.pdf.

113 U.S. Department of Energy, Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure.

114 Norman Bardsley, Stephen Bland, Lisa Pattison, Morgan Pattison, Kelsey Stober, Fred Walsh, and Mary Yamada, *Solid-State Lighting Research and Development Multi-Year Program Plan* (Washington, D.C.: U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, 2014), accessed July 2015, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf.

MANUFACTURING SUCCESS STORY

Legrand Employees Achieve 15.4 Percent Reduction over 26.2-Day "Energy Marathon"

Legrand is a manufacturing, global specialist in electrical and digital building infrastructures that effectively saved 588,540 kWh of electricity, enough energy to drive an electric car to the moon and back 3.3 times, in just 26.2 days during its "2014 Energy Marathon." These savings did not occur by chance, but rather through effectively leveraging previous efforts. First, Legrand became a Partner to the U.S. Department of Energy (DOE)'s Better Buildings, Better Plants Challenge, and committed to reducing its energy intensity by 20 percent from 2012 - 2022, on top of the 27 percent reduction the company achieved from 2009-2012. To tackle this new goal, Legrand conducted energy audits at manufacturing, warehouse, and office facilities, where the company identified energy efficiency opportunities with payback periods spanning immediate results to four years. Based on these audits, Legrand completed numerous technology upgrades and process changes across its facilities, and brainstormed new, innovative ways to engage its people.

In addition to DOE's resources, Legrand leveraged its own initiative, building on its "Power Down Day," a successful one-day energy efficiency event conducted in 2012, to create a 26.2-Day Energy Marathon. The Energy Marathon targeted longer-term energy behavior change, based on the idea that 'it takes 20 days to build a habit." Through the Energy Marathon individual sites established baseline electricity usage, and the site with the greatest percentage energy consumption reduction, compared to its baseline, was crowned the winner. A diverse steering committee and site leaders at each of the 18 participating locations drove energy savings at the facility level. For 26.2 days, site leaders read the facility's utility electric meter and reported the readings to a central event coordinator. Employees received daily tips for saving energy and event "standings" via emails, posters, and TV monitor displays – effectively driving competition through awareness and engagement.

As a result of employees' deliberate efforts to reduce energy consumption and some ready-to-implement technology changes at the facility level, the Energy Marathon reduced Legrand's electricity usage by

15.4 percent across the participating sites. In total, the company saved 588,540 kWh of electricity, preventing approximately 406 metric tons of CO_2 from entering the atmosphere. This amounted to a cost savings of $46,732 over the course of the 26.2-days. The winning facility achieved a 63.1 percent reduction vs. the baseline, while half of the participating sites exceeded a 20 percent reduction. Based on tracking data gathered since 2014, all sites are on goal to continuously reduce consumption based on Legrand's internal commitment and our Better Buildings, Better Plants Challenge pledge. Legrand has observed behavioral changes with more meetings and offices relying on natural light rather than overhead lighting. Part of the lasting impact is the awareness more of our employees have of our commitment to reduce our energy consumption. Since the majority of energy savings could be attributed to behavioral change and education, savings are expected to continue into the future in concurrence with repeating the competition and continuing energy education.

Looking beyond the event's tangible energy and cost savings, Legrand was able to bolster the visibility of its overall sustainability initiatives and highlight the importance of energy efficiency – both in terms of competiveness as a company and to the environment. The competition made saving energy fun and engaging for employees – something that will leave a lasting imprint on future sustainability events and campaigns. Legrand shares its experience in tools available for free download on its sustainability webpage.

A step-by-step guide to conducting your own Energy Marathon as well as other tools to help others save energy can be found at: http://www.legrand.us/aboutus/sustainability/high-performance-buildings/tools-and-downloads.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.3 Electric Utilities

Utilities—including investor-owned utilities, municipalities, and cooperatives—have significant potential to impact energy productivity through increased investments and reduced Btu consumption. In 2013, ratepayer-funded energy efficiency programs saved an estimated 23.16 billion kWh of electricity or 0.6 percent of U.S. retail electricity sales in 2013.[115] Such programs show the potential to increase energy productivity through reducing energy consumption. Although these energy efficiency impacts are important for increasing energy productivity, potentially even larger impacts could result from cost-effective investments. Investing in upgraded infrastructure and technologies, along with potential revenue increases from new product and services would induce economic growth. Through market transformation programs and other innovations, the electricity sector serves as a leader and test bed for enabling new technologies with products, services, and markets that contribute to energy productivity improvements. This section of the *Roadmap* takes a holistic look at the energy system and focuses on enhancing U.S. energy productivity through accelerated efforts to implement a smarter, modernized electric energy system.

Together with utilities, public utility commissions and public service commissions[116] can be drivers of electricity rate designs, distributed generation deployment, energy efficiency programs, and other strategies that increase energy productivity. For example, moving from traditional block electricity pricing to time-variant rates can be critical for the functioning of a smarter grid, integration of distributed energy resources (DER) like wind and solar, and adjusting to slower growth in electricity use. Actions by electric utilities contribute to all six energy productivity wedges:

Smart Energy Systems
Technologies for Buildings Energy Productivity
Financing for Buildings Energy Productivity
Water Infrastructure
Smart Manufacturing
Transportation

2.3.1 GRID INFRASTRUCTURE ENERGY PRODUCTIVITY

The term "smart grid" refers to modernization of the electricity delivery system through the deployment of information and communication technologies that can enable greater consumer interaction and choice, as well as monitor, protect,

115 Consortium for Energy Efficiency, *2014 State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts* (Boston: Consortium for Energy Efficiency, 2015), accessed July 2015, http://library.cee1.org/sites/default/files/library/12193/CEE_2014_Annual_Industry_Report.pdf.

116 The name utility regulatory entities vary by state. The most common names are "public utility commission" and "public service commission."

and automatically optimize the operation of its interconnected elements. Smart grid applications offer great potential to increase the economic efficiency, and at times the energy efficiency, of U.S. power generation, transmission, and distribution while creating a more versatile, resilient, and reliable electric power grid.

Elements of the smart grid can allow for energy productivity benefits by enabling more energy efficiency in a number of areas, such as either at the end use or in the transmission and distribution of energy; reduced energy losses in the transmission and distribution system; and the ability to enable end-users more choice in their electricity consumption-resulting in reduced electricity use instead of new generation. For example, use of smart meters allows for the elimination of transportation energy used for manual meter reading as well as less transportation energy used for utility repair crews due to more precise detection and understanding of local electricity outage.

The smart grid enables more rapid adoption of distributed power generation and storage as well as the increased use of electric vehicles to become available to consumers more readily and easily available to consumers, without barriers or restrictions. Smart grid technologies also permit utilities to more actively manage voltage levels along their distribution circuits; when voltage levels can be optimized and reduced through conservation voltage practices, a considerable amount of energy savings can be realized without compromising reliability. Without the development of the smart grid, the full value of many individual technologies like electric vehicles, automated household devices, demand response, distributed resources such as residential solar, and larger-industrial distributed generation might not be fully realized.

Multiple regional dialogue participants at Accelerate Energy Productivity 2030 dialogues emphasized the transformative potential of a standard protocol for data to be communicated between smart grid devices. In the QER, the Administration recommended that DOE work with industry, the Institute of Electrical and Electronics Engineers, state officials, and other interested parties to identify additional efforts the Federal Government can take to better promote open standards that enhance connectivity and interoperability on the electric grid.[117] DOE efforts to support the development of voluntary standards in a number of areas continue.[118] These standards will allow devices created and operated by different companies to communicate, contributing to interoperability between grid technologies and increasing the value of smart grid technologies for all consumers. Standards are also important for the adoption of smart manufacturing, as described previously in the section on advanced manufacturing.

2.3.1.1 Reducing Economic Losses from Power Outages

Studies conducted by the Electric Power Research Institute (EPRI) show the annual cost of power disturbances to the

117 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure.*

118 "Smart Buildings Equipment Initiative," U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, accessed July 2015, http://energy.gov/eere/buildings/downloads/smart-buildings-equipment-initiative.

U.S. economy ranges between $119 and $188 billion per year.[119] The societal cost of a massive blackout is estimated to be in the order of approximately $10 billion per event.[120]

Smart grid technologies and infrastructure, such as automated feeder switches and smart meters, offer utilities the potential to provide more reliable energy, particularly during challenging emergency conditions, while managing their costs more effectively through real-time metrics with the smart grid. These benefits that reduce costs for utilities create spillover benefits of lower electricity prices, or of no price increases, to customers. Lower costs and decreased infrastructure requirements in turn enhance energy productivity, and reduced costs increase economic activity, which benefits society.

2.3.1.2 Effects of a Flexible Smart Grid on Energy Productivity

Transitioning the country's electric energy system to a smarter, modern system could result in direct energy productivity benefits through enhanced infrastructure investments, and more significantly, indirect benefits through enabling two-way flow of electricity and information. Managing the flow of information and electricity in two directions (traditionally electricity flows in one direction from large power generation stations through transmission and distribution grids to consumers) will enable the effective integration of electric vehicles, smart buildings and houses, distributed generation systems (such as rooftop solar systems), and energy storage devices with the electric grid and open opportunities for new markets where participants are rewarded for providing enhancements in efficiency and resiliency. The total economic value generated from a fully deployed smart grid is estimated as high as $130 billion annually.[121]

2.3.1.3 Improving Electric Generating Unit Heat Rates to Gain Energy Productivity

Results of a recent analysis indicate that approximately 4.6 percent of electricity is consumed in the production of electricity itself, making the electric sector the second largest electricity consuming industry in the United States.[122] The performance of a thermoelectric power plant can be measured by its heat rate—the efficiency of conversion from fuel energy input to electrical energy output. A generating unit with a lower heat rate can generate the same quantity of electricity than a unit with a higher heat rate while consuming less fuel to generate electricity. Lower fuel use per unit of electricity generated also reduces the corresponding emissions of pollutants.

119 David Lineweber and Shawn McNulty, *The Cost of Power Disturbances to Industrial & Digital Economy Companies* (Palo Alto, CA: Electric Power Research Institute, 2001), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002000476.

120 119 U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations* (Washington, D.C.: U.S. Department of Energy, 2004), accessed July 2015, http://energy.gov/oe/downloads/blackout-2003-blackout-final-implementation-report.

121 Booth, Adrian, Mike Green, Humayun Tai, *U.S. Smart Grid Value at Stake: The $130 Billion Question* (McKinsey, 2010), accessed July 2015, http://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_130billionQuestion_VF.ashx.

122 C. Gellings, *Program on Technology Innovation: Electricity Use in the Electric Sector* (Palo Alto, CA: Electric Power Research Institute, 2001), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001024651.

Modern coal-fueled power plants now achieve net conversion efficiencies of over 39 percent.[123] A variety of technologies show potential to increase efficiency of power plants. Examples include: the incorporation of adjustable-speed-drive mechanisms for plant motors; turbine upgrades for higher temperatures and pressures; advanced materials for expanded operational temperature ranges; condenser upgrades; replacement seals and firing system upgrades and diagnostics; and sensors and controls for optimizing performance.[124]

Over 80 percent of the U.S. electric power generation capacity comes from thermal turbines.[125] Consequently, improving heat rates at existing generators can lower fuel costs and help achieve compliance with environmental regulations. A heat rate improvement of 1 percent on a single 500-megawatt (MW) base-loaded coal-fired unit can save $700,000 per year in fuel costs alone, and it can reduce carbon dioxide (CO2) emissions by approximately 40,000 tons per year.[126]

2.3.1.4 Using Utilities to Improve Energy Productivity by Delivering End-Use Energy Efficiency

Utilities started delivering energy efficiency services in the 1980s, many of which are now standard, with regulators adopting policies to encourage and mandate them. Demand side energy efficiency driven by the 2015 Clean Power Plan is expected result in a 7 percent reduction in electricity demand by 2030.[127] A utility faces the following financial concerns adopting an energy efficiency program:

- Failure to recover program costs in a timely way has a direct impact on utility earnings.
- Reductions in sales due to energy efficiency can reduce utility financial margins.
- As a substitute for new supply-side resources, energy efficiency reduces the earnings that a utility would otherwise earn on the supply resource.[128]

123 The Coal Utilization Research Council and the Electric Power Research Institute, *The CURC-EPRI, Advanced Coal Technology Roadmap* (Washington, D.C.: Coal Utilization Research Council, 2015), accessed July 2015, http://www.coal.org/#!curc-epri-roadmap/c1r5g.

124 "Sources of Greenhouse Gas Emissions: Electricity Sector Emissions," U.S. Environmental Protection Agency, last modified May 7, 2015, http://www.epa.gov/climatechange/ghgemissions/sources/electricity.html; U.S. Environmental Protection Agency Sector Policies and Programs Division, *Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Coal-Fired Electric Generating Units* (Research Triangle Park, NC: U.S. Environmental Protection Agency, 2010), accessed July 2015, http://www.epa.gov/nsr/ghgdocs/electricgeneration.pdf; Eric Grol, Thomas J. Tarka, Steve Herron, Paul Myles, and Joseph Saracen, *Options for Improving the Efficiency of Existing Coal-Fired Power Plants*, NETL-2013/1611 (Pittsburgh: National Energy Technology Laboratory, 2014), accessed July 2015, http://www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Publications/Efficiency-Upgrade-Final-Report.pdf.

125 U.S. Energy Information Administration, *Electric Power Annual 2007*, EIA-0348(2007) (Washington, D.C.: U.S. Department of Energy, 2009), accessed July 2015, http://www.eia.gov/electricity/annual/archive/03482007.pdf.

126 S. Korellis, Range and Applicability of Heat Rate Improvements (Palo Alto, CA: Electric Power Research Institute, 2014), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002003457&Mode=download.

127 "Fact Sheet: Energy Efficiency in the Clean Power Plan", United States Environmental Protection Agency, last updated August 20, 2015, http://www2.epa.gov/cleanpowerplan/fact-sheet-energy-efficiency-clean-power-plan.

128 National Action Plan for Energy Efficiency, *Aligning Utility Incentives with Investment in Energy Efficiency* (Washington, D.C.: U.S. Environmental Protection Agency, 2007), 2-1, accessed July 2015, http://www.epa.gov/cleanenergy/documents/suca/incentives.pdf.

These financial concerns can be effectively addressed through mechanisms such as decoupling and lost revenue adjustment mechanisms. These concerns are part of the broader discussion of evolving utility business models. The QER noted the impact and implications of new technologies, including those that facilitate increased energy productivity, including end-use efficiency on particularly the distribution part of utilities: "At high penetrations, many of these new technologies could challenge current distribution systems and the functional integrity of the current electricity system. New investments and changes to existing regulatory, policy, financial, and business structures may be necessary to fully realize the benefits of these technologies. Regulators and policymakers will need to address the operational issues associated with new technologies, as well as longer-term concerns, such as how the loss of revenue (and a utility's ability to cover fixed costs) and load resulting from increasing numbers of installations could challenge utilities' financial health under current business models."[129]

2.3.2 PROMOTING ENERGY PRODUCTIVITY IN RATE DESIGN

Since the year 2000, as noted in the QER, "many states have adopted policies to support utility investments in energy efficiency."[130] There are at least three different regulatory approaches being used: decoupling, lost revenue adjustment mechanism, and a broad set of methods to allow performance incentives. These efforts create a regulatory model that rewards utility shareholders for effective energy efficiency efforts that lower ratepayer bills in the long term. These three general categories of regulatory policy and rate-setting changes serve to address negative financial effects on utilities. Thus, they do modify the distribution utility's business model by making it at least neutral and in some cases, providing a financial return, for delivering energy efficiency to their customers, which represents a prime method of improving energy productivity.

The last decade and a half shows substantial growth in utility-delivered energy efficiency, whether through state's adopting mandates known as energy efficiency portfolio standards or allowing changes to distribution utility business models through the three regulatory policy and rate-setting categories noted earlier. Utility-delivered energy efficiency is projected to grow aggressively over the next decade through a combination of all these measures. The QER found that, "Appropriate valuation of new services and technologies and energy efficiency can provide options for the utility business model," but that "Different business models and utility structures rule out 'one-size-fits-all' solutions to challenges."[131]

While no single approach will be effective in meeting the needs of electricity customers in every part of the United States, information about the economic value of new grid services can provide clear signals to the range of entities that

129 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage*, and Distribution Infrastructure, 3-17.

130 U.S. Department of Energy, *Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure*, 3-20.

131 U.S. Department of Energy, *Transforming U.S. Energy Infrastructures in a Time of Rapid Change: The First Installment of the Quadrennial Energy Review, Summary for Policymakers* (Washington, D.C.: U.S. Department of Energy, 2015), S-15, accessed July 2015, http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report.

finance, plan, and operate the grid. Policies to provide consumers with affordable and reliable electricity must take into account the variety of business models for investing, owning, and operating electric grid infrastructure. Doing so could allow actors to make investments that deliver electric services at lowest cost. As new technologies develop, electric markets regulated by a patchwork of state and local jurisdictions may be hard-pressed to perform timely cost-benefit analysis to determine the value of new offerings to their ratepayers.

The federal government can use its convening power to gather information from a broad range of stakeholders, and it can provide tools and resources for understanding the value of services provided by new and innovative technologies. Such resources would allow policymakers to make informed decisions about how best to leverage new technologies in their communities to support growing energy productivity.[132] For example, Michigan passed the Clean, Renewable, and Efficient Energy Act in 2008. This act allowed certain utilities to decouple their rates thus making the utilities financially neutral to negative financials resulting from increased ratepayer energy efficiency; the act also required electric and natural gas utilities to help consumers increase the energy efficiency of their homes and businesses. These programs are expected to result in over $700 million in value to customers, and in 2011, the program achieved enough savings to power 1.5 million homes and heat 40,000 homes for a year.[133]

More sophisticated rate structures have the potential to (1) unleash additional new investments and innovations in distributed energy resources and (2) direct the deployment of these resources in a manner that maximizes the benefits to the system as a whole. With advanced rate structures, utility earnings could depend more on creating value for customers and achieving policy objectives. Freed from the business model that made new infrastructure a precondition for new profits, utilities could find earning opportunities in enhanced performance and in transactional revenues. With utilities focused on delivering value to customers, and not just on energy, productivity could be increased even while ratepayers consume less energy.

132 U.S. Department of Energy, *Transforming U.S. Energy Infrastructures in a Time of Rapid Change: The First Installment of the Quadrennial Energy Review, Summary for Policymakers.*

133 John D. Quackenbush, Greg R. White, and Sally A. Talberg, Report on the *Implementation of P.A. 295 Utility Energy Optimization Programs* (Lansing: Michigan Public Service Commission, 2015), accessed July 2015, http://www.michigan.gov/documents/mpsc/PA_295_Renewable_Energy_481423_7.pdf. Sept. 2013.

UTILITY SUCCESS STORY

Gulf Power's "Energy Select" Program Places Energy Efficiency in Consumers' Hands

Gulf Power, a subsidiary of Southern Company, is an investor-owned electric utility that serves more than 435,000 residential customers in northwest Florida. As are many investor-owned utilities, electric utilities are often mandated by local, state, and federal regulators to increase efficiency and sustainability measures while continuing to meet ever-increasing demand for power. Demand-side management programs, in the form of a reliably controlled demand reduction during critical-peak periods, have become a popular tool to meet these demands. However, the challenge for utilities with this type of demand-side management program is to obtain the amount of load control and verification they require while sufficiently incentivizing customers to participate.

As early as 1989, Gulf Power began to develop this solution to meet this challenge with the help of the Florida Public Service Commission. After years of development, Gulf Power officially launched Energy Select in 2000 as part of its broader EarthCents program and quickly gained attention as the first utility to provide a fully automated critical peak pricing program in the United States.

Energy Select is a demand-side management program that employs price-responsive programmable thermostats and timers for water heater and pool pumps. And, it uses a "residential service variable pricing" rate that features four different prices based on the time of day, the day of week, and the season that reflect the actual cost of producing electricity during those periods. With this program, Gulf Power found a way to combine dynamic pricing with a consumer-controlled management system to incentivize behavioral change in customers that avoids using excess electricity based on daily schedules, comfort levels, or market patterns—effectively reducing peak load levels and enabling reliable electric service.

On average, the program helps over 15,000 customers save up to 15 percent annually on electricity purchases. The benefits of Energy Select have also translated to a boost in overall customer satisfaction with the electric utility service itself, resulting in customer satisfaction rates as high as 95 percent and allowing program participants to take advantage of lower electricity prices 87 percent of the time.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

For more information, see www.gulfpower.com/residential/earthcents/energy-select/.

2.4 Water Utilities

In a 2002 report, EPRI estimated that 4 percent of the nation's electricity use goes towards moving and treating water and wastewater.[134] Providing the same water services while consuming significantly less energy offers a significant contribution to meeting the productivity goal. Actions taken by public and private water utilities contribute to two energy productivity wedges:

Smart Energy Systems
Water Infrastructure

Energy consumption by public drinking water and wastewater utilities represents a substantial cost for both public and private water systems. The cost of energy for municipal water systems can be extraordinarily burdensome for localities, accounting for as much as 25-40 percent of their energy bills.[135] Local governments can reduce energy use at water and wastewater facilities through energy efficiency programs, waste to energy technologies, measures that promote water conservation, investments that prevent water loss and reduce storm water.[136] For example, the Missouri Water Utilities Partnership, a public-private partnership, identified and implemented strategies projected to reduce water-related electricity use by more than 8 million kWh per year, which is enough energy to power over 730 homes for a year.[137]

Infrastructure is also pivotal to ensuring water and energy savings. Nationwide, aging, leaking infrastructure results in significant energy waste, with national estimates of leaks and other losses as high as 20-25 percent.[138] This indirectly translates to energy waste from additional required treatment and pumping. The situation can be addressed through advanced leak monitoring, advanced pressure management, and accelerated replacement of buried infrastructure.

134 R. Goldstein and W. Smith, *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment—The Next Half Century* (Palo Alto, CA: Electric Power Research Institute, 2002), accessed July 2015, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001006787.

135 Malcolm Pirne, *Statewide Assessment of Energy Use by the Municipal Water and Wastewater Sector* (Albany: New York State Energy Research and Development Authority, 2008).

136 Design features that reduce stormwater include permeable pavements, green roofs, and rain gardens. See "Stormwater Management Best Practices," U.S. Environmental Protection Agency, last modified November 5, 2012, http://www.epa.gov/oaintrnt/stormwater/best_practices.htm.

137 U.S. Environmental Protection Agency, *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs* (Washington, D.C.: U.S. Environmental Protection Agency, 2013), accessed July 2015, http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf.

138 Black & Veatch, "Buried Infrastructure", accessed July 2015, http://bv.com/reports/2013/2013-water-utility-report/buried-infrastructure; Ashley Halsey III, "Billions needed to upgrade America's leaky water infrastructure," Washington Post, January 2, 2012, http://www.washingtonpost.com/local/billions-needed-to-upgrade-americas-leaky-water-infrastructure/2011/12/22/gIQAdsE0WP_story.html.

At drinking water plants, the largest energy use (about 80 percent) is to operate motors for pumping.[139] There is a recognized potential to improve the efficiency of water utility pumping processes by as much as 30 percent.[140] Water utilities like American Water are implementing pump efficiency programs. Improving the efficiency of motors used in water pumps from the current average of 55 percent to 80 percent would save 10 million MWh per year, the equivalent of lighting a city the size of Chicago for over two years.[141]

There is also significant opportunity for improving the wastewater aeration process, which consumes 30-50 percent of all energy in wastewater treatment plants. This can be accomplished through the use of more efficient aeration or the use of anaerobic processes that do not require aeration. Nutrient removal is also energy-intensive. Thus, more efficient microbial processes to remove nitrogen and phosphorus from wastewater, can also significantly reduce energy consumption.[142]

Waste streams from wastewater treatment plants provide a valuable energy source that can displace primary energy consumption. There is enough embedded energy in the waste streams of many wastewater treatment plants to achieve net zero or even net positive energy consumption. For example, many plants are currently using methane digesters with CHP to produce biogas and/or electricity from their waste streams and reduce the amount of electricity they draw from the grid.

Beyond improving the efficiency with which utilities move and treat water, energy savings can be realized by more efficient end-use of water. Indeed, "water-related energy consumption was 12.6 percent of national primary energy consumption in 2010."[143] Reducing this end user water consumption can thus have an indirect and significant impact on energy consumption. Outdoor watering practices can also indirectly waste energy. Technologies such as drip irrigation and low-flow plumbing fixtures can improve water use efficiency, which indirectly translates into energy savings.

2.4.1 RATE REFORM

Water utilities have the same financial conundrum as energy utilities do when it comes to incenting water and energy efficiency. Concerns over cost recovery and losses of sales limit the financial viability of energy and water efficiency programs. Under most rate structures, there are no water efficiency incentives, as recovery of fixed costs is dependent

139 Claudia Copeland, Energy-Water Nexus: The Water Sector's Energy Use (Washington, D.C.: U.S. Congressional Research Service, 2014), accessed August 2015, http://fas.org/sgp/crs/misc/R43200.pdf.

140 EPRI and WRF, Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, 2013.

141 American Water, *The Water-Energy Nexus: EPA's Clean Power Plan* (Voorhees, NJ: American Water, 2014), accessed July 2015, http://www.amwater.com/files/WaterEnergy%20EPA%20Clean%20Power%20Plan%20v2.pdf.

142 U.S. Department of Energy, The Water-Energy Nexus: Challenges and Opportunities (Washington, D.C.: U.S. Department of Energy, 2015), accessed August 2015, http://www.energy.gov/sites/prod/files/2014/07/f17/Water%20Energy%20Nexus%20Full%20Report%20July%202014.pdf.

143 Claudia Copeland, Energy-Water Nexus: The Water Sector's Energy Use (Washington, D.C.: U.S. Congressional Research Service, 2014), accessed August 2015, http://fas.org/sgp/crs/misc/R43200.pdf.

on volume of water sold. This clashes with an ever-increasing need to be more resource efficient given the realities of water scarcity, stressed water systems and droughts, as well as rising energy costs.

Decoupling, and other investment recovery reforms, is vital to ensuring that water and wastewater utilities have the incentives and the tools to reduce water and energy consumption. By separating volumes of water sold, from rates charged, decoupling enables water companies to help customers use less water and therefore save more energy. Likewise, investment recovery reform can help accelerate the replacement of aging leaking water mains, thus reducing energy waste. These regulatory reforms will ultimately minimize energy costs and reduce carbon emissions related to water and wastewater services.

WATER UTILITY PUMP EFFICIENCY ENERGY SAVINGS SUCCESS STORY

American Water

Much of American Water's energy efficiency work concentrates on improving pump efficiencies through refurbishment and/or replacement. A total of 52 pump refurbishments/replacements were completed from 2011-2013, at a cost of approximately $6 million, and provided an estimated energy reduction of 8 million kWh/year.

American Water manages its energy program using an Energy Usage Index (EUI) metric derived by dividing total power usage in megawatt-hours (MWh) by the volume of water sold in million gallons (MG) during a discrete period of time. The current baseline for this metric is 2.89 based on 2011-2013 operating data. The EUI data is collected and monitored to serve as a barometer for the condition of the pump fleet. Specifically, as pumps age, they wear and become less hydraulically efficient, which translates to more power required to deliver the same volume of water. American Water's pumping inventory is comprised of about 7,500 centrifugal pumping units. Of this, it is estimated that about 20 percent of the largest pumps consume 80 percent of American Water's total power usage.

American Water also conducts wire-to-water efficiency testing to monitor the efficiency of pumps and motors. We deliver over a billion gallons of water each day, so even a small increase in efficiency can yield energy savings. Research has shown that the average "wire-to-water" efficiency of existing "in-field" water utility pumps is about 60 percent. New installations are designed to achieve efficiencies of between 76 percent and 82 percent. American Water sees this as a major opportunity to decrease its carbon footprint. By replacing or refurbishing older pumps, studies have shown that pump efficiencies can be restored to their original efficiencies of 76-82 percent. This efficiency gain may yield energy savings of 10-20 percent at facilities that have completed pump improvements.

American Water pump refurbishment programs maintain, repair and replace pumps, motors and variable frequency drive (VFD) equipment. The cost of pump replacement/ refurbishment to recover capacity and improve efficiency is weighed against the typical decline in efficiency/capacity over time. American Water has vibration analysts on staff to extend pump service life through predictive maintenance.

For more information, see: http://files.shareholder.com/downloads/AMERPR/599810257x0x530218/15116DF7-78E3-45BA-BB9C-6101BD705B70/WP_Innovations_in_Energy_Use_White_Paper_FINAL.pdf and http://files.shareholder.com/downloads/AMERPR/4046241639x0x798496/690877E9-F9D4-4EC2-8324-340C2CCA48F3/Water-Energy_Efficiency-DOE_Fact_Sheet_-_08-2014.pdf.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

2.5 Higher Education Institutions

Increasing energy productivity across all sectors requires a suitably prepared workforce. And, cross-disciplinary coursework is needed to support the needs of emerging areas of energy productivity, such as the Smart Grid, advanced manufacturing, and building energy systems. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers.Actions taken by higher education institutions contribute to four energy productivity wedges:

Smart Energy Systems
Technologies for Buildings Energy Productivity
Smart Manufacturing
Transportation

2.5.1 WORKFORCE TRAINING

Additional energy productivity gains can come from efficiently operating and maintaining buildings. Building operators can realize annual energy bill savings of 5-20 percent by implementing operations and maintenance (O&M) best practices, including operating equipment only when needed, performing preventative O&M, and tracking performance.[144]

The Building Operator Certification (BOC®) is a training and certification program that provides building operators with the skills and knowledge to implement the types of O&M best practices that can help maximize the efficiency of existing and future buildings. BOC certification is offered by several Regional Energy Efficiency Organizations as well as community and technical colleges in the Northeast, Mid-Atlantic, Southeast, and the West.[145] Annual energy and utility bill savings specific to companies with BOC-certified operators are estimated to be 170,000 kWh per year and $12,000 per year, respectively, which is enough electricity to power nearly 100 refrigerators for a year.[146]

While higher education can lead to certain careers that will help accelerate energy productivity, many job opportunities exist in the energy and advanced manufacturing fields that do not require four-year degrees. Technical and community

144 "Operations and maintenance reports," Energy Star, accessed July 2015, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/comprehensive-approach/operations-and; Portland Energy Conservation, Inc., *Fifteen O&M Best Practices for Energy Efficient Buildings* (Washington, D.C.: U.S. Department of Energy and U.S. Environmental Protection Agency, 1999), accessed July 2015, https://www.energystar.gov/sites/default/files/buildings/tools/Fifteen%20O%26M%20Best%20Practices.pdf.

145 "Training Locations & Schedules," Building Operator Certification, last updated August 11, 2015, http://www.theboc.info/h-training-locations.html.

146 "Value & Benefits of BOC," Building Operator Certification, last updated August 24, 2010, http://www.theboc.info/w-value-benefits.html.

colleges can provide the skills and knowledge for the next generation of energy and manufacturing industry employees. Mississippi's Get on the Grid[147] and Ohio's Advanced Manufacturing Industry Partnership[148] are examples of the types of workforce training programs that can be leveraged to increase energy productivity.

The workforce of an advanced energy economy needs to not only have the skills to operate today's technologies but needs to have the skills and support to make further innovations. Partnerships with industry and businesses, such as the DOE's Building University Innovators and Leadership Development (BUILD) program, can further help support educating and training future innovators in energy productivity.

2.5.2 ACCELERATING ENERGY PRODUCTIVITY FROM THE LAB TO THE REAL WORLD

Colleges and universities are instrumental partners for carrying out federally funded R&D. While the growth of federal R&D funding has largely stagnated since 2004, universities are contributing a larger share of funding and they were responsible for over $12 billion (FY 2014 dollars) of the $64 billion (FY 2014 dollars) total university science and engineering R&D funding in 2012.[149]

Universities can play an important role in transferring innovative technologies to businesses. Universities offer unique opportunities to act as real world testbeds for technologies and practices that increase energy productivity. For instance, the Future Renewable Electric Energy Delivery and Management (FREEDM) System Center, directed by North Carolina State University, supports fundamental research for breakthrough energy storage and power semiconductor technologies as well as partnerships with businesses to facilitate the transition of research into commercially viable products.[150] Several technologies developed by FREEDM have received commercial licenses.[151]

147 "Get on the Grid," Mississippi Energy Institute, accessed July 2015, http://www.getonthegridms.com/.

148 "Advanced Manufacturing Industry Partnership," Partners for a Competitive Workforce, accessed July 2015, http://www.competitiveworkforce.com/Advanced-Manufacturing.html.

149 "R&D at Colleges and Universities,"American Association for the Advancement of Science, last updated August 14, 2015, http://www.aaas.org/page/rd-colleges-and-universities.

150 "About: Center Goals," NSF FREEDM Systems Center, North Carolina State University, accessed July 2015, http://www.freedm.ncsu.edu/index.php?s=1&p=7.

151 NSF FREEDM Systems Center, "FREEDM Marks Progress in Innovation, Economic Impact," news release, undated, http://www.freedm.ncsu.edu/index.php?s=2&t=news&p=184.

HIGHER EDUCATION INSTITUTIONS SUCCESS STORY

North Carolina State University Creates Electricity at Renovated Utility Plant

When North Carolina State University (NC State) faced the challenge of deferred maintenance on equipment in its central utility plants with no available capital funding, university leadership used a $61 million energy performance contract to finance the addition of modern CHP technology. The new CHP facility enables NC State to generate some of its own electricity, and the money the university saves in avoided utility-provided energy costs pays back the loan that financed the CHP technology and boiler replacements.

Founded in 1887, NC State University has a campus community of more than 40,000 students, faculty, and staff in Raleigh. With an annual utility budget of approximately $32 million, the university provides electricity, steam, chilled water, and domestic water to more than 15 million square feet of campus building space.

As do many higher education institutions, NC State faces the challenge of funding vital maintenance on aging buildings and infrastructure, such as utility systems. As several crucial campus boilers exceeded the end of useful life, the university had no capital funding available for the replacement of this equipment. The university also faced challenges related to air quality compliance, as the old boilers relied on #6 fuel oil. NC State needed funding for new, cleaner-burning natural gas boilers and related equipment.

The university turned to an energy performance contract-funding model to finance replacement of critical boilers. A performance contract allows an owner to pay for a renovation through the energy savings generated by efficiency improvements. Using a performance contract, NC State was able to incorporate CHP technology on campus. The $61 million performance contract, financed over 17 years, also allowed the addition of two natural gas fired 5.5-MW combustion gas turbine generators and two 50,000-pound-per-hour heat recovery steam generators to the existing Cates Utility Plant in 2012. The contract also financed replacement of aging boilers, utility interconnects, and auxiliary equipment at the nearby Yarbrough Steam Plant. CHP allows NC State to create its own electricity and converts “waste heat,” which would be unused in traditional power plants, into energy. By using this campus-generated energy, NC State buys less energy from local utility companies.

In addition to more reliable steam production and better air quality compliance, the CHP facility reduced energy use and carbon emissions while expanding the university's resiliency and capacity for future growth. In the CHP plant's first two years, more than $10 million of energy costs were avoided and emissions associated with utility production on the university's central and north campuses dropped 24 percent. Educational benefits also resulted. Many NC State engineering students tour the facility to see CHP technology in action. The savings associated with the project have prompted the university to consider adding more CHP capacity at its nearby Centennial Campus utility plant.

An animation of CHP technology on campus is available at sustainability.ncsu.edu/chp/NCSU Case Study.

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2.6 Households

Households account for a large portion of U.S. energy use, and household purchases of goods and services drive much of the U.S. economy. Residential buildings and personal transportation together represented roughly 40 percent of primary energy use in 2014.[152] Household energy use is even more significant when the energy required to produce consumer goods and services, so called "embodied energy," is considered. Also, household expenditures constitute a large portion of overall economic activity.

The concept of household energy productivity may not be as intuitive as it is for a business, but the fundamental aspects are the same. Households can choose to purchase goods and services that allow more productive use of energy in providing services such as transportation, indoor comfort and illumination, and entertainment. However, these purchasing decisions can be clouded by market failures such as incomplete information and split incentives whose remedies may require government policies. Strategies in this section were developed using feedback from the regional dialogues, the roundtable discussions, and goal endorsers. Actions taken by households contribute to two energy productivity wedges:

Technologies for Buildings Energy Productivity
Transportation

2.6.1 ENERGY PRODUCTIVITY AT HOME

Households can reap energy productivity benefits by participating in the *Roadmap* strategies identified for government and businesses. The goal of many of these strategies is to enable households to choose the most energy-efficient products, which translates into savings on energy bills. Purchasing more energy-efficient appliances, in addition to taking other energy efficiency measures such as installing insulation, could reduce household electricity and natural gas use by 34 percent and 35 percent respectively and could result in utility bill savings of $83 billion (in 2007 dollars) by 2030.[153]

152 The sum of residential buildings, light-duty vehicles, bus transportation, passenger rail, and air primary energy use is from U.S. Energy Information Administration, *Annual Energy Outlook 2015 with Projections to 2040* (Washington, D.C.: U.S. Energy Information Administration, 2015), accessed July 2015, http://www.eia.gov/forecasts/aeo/.

153 America's Energy Future Energy Efficiency Technologies Subcommittee, National Academy of Sciences, National Academy of Engineering, and National Research Council, *Real Prospects for Energy Efficiency in the United States* (Washington, D.C.: National Academies Press, 2010).

Many strategies aim to improve the amount and quality of energy information available to households in order to allow consumers to make better-informed decisions on the use of energy in their home and to encourage early adoption of more energy-efficient products. Information-based strategies have been found to reduce electricity use by 7 percent.[154] The federal government provides a suite of websites that address the many facets of household energy efficiency, including homes (http://www.energysaver/.gov) and transportation (www.fueleconomy.gov). Utilities and companies are offering households greater visibility into home energy use. For example, they are providing homeowners and others the option to compare energy use with that of that their neighbors and similar houses.[155] A collaboration of the University of Florida and the International Carbon Bank and Exchange took energy data visibility a step further and created an online platform where anyone can view electricity use and building characteristics of homes in Gainesville, Florida.[156] Initiatives like DOE's Green Button initiative allow households to access their electricity meter data in a standardized format.[157] Green Button also allows users to automatically connect their data to services that will evaluate opportunities to reduce their electric bills.

As many as 37 states and the District of Columbia incentivize the use of EVs.[158] The Federal government and certain states, including California, Colorado, Connecticut, Louisiana, and Maryland, offer rebates or tax credits for purchases of EVs.

154 Magali A. Delmas, Miriam Fischlein, and Omar I. Asensio, "Information strategies and energy conservation behavior: A meta-analysis of experimental studies from 1975 to 2012," *Energy Policy* 61 (2013): 729–739, accessed July 2015, http://dx.doi.org/10.1016/j.enpol.2013.05.109.

155 Research points to the need at some minimal frequency to provide households with reports on their energy use in order for energy savings to persist. See Hunt Allcott and Todd Rogers, "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation," *American Economic Review* 104:10 (2014): 3003–3037, accessed July 2015, http://dx.doi.org/10.1257/aer.104.10.3003.

156 "Gainesville Green: Your Home Energy Tracking System," Gainesville Green, accessed July 2015, http://www.gainesville-green.com.

157 "Helping You Find and Use Your Energy Data," Green Button Data, accessed July 2015, http://www.greenbuttondata.org/.

158 Kristy Hartman, "State Efforts Promote Hybrid and Electric Vehicles," National Conference of State Legislators, June 29, 2015, http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx.

HOUSEHOLDS SUCCESS STORY

Opower Partners with the Nation's Utilities to Drive Energy Savings through Customer Engagement and Applied Behavioral Science

For utilities around the world, keeping the lights on is no longer enough. The utility industry is now in a time of significant change, and utilities are placing technology at the center of their strategies to navigate the path to a successful future. Today's utility customer only spends about 9 minutes thinking about their energy consumption each year, so utilities are challenged to make every moment of customer contact matter.

By combining data management, analytics, and behavioral science, Opower's customer engagement platform positions utilities as energy advisors to the customers they serve. Opower's technology platform analyzes more than 300 billion meter reads to deliver its services, and created enough energy savings to power all the homes in a city of 1 million people for a year. Opower has facilitated savings over 8 terawatt-hours of electricity to date, which equates to over $1 billion saved by customers on their monthly energy bills, affecting more than 50 million households today.

EXAMPLE: OPOWER'S CUSTOMER ENGAGEMENT PLATFORM

The utility National Grid Massachusetts (National Grid MA) needed to meet a strict state energy efficiency mandate, and traditional solutions like retrofitting and appliance rebates incurred high costs with limited return on investment. Furthermore, National Grid MA wanted to elevate its levels of customer engagement and satisfaction.

Opower's software gave National Grid MA the applications it needed to transform their customer experience. Built specifically for the energy industry, Opower's customer engagement platform met National Grid MA's need by combining the efficiency of the cloud with insightful analytics, applied behavioral science, and great design.

EXAMPLE: OPOWER'S HOME ENERGY REPORT

National Grid MA deployed Opower's Home Energy Report (HER) program, a tailored energy usage evaluation that offers personalized energy-saving tips, anonymously compares customers' energy usage with that of neighbors with similar home size and demographics, and suggests lifestyle changes to reduce their energy consumption. HERs are proven to reduce residential consumption by 1.5-3 percent across a utility's territory, and furthermore have shown to increase positive customer sentiment towards utilities.

Several years after deploying Opower's energy efficiency program in Massachusetts, National Grid MA announced that customers saved over $70 million on their energy bills. Working with Opower, National Grid MA helped customers reduce their electricity usage by 300 million kilowatt hours (kWh) and gas usage by 18 million therms – the equivalent of eliminating more than 300,000 metric tons of carbon dioxide from the environment.

Reference to a non-federal entity does not constitute an endorsement on the part of DOE or the U.S. government.

Footnote 7 Document

Clean Water Council, "*Sudden Impact: An Assessment of Short Term Economic Impacts of Water and Wastewater Construction Projects in the United States*," 2008.

Sudden Impact

An Assessment of Short-Term Economic Impacts of Water and Wastewater Construction Projects in the United States

CLEAN WATER COUNCIL
Committed to America's Water Infrastructure

Acknowledgement

This assessment was prepared for the Clean Water Council (CWC), a coalition of 35 national organizations dedicated to protecting and enhancing America's water and wastewater infrastructure. The report was prepared by PA Consulting Group, a leading global management, systems and technology consulting firm.

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- American Council of Engineering Companies
- American Road and Transportation Builders Association
- American Society of Civil Engineers
- Associated Equipment Distributors
- Association of Equipment Manufacturers
- Caterpillar
- Ductile Iron Pipe Research Association
- John Deere Construction Equipment Company
- Laborers-Employers Cooperation and Education Trust
- National Stone, Sand and Gravel Association
- National Utility Contractors Association
- Plastics Pipe Institute
- Portland Cement Association
- The Vinyl Institute
- Water and Sewer Distributors of America

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Please visit www.waternewsupdate.com for additional information about the CWC.

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Photo courtesy of the Ductile Iron Pipe Research Association

Background and Purpose

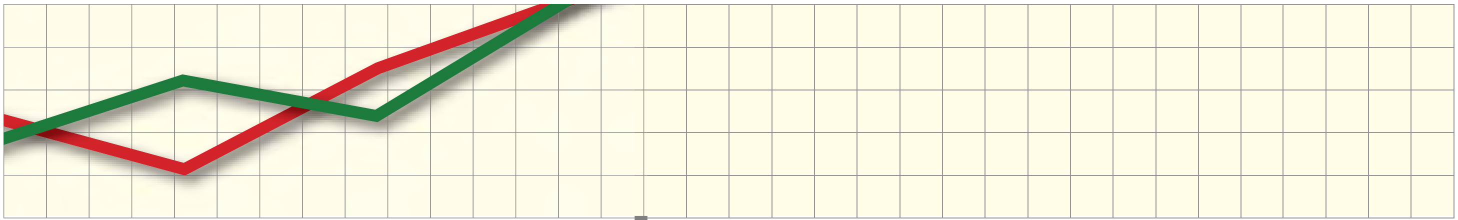
Water and wastewater pipelines, treatment plants and related facilities are core components of our environmental infrastructure. The condition of our nation's environmental infrastructure has deteriorated significantly as a direct result of perpetual underinvestment. Water and wastewater capital "needs estimates" produced by the U.S. Environmental Protection Agency (EPA) are nothing short of staggering. In fact, the EPA's *2002 Clean Water and Drinking Water Infrastructure Gap Analysis* forecast an alarming $534 billion gap between current investment and projected needs over 20 years for water and wastewater infrastructure if federal funding was not increased. (That funding has in fact been significantly cut over the past few years.) Two years later, the EPA's *2004 Clean Watersheds Needs Survey* documented existing nationwide wastewater infrastructure needs alone at $202.5 billion. In 2009, EPA projected 20-year needs for drinking water infrastructure alone at $334.8 billion.


Photo courtesy of the Plastics Pipe Institute

In addition, the American Society of Civil Engineers (ASCE) has given America's wastewater infrastructure and drinking water infrastructure letter grades of "D minus" in their most recent (January, 2009) *Report Card for America's Infrastructure*. Clearly, there is a consensus among government, industry and academic professionals that the condition of this infrastructure has gone from bad to worse. This consensus is supported by the first-hand experiences of communities across the land as they manage the fallout from collapsed and deteriorated water and wastewater facilities. (See www.waternewsupdate.com for daily reports highlighting environmental infrastructure failures.)

In light of the size and scope of the documented national needs, legislators, policy makers and planners at all levels of government need to know the short-term economic impacts and value added to local economies by construction projects pertaining to water treatment and distribution, and wastewater collection and treatment. This assessment provides data demonstrating that water, sewer and storm water management projects do in fact add immediate value to the local economy in three well-defined ways during the time period of construction:

1. Direct impacts through jobs and the purchase of materials and supplies directly related to the construction and operation of



the project.

2. Indirect impacts through jobs and the purchase of equipment, materials and supplies by vendors indirectly related to the construction and operation of the project.
3. Induced impacts supported by spending and re-spending of the income earned by workers in 1 and 2 above, often described as the "multiplier effect."

There are also long-term economic benefits that result from these projects during the multi-decade life expectancy of each facility, including higher private sector profitability, increased private investment in plant and equipment, improved labor productivity, a stronger tax base and future employment.

These benefits are summarized in *America's Environmental Infrastructure* (1990), which is available by request from the CWC. In addition, these projects generate a number of quality of life benefits, such as a reliable supply of clean water for human consumption and household use, public safety (fire protection and flood control), and environmental protection (safeguarding our waterways, fisheries, recreational lands, and flora and fauna from sewage, contaminated storm water runoff and other forms of pollution). While these lasting benefits are not the focus of this short-term economic assessment, it is important to recognize that they occur.

Photo courtesy of John Deere Construction Equipment Company

Key Findings

Investments in water and wastewater infrastructure have immediate, substantial and far-reaching effects on the economy.

- At the national level, an investment of $1 billion almost triples in size as total demand for goods and services reaches an estimated $2.87 to $3.46 billion.
- The total effect on economic demand is smaller at the state level, but direct investments in water and wastewater infrastructure can nearly double as expenditures for necessary supplies and household spending impact the economy.
- Spending to rebuild our infrastructure affects a wide range of economic sectors. Engineering services, heavy equipment, truck transport, and pipe materials are needed to complete infrastructure projects, but businesses and households, in turn, spend money on goods and services across a wide array of sectors.
- An estimated 20,003 to 26,669 jobs can result from a national investment of $1 billion. These opportunities are spread across the economy with more than one-half of the jobs in industries other than water and wastewater construction.
- Personal incomes and economic security are impacted by infrastructure investment. An increase in total employee compensation accompanies job creation at the national, state, and local levels.
- State and local revenues increase as infrastructure is built or improved, though the size of effects vary by location, size, and type of project.


Photo courtesy of the American Council of Engineering Companies

Methodology

Our study is designed to estimate the economic impacts of water and wastewater infrastructure on local, state, and national economies. Key objectives included quantifying the following effects:

- What is the indirect effect of infrastructure investment? That is, what is the economic impact on industries that supply necessary products and services, such as engineering services, truck transport, or pipelines?
- What is the impact on economic demand as households re-spend income in the local economy? That is, to what extent are other businesses (e.g., retail establishments, professional and personal services, housing) affected as infrastructure projects provide jobs and personal income to households?
- How many jobs can be attributed to infrastructure investment? Are these jobs primarily in water and wastewater construction sectors or are relatively large numbers of jobs also created in other sectors?

To address these questions, the study uses data from recently completed projects across 5 states, draws on regional input-output models that allow us to differentiate among impacts, and utilizes local data as well as hypothetical scenarios to estimate effects at local, state, and national levels of analysis.

We defined a study area comprised of five states: California, Georgia, Minnesota, New Mexico, and Pennsylvania. These states were selected to capture a range of economic conditions as well as regional variation in climate and labor markets.

Estimates of local economic impacts are based on data from recently completed projects. While limited to only 5 states, these projects capture variation in size (fairly small to very large) and type (e.g., replacing, rehabilitating, or installing new water and wastewater pipes or treatment facilities). State- and national-estimates are based on hypothetical investments of $1 billion to facilitate comparison.

We invited members of the National Utility Contractors Association in the five target states to provide data on water and wastewater projects. Data on project type, location, contract value and costs were gathered for 116 projects from 35 contractors and represented 73 counties across the five states.

Project cost data were analyzed using input-output models. These models are a technique for quantifying the transactions between industries: When a firm in Industry A receives a $1M order to install new water pipes, it must purchase supplies and services from firms in Industries B, C, and D. Input-output models capture these relationships and make it possible to estimate economic effects above and beyond the initial investments.

We used IMPLAN – a computer software package for input-output modeling – to estimate the indirect effects of infrastructure investment (impact on industries that are related to water and wastewater construction) as well as the secondary effects of household spending in the local economy. Using IMPLAN, we can also estimate impacts on jobs, employee compensation, and

Photo courtesy of Caterpillar

Methodology

state and local tax revenues.

We also used RIMS II (Regional Input-Output Modeling System) to examine the national and state-level effects of infrastructure investment. Like IMPLAN, RIMS II is a method for accounting for interindustry relationships within a geographic region using I-O tables that show, for each industry, the distribution of the inputs purchased and the outputs sold. Because the methodologies underlying IMPLAN and RIMS II differ, we use both approaches to estimate the range of impacts on jobs, employee compensation, and output.

Design Study

The study is designed to reflect regional and local variation.

Study area: California, Georgia, Minnesota, New Mexico, and Pennsylvania define the geographic boundaries over which economic impacts were measured. These states were selected to reflect variation in region, local economies, climate, and labor conditions.

Case Studies: Actual construction projects within each state capture variation in project size and local economies. In addition, taking inventory of what is known about actual projects fuels the models with real-world data and more accurately reflects existing activity.

Time frame for analysis: Projects completed in 2006 and 2007 were eligible for selection to ensure results were based on recent construction activity.

Develop Model

Transparency is essential for building a credible model.

Software: IMPLAN and RIMS II are computer software packages that consist of procedures for estimating local input-output models and associated databases.

Input-Output models: Input-output models are a technique for quantifying interactions between firms, industries, and social institutions within a local economy. IMPLAN models include outputs and inputs

Photo courtesy of the Water and Sewer Distributors of America from 440 industrial sectors, value added, employment, wages and business taxes paid, imports and exports, final demand by households and government, capital investment, business inventories, marketing margins, and inflation factors. RIMS II provides multipliers for nearly 500 industries.

Multipliers: Multipliers quantify how certain changes (i.e., in jobs, earnings, or sales) in one industry will have effects on other industries in the region. Multipliers are aptly called estimators of the 'ripple effect' and are available at the national, state and county levels.

Data sources: The economic source data for IMPLAN models includes the system of national accounts for the US based on data collected by the US Department of Commerce, US Bureau of Economic Activity, US Bureau of Labor Statistics, and other federal and state agencies. All analyses used 2007 IMPLAN data (released in October 2008). RIMS II uses national and regional I-O tables from the US Bureau of Economic Activity.

Industry: The 2007 IMPLAN data classifies water and wastewater pipe construction activity in the 'Construction of other new non-residential structures' which corresponds to the updated classification used by the US Bureau of Economic Activity. The corresponding RIMS II sector is construction.

Collect Case Studies

Actual project data provide real world results.

Sample: Members of the National Utility Contractors Association in the five target states were invited by phone and email to provide data on water and wastewater pipe construction projects completed in 2006 and 2007. In total, data from 116 projects were analyzed, representing 35 contractors, 5 states, and 73 counties.

Data collection: Respondents reported project data electronically or by fax. Information was collected on type and location of project, contract value and project costs, and year of completion. As needed, follow-up phone calls were made to clarify questions about the data or try to obtain additional information.

Data checks: County-level data can be unreliable if the county has sparse economic activity or is thinly populated. Internal checks were conducted to ensure case data and local level inputs used were reliable and in-line with state inputs.

Estimate Impacts

Economic impact results help prioritize planning & investment decisions.

The economic impacts at the state level, and county level for actual pipe construction projects, were estimated using IMPLAN software and economic multiplier data. Briefly, the analysis produced the following estimates:

Direct effects: The output, jobs, and income that are directly related to the construction of the project.

Indirect effects: The additional output, jobs, and incomes for suppliers and vendors indirectly related to the construction project. These reflect the broader impacts in the community such as expanding business among local vendors and suppliers.

Induced effects: The expansion of local commercial business as a result of income re-spent by persons employed by the construction project sector or by the suppliers and vendors that indirectly support that sector.


Photo courtesy of the Vinyl Institute

Results and Analysis - United States

A $1 billion investment in water and wastewater infrastructure at the national level has substantial and far-reaching effects throughout the economy.

- The total effect of a $1 billion investment almost triples in size to an estimated $2.87 to $3.46 billion in economic demand.
- Industries indirectly related to water and wastewater infrastructure experience an estimated $918 million in demand. These industries are indirectly affected by investments in water and wastewater infrastructure because they provide services that support project design (e.g., architectural and engineering services) or products and supplies essential for project completion (e.g., industrial machinery and equipment, truck transport).

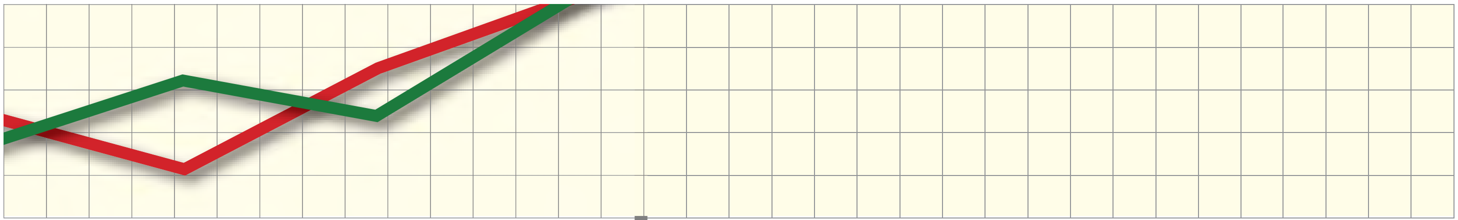

Photo courtesy of the American Society of Civil Engineers

- Ripple effects on economic demand can range across a number of industries and amount to an estimated $949 million. A wide range of industries that are not related, directly or indirectly, to building or improving water and wastewater infrastructure nonetheless see demand for their products or services increase as households re-spend income in the economy. These effects occur in sectors as varied as bookkeeping services, energy and telecommunications, health care, motor vehicles, food retail stores, dining establishments, and amusement and recreation services.

What Jobs?

Besides construction jobs, a $1 billion investment in water and sewer projects generates measurable national employment in 325 other standard industry classifications, everything from tires to tortillas. For every 20,003 jobs created, at least 100 workers are hired in the short-term, in each of the following industry segments:

Construction other new non-residential	8,366
Architectural, engineering, and related services	851
Food services and drinking places	738
Wholesale trade	498
Real estate	469
Employment services	420
Offices of physicians, dentists, and other health practitioners	273
Hospitals	266
Services to buildings and dwellings	229
Truck transportation	224
Retail - General merchandise	222
Retail - Food and beverage	218
Automotive repair and maintenance, except car washes	194
Legal services	178
Nursing and residential care facilities	178
Monetary authorities and depository credit intermediation	166
Retail - Motor vehicle and parts	159
Management of companies and enterprises	153
Securities, commodity contracts, investments, and related activities	151
Accounting, tax preparation, bookkeeping, and payroll services	145
Civic, social, professional, and similar organizations	145
Private households	145
Retail - Nonstore	136
Maintenance and repair construction of nonresidential maintenance and repair	127
Retail - Clothing and clothing accessories	117
Insurance carriers	114
Retail - Miscellaneous	109



- An estimated 20,003 to 26,669 jobs are created. About one-half of these jobs are in industries outside of water and wastewater construction, further illustrating the broad reach of the initial investment.
- The economic security of households is strengthened. Total employee compensation – a category that includes wages and salaries as well as contributions to social insurance programs such as Social Security – is enhanced by an estimated $1 billion. Job creation includes an estimated 8,366 jobs in the pipe construction sector where average earnings of more than $50,000 exceeds median household income for the US.

A $1B investment in pipe construction in the United States results in the following economic impacts:

Total output	**2867.5-3461.7 M**
Business expenditures	1000.0 M
Sales of suppliers	918.5 M
Household spending	949.0 M
Personal Income	**1011.2-1062.9 M**
State and local tax revenue	**82.4 M**
Employment	**20,003-26,669 jobs**
Pipe construction	8,366 jobs
Other	11,637 jobs
Average Earnings	**$50,396**

Photo courtesy of the National Stone, Sand and Gravel Association

Results and Analysis - California

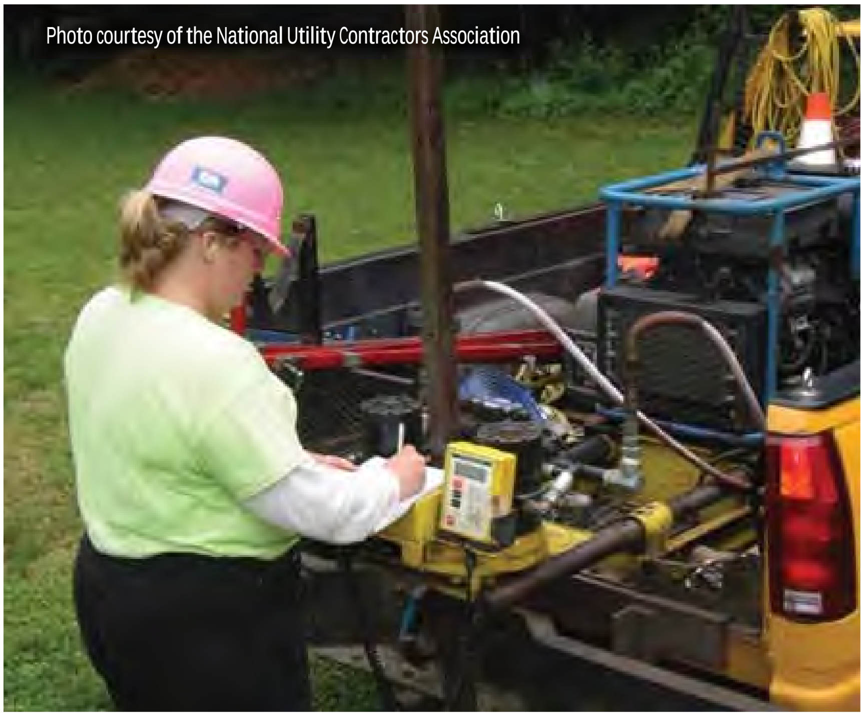


Photo courtesy of the National Utility Contractors Association

A new 84" groundwater replenishment project in Orange County illustrates the local economic impacts of these investments in the water and wastewater infrastructure. The $2.5 million project fell just short of generating another $2 million in demand for goods and services across other economic sectors. Industries that support water and wastewater construction by providing services and supplies experienced $780,000 in demand. Re-spending of income in the local economy generated $950,000 in sales. About 28 jobs were created, 17 of which were in the construction sector. An estimated $1.8 million in employee compensation (wages, salaries, and payroll contribution to social insurance programs) derived from the initial $2.5 million project, which also raised state and local tax revenues by approximately $110,000.

- An investment of $1 billion in California's water and wastewater infrastructure would result in an estimated $1.8 to 2.5 billion demand for goods and services across the state's economy.
- Industries that provide goods and services in support of infrastructure projects would experience over $370 million in economic demand. A wide range of other industries would sell an estimated $448 million in goods and services as businesses and households spend money in the economy.
- 12,390 to 19,574 jobs would be created. About 7,000 of these jobs would be in the pipe construction sector where average earnings of $68,000 exceed the statewide median household income of about $50,000.
- We analyzed data on 16 recently completed projects that ranged in size from $250,000 to $60 million and covered 12 counties.

A $1B investment in pipe construction in California results in the following economic impacts:

Total output of the region	**1826-2511.3 M**
Local business expenditures	1000.0 M
Sales of suppliers	377.5 M
Household spending	448.5 M
Personal Income	**775.2-815.2 M**
State and local tax revenue	**47.5 M**
Employment	**12,390-19,574 jobs**
Pipe construction	7,085 jobs
Other	5,305 jobs
Average Earnings	**$68,099**

Case Studies

Project Name	Booster Pump Station	Bypass Mud Outlets	Interceptor Overflow Structures	Force Main Reconstruction
County	**Alameda**	**Alameda**	**Alameda**	**Contra Costa**
Total output of the region	**11.98 M**	**2.94 M**	**1.61 M**	**5.06 M**
Local business expenditures	7.22 M	1.77 M	0.97 M	3.17 M
Sales of suppliers	2.06 M	0.51 M	0.28 M	0.89 M
Household spending	2.70 M	0.66 M	0.36 M	1.00 M
Personal income	**5.49 M**	**1.35 M**	**0.74 M**	**2.29 M**
State & local tax revenue	**0.31 M**	**0.07 M**	**0.04 M**	**0.11 M**
Employment	**79**	**19**	**11**	**33**
Pipe construction	47	12	6	21
Other	32	7	5	12

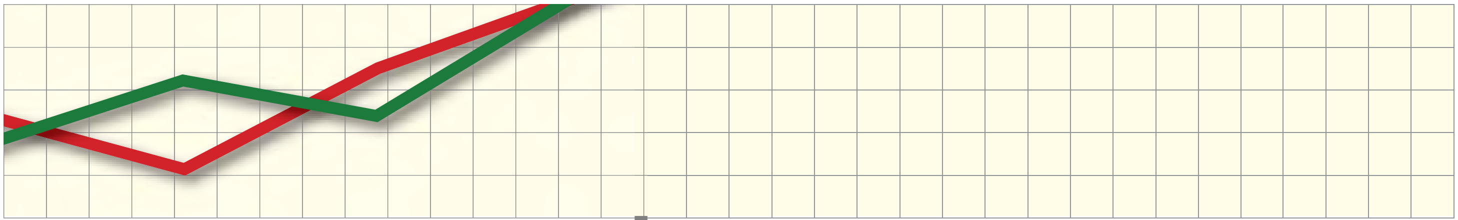
Orange County groundwater replenishment project courtesy of Pacific Boring

Results and Analysis - California

Case Studies

Project Name	Sewer Lines	Water/Sewer Replacement	GWRS Unit II	Force Main
County	**Kern**	**Merced**	**Orange**	**Sacramento**
Total output of the region	**0.65 M**	**1.65 M**	**4.17 M**	**55.66 M**
Local business expenditures	0.40 M	1.17 M	2.45 M	34.9 M
Sales of suppliers	0.13 M	0.22 M	0.78 M	9.91 M
Household spending	0.12 M	0.27 M	0.95 M	10.9 M
Personal income	**0.27 M**	**0.66 M**	**1.84 M**	**24.7 M**
State & local tax revenue	**0.02 M**	**0.03 M**	**0.11 M**	**1.35 M**
Employment	**5**	**13**	**28**	**412**
Pipe construction	3	9	17	251
Other	2	4	11	161

Photo courtesy of Association of Equipment Manufacturers



Project Name	36" Waterline	Upper NW Interceptor	WWTP Improve.	Transmission Main
County	**Sacramento**	**Sacramento**	**San Benito**	**San Francisco**
Total output of the region	**2.28 M**	**1.83 M**	**0.33 M**	**0.52 M**
Local business expenditures	1.43 M	1.15 M	0.25 M	0.35 M
Sales of suppliers	0.41 M	0.33 M	0.04 M	0.09 M
Household spending	0.48 M	0.36 M	0.04 M	0.08 M
Personal income	**1.01 M**	**0.81 M**	**0.14 M**	**0.25 M**
State & local tax revenue	**0.05 M**	**0.04 M**	**0.01 M**	**0.01 M**
Employment	**17**	**14**	**3**	**3**
Pipe construction	10	8	2	2
Other	7	6	1	1

Project Name	Storm Drainage Improvements	Interceptor Rehab	Sanitary Sewer Trunk Line	Force Main
County	**San Joaquin**	**Santa Clara**	**Tulare**	**Yolo**
Total output of the region	**6.14 M**	**6.75 M**	**7.75 M**	**90.85 M**
Local business expenditures	3.97 M	4.47 M	5.35 M	60.79 M
Sales of suppliers	0.92 M	1.12 M	1.10 M	16.53 M
Household spending	1.25 M	1.16 M	1.30 M	13.53 M
Personal income	**2.64 M**	**3.18 M**	**3.26 M**	**40.66 M**
State & local tax revenue	**0.15 M**	**0.16 M**	**0.17 M**	**2.05 M**
Employment	**46**	**43**	**63**	**663**
Pipe construction	29	29	42	429
Other	17	14	21	234

Results and Analysis - Georgia

- An investment of $1 billion in Georgia's water and wastewater infrastructure would result in an estimated $1.76 to 2.6 billion demand for goods and services across the state's economy.
- Industries that provide goods and services in support of infrastructure projects would experience over $390 million in economic demand. A wide range of other industries would sell an estimated $365 million in goods and services as households spend money in the economy.
- 14,867 to 22,254 jobs would be created with slightly fewer than 6,000 occurring in sectors other than water and wastewater construction. Nearly 9,000 jobs would be in the pipe construction sector where earnings average $44,260.
- We analyzed data on 33 recently completed projects that ranged in size from $100,000 to $164 million and covered 20 counties.

A $4.3 million wastewater treatment plant in Chatham County illustrates the local economic impacts of these investments. The plant generated another $2.6 million in demand for goods and services across other economic sectors. Slightly less than $1.5 million was spent on goods and services that support construction of treatment plants, such as engineering services, industrial machinery, and other equipment and supplies. As households paid for goods and services as varied as telecommunications and child care services, the local economy experienced an estimated $1 million in demand. More than 60 jobs were created, more than 20 of which were in industries other than pipe construction. An estimated $2.6 million in employee compensation (wages, salaries, and payroll contribution to social insurance programs) results from the initial $4.3 million investment, and state and local tax revenues increase an estimated $160,000.

A $1B investment in pipe construction in Georgia results in the following economic impacts:

Total output of the region	**1758.6-2601.8 M**
Local business expenditures	1000.0 M
Sales of suppliers	392.9 M
Household spending	365.7 M
Personal Income	**667.9-811.1 M**
State and local tax revenue	**44.5 M**
Employment	**14,867-22,254 jobs**
Pipe construction	8,959 jobs
Other	5,908 jobs
Average Earnings	**$ 44,260**

Case Studies

Project Name	12" DIP Water Main	New Sewer & Water Lines	Wastewater Treatment Plt	Wastewater Treatment Plt
County	Barrow	Bibb	Chatham	Chattooga
Total output of the region	**0.28 M**	**1.77 M**	**6.94 M**	**9.90 M**
Local business expenditures	0.20 M	1.09 M	4.31 M	8.13 M
Sales of suppliers	0.04 M	0.39 M	1.46 M	0.98 M
Household spending	0.04 M	0.29 M	1.17 M	0.79 M
Personal income	**0.10 M**	**0.66 M**	**2.66 M**	**3.28 M**
State & local tax revenue	**0.01 M**	**0.04 M**	**0.16 M**	**0.14 M**
Employment	**3**	**16**	**62**	**103**
Pipe construction	2	10	39	83
Other	1	6	23	20

Project Name	Pump Station	WWTP Improvements	Sewer & Water Line Replace.	New Sewer & Water Lines
County	Cherokee	Clarke	Cobb	Cobb
Total output of the region	**0.60 M**	**43.03 M**	**1.50 M**	**1.09 M**
Local business expenditures	0.42 M	31.07 M	0.93 M	0.67 M
Sales of suppliers	0.10 M	6.93 M	0.30 M	0.22 M
Household spending	0.07 M	5.03 M	0.28 M	0.20 M
Personal income	**0.22 M**	**16.10 M**	**0.61 M**	**0.44 M**
State & local tax revenue	**0.01 M**	**0.85 M**	**0.04 M**	**0.03 M**
Employment	**6**	**397**	**13**	**9**
Pipe construction	4	286	8	6
Other	2	111	5	3

Results and Analysis - Georgia

Case Studies

Project Name	WWTP Expansion	Water Filter Plant	New Water & Sewer Lines	New Sewer & Water Lines
County	**Coweta**	**Dekalb**	**Dekalb**	**Dekalb**
Total output of the region	**17.74 M**	**267.2 M**	**0.55 M**	**0.34 M**
Local business expenditures	12.6 M	164.9 M	0.34 M	0.21 M
Sales of suppliers	2.86 M	51.6 M	0.11 M	0.06 M
Household spending	2.27 M	50.7 M	0.10 M	0.06 M
Personal income	**6.39 M**	**107.0 M**	**0.22 M**	**0.13 M**
State & local tax revenue	**0.36 M**	**6.68 M**	**0.01 M**	**0.01 M**
Employment	**169**	**2246**	**5**	**3**
Pipe construction	120	1410	4	2
Other	49	836	1	1

Chatham County wastewater treatment plant courtesy of PF Moon & Company, Inc.

Project Name	Storm Drain Improvements	New Sewer & Water Lines	Wastewater Treatment Plt	Pump Station
County	**Dougherty**	**Fayette**	**Floyd**	**Floyd**
Total output of the region	**4.46 M**	**0.20 M**	**6.15 M**	**1.33 M**
Local business expenditures	3.00 M	0.13 M	4.20 M	0.91 M
Sales of suppliers	0.92 M	0.04 M	0.97 M	0.21 M
Household spending	0.55 M	0.03 M	0.97 M	0.21 M
Personal income	**1.73 M**	**0.08 M**	**2.15 M**	**0.47 M**
State & local tax revenue	**0.09 M**	**<0.01 M**	**0.13 M**	**0.03 M**
Employment	**42**	**2**	**58**	**13**
Pipe construction	27	1	40	9
Other	15	1	18	4

Project Name	Pump Station	Sanitary Sewer	Gravity Sewer	Sewer & Water Line Rehab
County	**Floyd**	**Forsyth**	**Forsyth**	**Fulton**
Total output of the region	**0.60 M**	**4.37 M**	**0.20 M**	**0.84 M**
Local business expenditures	0.41 M	2.95 M	0.14 M	0.55 M
Sales of suppliers	0.10 M	0.81 M	0.04 M	0.17 M
Household spending	0.10 M	0.61 M	0.03 M	0.11 M
Personal income	**0.17 M**	**1.84 M**	**0.09 M**	**0.34 M**
State & local tax revenue	**0.01 M**	**0.10 M**	**<0.01 M**	**0.02 M**
Employment	**6**	**34**	**2**	**7**
Pipe construction	4	24	1	5
Other	2	10	1	2

Results and Analysis - Georgia

Case Studies

Project Name	New Sewer & Water Lines	Gravity Sewer	Reuse Pipeline and Diffuser	Water Line Improvements
County	**Fulton**	**Gordon**	**Gwinnett**	**Gwinnett**
Total output of the region	**0.16 M**	**0.23 M**	**42.87 M**	**29.20 M**
Local business expenditures	0.11 M	0.18 M	26.25 M	17.88 M
Sales of suppliers	0.03 M	0.03 M	8.35 M	5.69 M
Household spending	0.02 M	0.03 M	8.27 M	5.63 M
Personal income	**0.07 M**	**0.08 M**	**17.64 M**	**12.02 M**
State & local tax revenue	**<0.01 M**	**<0.01 M**	**1.09 M**	**0.75 M**
Employment	**1**	**2**	**339**	**231**
Pipe construction	1	2	211	144
Other	0	0	128	87


Chatham County wastewater treatment plant courtesy of PF Moon & Company, Inc.

Project Name	Sanitary Sewer	Sanitary Sewer Replacement	Water & Sewer Utility Relocations	Sewer & Water Line Repairs
County	**Gwinnett**	**Gwinnett**	**Gwinnett**	**Gwinnett**
Total output of the region	**15.25 M**	**6.66 M**	**4.90 M**	**0.83 M**
Local business expenditures	9.34 M	4.08 M	3.00 M	0.51 M
Sales of suppliers	2.97 M	1.30 M	0.95 M	0.16 M
Household spending	2.94 M	1.28 M	0.95 M	0.16 M
Personal income	**6.28 M**	**2.74 M**	**2.02 M**	**0.34 M**
State & local tax revenue	**0.39 M**	**0.17 M**	**0.13 M**	**0.02 M**
Employment	**120**	**53**	**39**	**7**
Pipe construction	75	33	24	4
Other	45	20	15	3

Project Name	Pump Station	WWTP Expansion	Water Extension	Water Main Connections	35,000 LF 12" Water Main
County	**Henry**	**Newton**	**Putnam**	**Richmond**	**Troup**
Total output of the region	**10.72 M**	**16.50 M**	**7.03 M**	**1.35 M**	**1.44 M**
Local business expenditures	7.32 M	12.50 M	5.44 M	1.00 M	1.06 M
Sales of suppliers	1.84 M	1.92 M	0.86 M	0.20 M	0.18 M
Household spending	1.56 M	2.08 M	0.73 M	0.15 M	0.19 M
Personal income	**3.94 M**	**6.19 M**	**2.40 M**	**0.52 M**	**0.54 M**
State & local tax revenue	**0.23 M**	**0.31 M**	**0.13 M**	**0.03 M**	**0.03 M**
Employment	**101**	**149**	**68**	**12**	**13**
Pipe construction	69	113	54	9	10
Other	31	36	14	3	3

Results and Analysis - Minnesota


Photo courtesy of the Laborers-Employers Cooperation and Education Trust

- An investment of $1 billion in Minnesota's water and wastewater infrastructure would result in an estimated $1.8 to 2.4 billion demand for goods and services across the state's economy.
- Industries that provide goods and services in support of infrastructure projects would experience over $400 million in economic demand. A wide range of other industries would sell an estimated $396 million in goods and services as households spend money in the economy.
- 14,698 to 20,397 jobs would be created with about 6,000 occurring in sectors other than water and wastewater construction and 8,500 jobs in the construction sector where earnings average $48,122.
- We analyzed data on 11 recently completed projects that ranged in size from $900,000 to $14 million and covered 10 counties.

A $1.8 million storm water treatment project in Hennepin County illustrates the local economic impacts of these investments. The storm water treatment project generated another $1.1 million in demand for goods and services across other economic sectors. About $600,000 was spent on goods and services needed to complete the project, including engineering services, industrial machinery, and other equipment and supplies. Another $500,000 of other goods and services were sold as a result of household spending. More than 20 jobs were created, 15 in the water pipe construction sector. An estimated $1.2 million in employee compensation (wages, salaries, and payroll contribution to social insurance programs) derived from the initial $1.8 million investment, and state and local tax revenues were affected an estimated $70,000.

A $1B investment in pipe construction in Minnesota results in the following economic impacts:

Total output for the region	**1802.3- 2409.4 M**
Local business expenditures	1000.0 M
Sales of suppliers	406.3 M
Household spending	396.0 M
Personal Income	**685.2-758.3 M**
State and local tax revenue	**44.1 M**
Employment	**14,698-20,397 jobs**
Pipe construction	8,591 jobs
Other	6,107 jobs
Average Earnings	**$ 48,122**

Case Studies

Project Name	Utility Line Reconstruction	Collection Sys Improvements	Storm water Treatments	Water Collection Sys	Wastewater System
County	Blue Earth	Douglas	Hennepin	Kandiyohi	Wabasha
Total output of the region	**1.75 M**	**4.39 M**	**2.97 M**	**2.21 M**	**1.74 M**
Local business expenditures	1.14 M	2.98 M	1.89 M	1.56 M	1.44 M
Sales of suppliers	0.32 M	0.73 M	0.59 M	0.34 M	0.15 M
Household spending	0.29 M	0.68 M	0.49 M	0.31 M	0.15 M
Personal income	**0.67 M**	**1.60 M**	**1.27 M**	**0.85 M**	**0.56 M**
State & local tax revenue	**0.04 M**	**0.10 M**	**0.07 M**	**0.05 M**	**0.02 M**
Employment	**16**	**43**	**23**	**21**	**18**
Pipe construction	10	28	15	14	15
Other	6	15	8	7	3

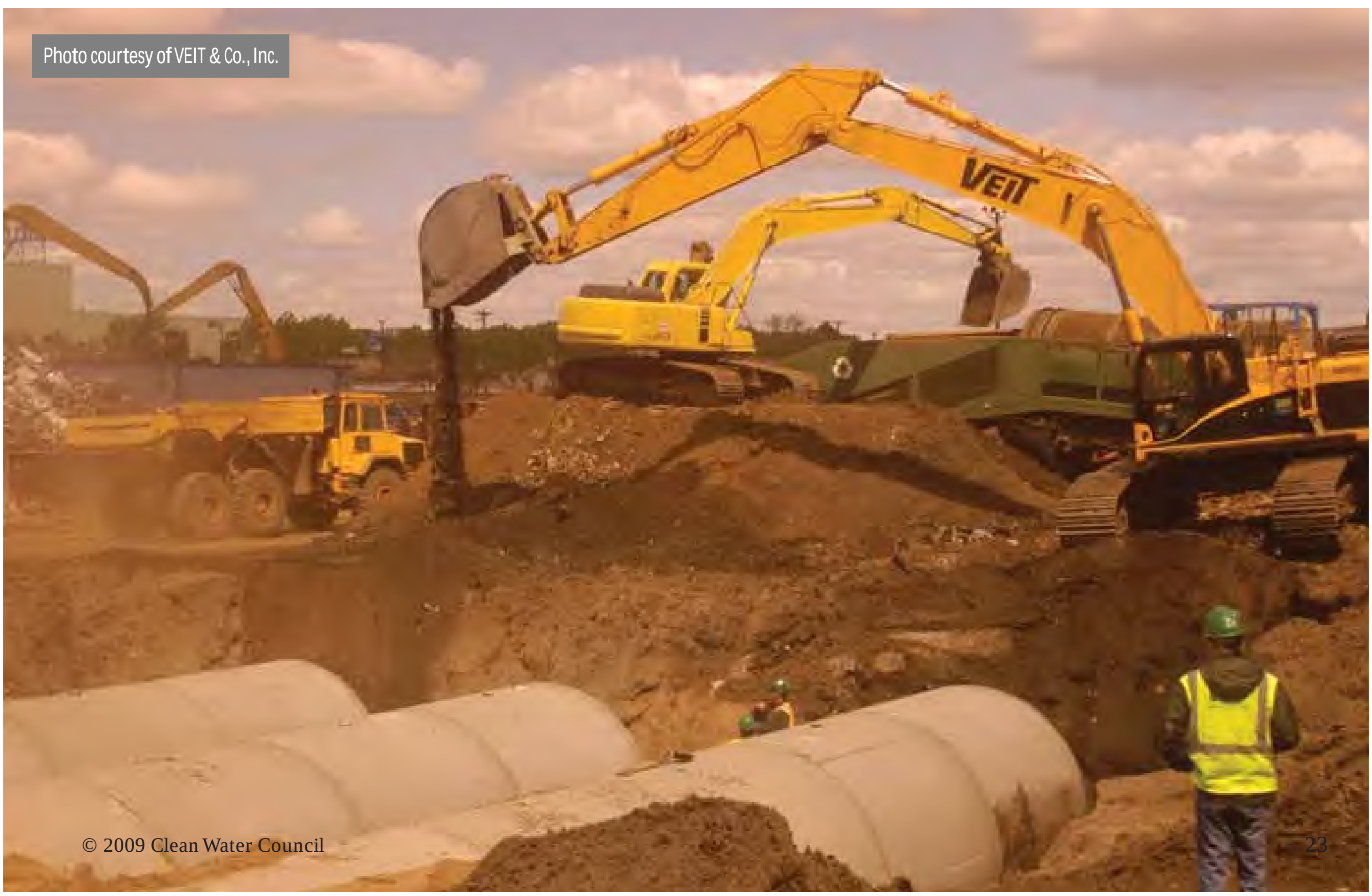


Photo courtesy of VEIT & Co., Inc.

Results and Analysis - Minnesota

Case Studies

Project Name	Sewer Lining	Sewer Lining	Sanitary & Storm Sewer Improve.	Storm Sewer Replacement	Utility Rehabilitation	Water Main Extension
County	Ramsey	Ramsey	Renville	St. Louis	Wadena	Wright
Total output of the region	**2.06 M**	**1.88 M**	**17.72 M**	**1.67 M**	**3.53 M**	**1.25 M**
Local business expenditures	1.33 M	1.22 M	14.4 M	1.12 M	2.59 M	0.90 M
Sales of suppliers	0.37 M	0.34 M	1.78 M	0.27 M	0.54 M	0.18 M
Household spending	0.35 M	0.32 M	1.54 M	0.28 M	0.41M	0.17 M
Personal income	**0.91 M**	**0.83 M**	**5.95 M**	**0.65 M**	**1.14 M**	**0.48 M**
State & local tax revenue	**0.05 M**	**0.04 M**	**0.26 M**	**0.03 M**	**0.07 M**	**0.03 M**
Employment	**15**	**14**	**179**	**15**	**37**	**11**
Pipe construction	10	9	145	10	27	8
Other	5	5	34	5	10	3


Photo courtesy of VEIT & Co., Inc.

Results and Analysis - New Mexico

- An investment of $1 billion in New Mexico's water and wastewater infrastructure would result in an estimated $1.7 to 2 billion demand for goods and services across the state's economy.
- Industries that provide goods and services in support of infrastructure projects would experience almost $390 million in economic demand. A wide range of other industries would sell an estimated $320 million in goods and services as households spend money in the economy.
- 15,329 to 20,901 jobs would be created with 6,000 occurring in sectors other than water and wastewater construction and more than 9,000 jobs would be in the pipe construction sector where earnings average $40,930.
- We analyzed data on 18 recently completed projects that ranged in size from $120,000 to $9.2 million and covered 10 counties.

A $2.6 million project to install new water and sewer lines in Dona Aña County illustrates the local economic impacts of these investments. Altogether the infrastructure investment resulted in slightly less than $4 million in demand for products and services. In addition to the $2.6 million investment for the water and sewer lines, about $730,000 were spent on supplies and services necessary to complete such work. Re-spending of income resulted in another $610,000 in local economic demand as households paid for goods and services ranging from rent, motor vehicles, and gasoline to amusement centers and beverage establishments. More than 40 jobs were created, including an estimated 27 in water pipe construction sector and another 15 across other economic sectors. An estimated $1.3 million in employee compensation (wages, salaries, and payroll contribution to social insurance programs) derived from the initial $2.6 million investment, and state and local tax revenues were affected an estimated $80,000.

A $1B investment in pipe construction in New Mexico results in the following economic impacts:

Total output of the region	**1711-2014.5 M**
Local business expenditures	1000.0 M
Sales of suppliers	389.2 M
Household spending	321.8 M
Personal Income	**607.6-662.1 M**
State and local tax revenue	**39.4 M**
Regional Employment	**15,329-20,901 jobs**
Pipe construction	9,272 jobs
Other	6,057 jobs
Average Job Compensation	**$40,930**


Photo courtesy of the Associated Equipment Distributors

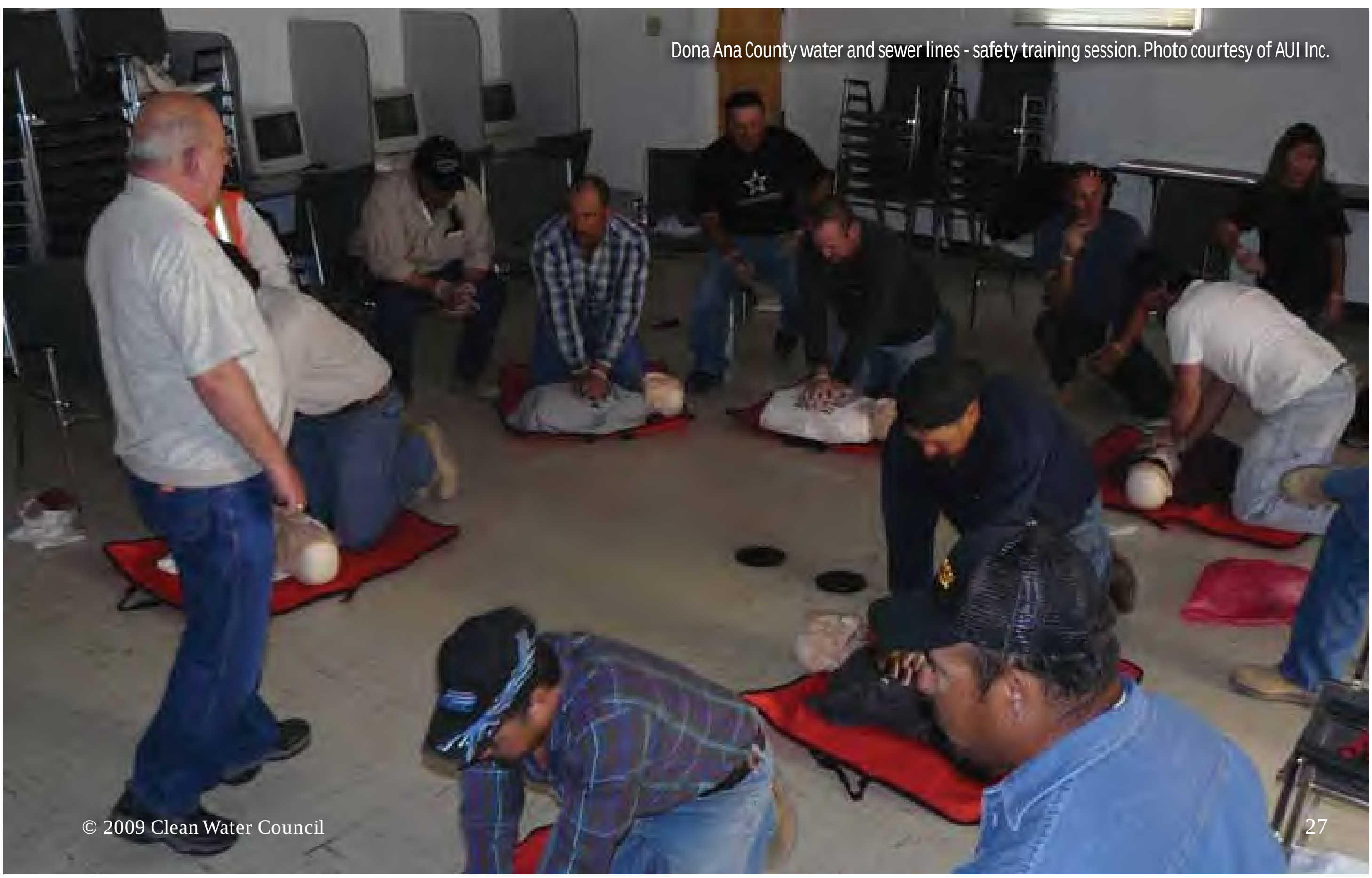
Results and Analysis - New Mexico

Case Studies

Project Name	Water & Wastewater Trans Lines	New 36" & 60" Water Lines	Water & Sewer Lines	Water & Sewer Line Improve.
County	Bernalillo	Bernalillo	Bernalillo	Bernalillo
Total output of the region	**14.45 M**	**5.27 M**	**4.94 M**	**0.50 M**
Local business expenditures	9.21 M	3.36 M	3.15 M	0.32 M
Sales of suppliers	2.82 M	1.03 M	0.96 M	0.10 M
Household spending	2.42 M	0.88 M	0.83 M	0.08 M
Personal income	**5.58 M**	**2.03 M**	**1.91 M**	**0.20 M**
State & local tax revenue	**0.31 M**	**0.11 M**	**0.11 M**	**0.01 M**
Employment	**130**	**47**	**44**	**4**
Pipe construction	82	30	28	3
Other	48	17	16	1

Project Name	Sewer Line & Storm Drain Improve.	Water Line Replacement	Pipe Bursting	Sewer Line & Lift Station	Wastewater Treatment Plt
County	Dona Ana	Guadalupe	Otero	Rio Arriba	San Juan
Total output of the region	**0.81 M**	**1.66 M**	**0.72 M**	**0.39 M**	**4.92 M**
Local business expenditures	0.54 M	1.46 M	0.56 M	0.30 M	3.33 M
Sales of suppliers	0.15 M	0.12 M	0.08 M	0.05 M	0.81 M
Household spending	0.12 M	0.08 M	0.08 M	0.04 M	0.78 M
Personal income	**0.27 M**	**0.59 M**	**0.24 M**	**0.13 M**	**1.88 M**
State & local tax revenue	**0.02 M**	**0.02 M**	**0.01 M**	**0.01 M**	**0.11 M**
Employment	**8**	**16**	**8**	**4**	**42**
Pipe construction	5	14	6	3	28
Other	3	2	2	1	14

Project Name	Water & Sewer Line Improve.	Water & Sewer Line Improve.	WWTP Upgrade	New Water & Sewer Lines
County	**Bernalillo**	**Cibola**	**Cibola**	**Dona Ana**
Total output of the region	**0.47 M**	**0.69 M**	**0.56 M**	**3.98 M**
Local business expenditures	0.30 M	0.54 M	0.44 M	2.65 M
Sales of suppliers	0.09 M	0.06 M	0.05 M	0.73 M
Household spending	0.08 M	0.08 M	0.07 M	0.61 M
Personal income	**0.18 M**	**0.26 M**	**0.22 M**	**1.35 M**
State & local tax revenue	**0.01 M**	**0.01 M**	**0.01 M**	**0.08 M**
Employment	**4**	**6**	**5**	**42**
Pipe construction	3	5	4	27
Other	1	1	1	15


Dona Ana County water and sewer lines - safety training session. Photo courtesy of AUI Inc.

Results and Analysis - New Mexico

Case Studies

Project Name	New Well Bldg, Pump, & Lines	Sewer Improvements	WWTP Expansion	Water Storage Tank Upgrade	WWTP Upgrade
County	**Sandoval**	**Sandoval**	**Santa Fe**	**Santa Fe**	**Taos**
Total output of the region	**1.62 M**	**0.16 M**	**4.93 M**	**0.31 M**	**2.34 M**
Local business expenditures	1.20 M	0.12 M	3.27 M	0.20 M	1.72 M
Sales of suppliers	0.24 M	0.02 M	0.90 M	0.06 M	0.29 M
Household spending	0.18 M	0.02 M	0.76 M	0.05 M	0.33 M
Personal income	**0.62 M**	**0.06 M**	**1.73 M**	**0.11 M**	**0.79 M**
State & local tax revenue	**0.03 M**	**<0.01 M**	**0.10 M**	**0.01 M**	**0.04 M**
Employment	**15**	**2**	**50**	**3**	**24**
Pipe construction	11	1	32	2	17
Other	4	1	18	1	7

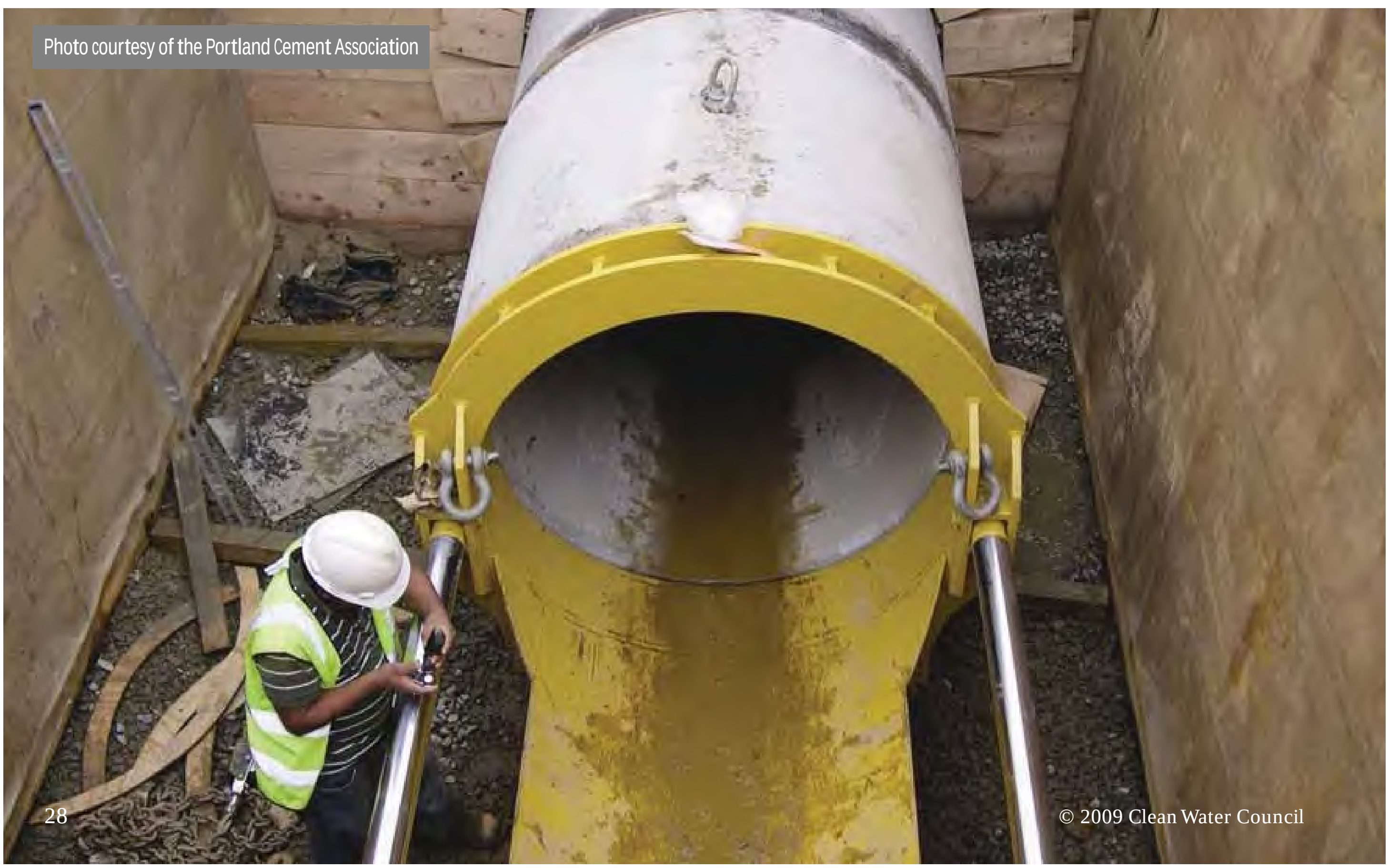


Photo courtesy of the Portland Cement Association

Results and Analysis - Pennsylvania

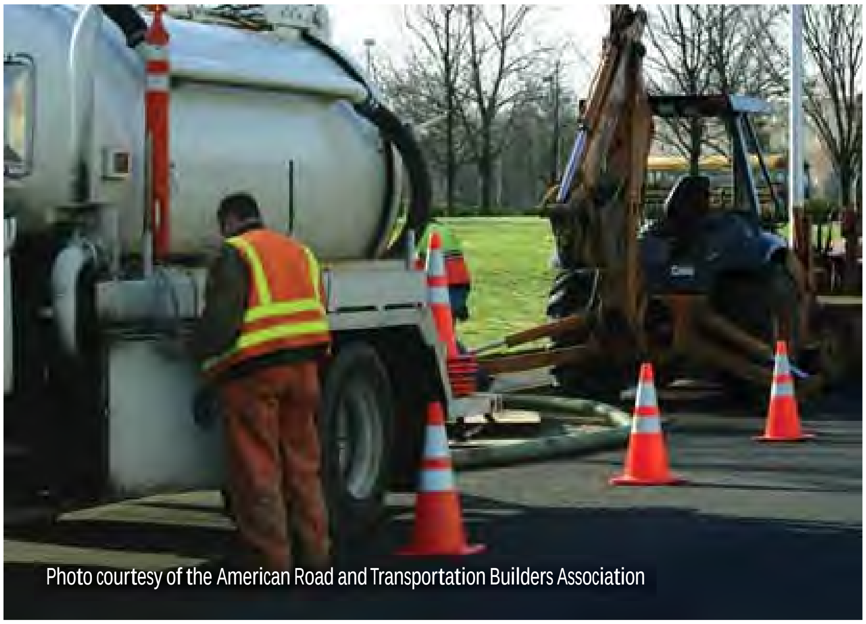


Photo courtesy of the American Road and Transportation Builders Association

- An investment of $1 billion in Pennsylvania's water and wastewater infrastructure would result in an estimated $1.8 to 2.6 billion demand for goods and services across the state's economy.
- Industries that provide goods and services in support of infrastructure projects would experience almost $430 million in economic demand. A wide range of other industries would sell an estimated $438 million in goods and services as households spend money in the economy.
- 14,524 to 20,037 jobs would be created with more than 6,000 in sectors other than water and wastewater construction and more than 8,000 jobs in the pipe construction sector where earnings average $52,037.
- We analyzed data on 38 recently completed projects that ranged in size from $80,000 to $10.3 million and covered 21 counties.

A $2 million pumping station in in Bucks County illustrates the local economic impacts of these investments. Altogether the infrastructure investment resulted in about $3.2 million in demand for products and services. In addition to the $2 million investment for the pumping station, about $640,000 were spent on supplies and services necessary to complete such work. Re-spending of household income resulted in another $570,000 in demand for goods and services in the local economy. More than 20 jobs were created, most of which (17) were in the water pipe construction sector and another 9 across other economic sectors. An estimated $1.3 million in employee compensation (wages, salaries, and payroll contribution to social insurance programs) derived from the initial $2 million investment, and state and local tax revenues were affected an estimated $80,000.

A $1B investment in pipe construction in Pennsylvania results in the following economic impacts:

Total output of the region	**1867-2609.7 M**
Local business expenditures	1000.0 M
Sales of suppliers	428.9 M
Household spending	438.2 M
Personal Income	**725.9-790 M**
State and local tax revenue	**46.6 M**
Regional Employment	**14,524-20,037 jobs**
Pipe construction	8,247 jobs
Other	6,277 jobs
Average Earnings	**$ 52,037**

Results and Analysis - Pennsylvania

Case Studies

Project Name	Sanitary Sewer System Improvements	Interceptor Replacement	Water Line & Services	Sanitary Sewer Replacement
County	**Adams**	**Allegheny**	**Beaver**	**Beaver**
Total output of the region	**0.78 M**	**0.79 M**	**1.87 M**	**1.70 M**
Local business expenditures	0.55 M	0.48 M	1.24 M	1.13 M
Sales of suppliers	0.11 M	0.16 M	0.33 M	0.30 M
Household spending	0.12 M	0.15 M	0.30 M	0.28 M
Personal income	**0.30 M**	**0.33 M**	**0.75 M**	**0.69 M**
State & local tax revenue	**0.02 M**	**0.02 M**	**0.04 M**	**0.03 M**
Employment	**7**	**6**	**16**	**15**
Pipe construction	5	4	11	10
Other	2	2	5	5

Project Name	Valve Vault & Tie-ins	Water & Sewer Extension	Sewer & Water Lines	Pipe Bursting, Reline & Rehab
County	**Beaver**	**Bedford**	**Bedford**	**Blair**
Total output of the region	**0.12 M**	**1.89 M**	**0.39 M**	**7.57 M**
Local business expenditures	0.08 M	1.43 M	0.29 M	4.92 M
Sales of suppliers	0.02 M	0.21 M	0.04 M	1.38 M
Household spending	0.02 M	0.26 M	0.05 M	1.26 M
Personal income	**0.05 M**	**0.73 M**	**0.15 M**	**2.84 M**
State & local tax revenue	**<0.01 M**	**0.04 M**	**0.01 M**	**0.16 M**
Employment	**1**	**17**	**4**	**72**
Pipe construction	1	12	3	46
Other	0	5	1	26

Project Name	Wastewater Treatment Plant	New Pumping Station	Pumping Station Rehab.	New Collector Sewer
County	**Bucks**	**Bucks**	**Bucks**	**Butler**
Total output of the region	**3.95 M**	**3.22 M**	**1.87 M**	**16.45 M**
Local business expenditures	2.45 M	2.00 M	1.16 M	10.35 M
Sales of suppliers	0.79 M	0.64 M	0.37 M	3.48 M
Household spending	0.70 M	0.57 M	0.33 M	2.63 M
Personal income	**1.59 M**	**1.30 M**	**0.75 M**	**6.34 M**
State & local tax revenue	**0.09 M**	**0.08 M**	**0.04 M**	**0.36 M**
Employment	**32**	**26**	**15**	**136**
Pipe construction	21	17	10	87
Other	11	9	5	49

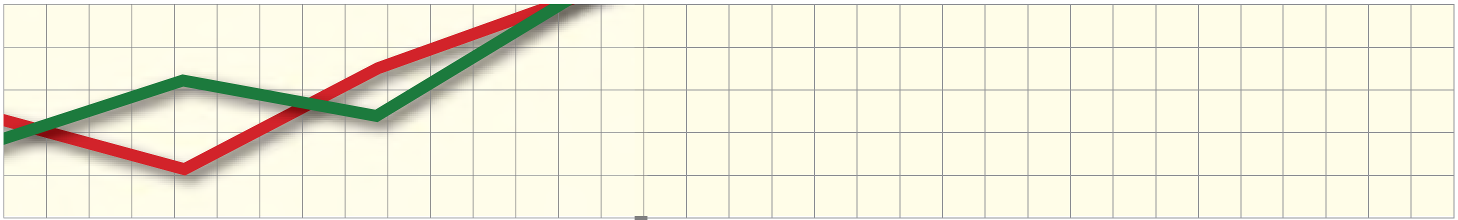
Bucks County Pumping Station, courtesy of C&T Associates Inc.

Results and Analysis - Pennsylvania

Case Studies

Project Name	New Collector Sewer & Appurt.	Sewer Main & Lateral Rpl.	Sewer Main & Lateral Rpl.	Waste Water Collection Sys
County	Butler	Clearfield	Clearfield	Clearfield
Total output of the region	**14.9 M**	**10.89 M**	**8.07 M**	**4.67 M**
Local business expenditures	9.35 M	7.39 M	5.48 M	3.12 M
Sales of suppliers	3.13 M	1.92 M	1.43 M	0.82 M
Household spending	2.37 M	1.57 M	1.17 M	0.67 M
Personal income	**5.72 M**	**4.00 M**	**2.97 M**	**1.71 M**
State & local tax revenue	**0.32 M**	**0.21 M**	**0.15 M**	**0.09 M**
Employment	**122**	**105**	**78**	**45**
Pipe construction	78	70	52	30
Other	44	35	26	15

Bucks County Pumping Station, courtesy of C&T Associates Inc.



Project Name	Pump Station Sludge Tank	Sanitary Sewer Replacement	Sewer Lines	Sewer Extension
County	**Dauphin**	**Dauphin**	**Fayette**	**Franklin**
Total output of the region	**4.19 M**	**1.94 M**	**7.57 M**	**0.55 M**
Local business expenditures	2.75 M	1.27 M	5.12 M	0.37 M
Sales of suppliers	0.81 M	0.37 M	1.32 M	0.09 M
Household spending	0.63 M	0.29 M	1.13 M	0.09 M
Personal income	**1.77 M**	**0.82 M**	**2.90 M**	**0.21 M**
State & local tax revenue	**0.09 M**	**0.04 M**	**0.15 M**	**0.01 M**
Employment	**34**	**16**	**70**	**5**
Pipe construction	22	10	46	3
Other	12	6	24	2

Project Name	Sanitary Sewer	Wastewater System Improvement	Sewer Lines & Appurt.	Wastewater Treatment Plt
County	**Huntingdon**	**Jefferson**	**Jefferson**	**Jefferson**
Total output of the region	**1.50 M**	**8.31 M**	**3.65 M**	**1.49 M**
Local business expenditures	1.13 M	6.16 M	2.70 M	1.11 M
Sales of suppliers	0.17 M	1.15 M	0.51 M	0.21 M
Household spending	0.20 M	1.00 M	0.44 M	0.18 M
Personal income	**0.54 M**	**2.84 M**	**1.25 M**	**0.51 M**
State & local tax revenue	**0.03 M**	**0.14 M**	**0.06 M**	**0.03 M**
Employment	**14**	**84**	**37**	**15**
Pipe construction	11	62	27	11
Other	3	22	10	4

Results and Analysis - Pennsylvania

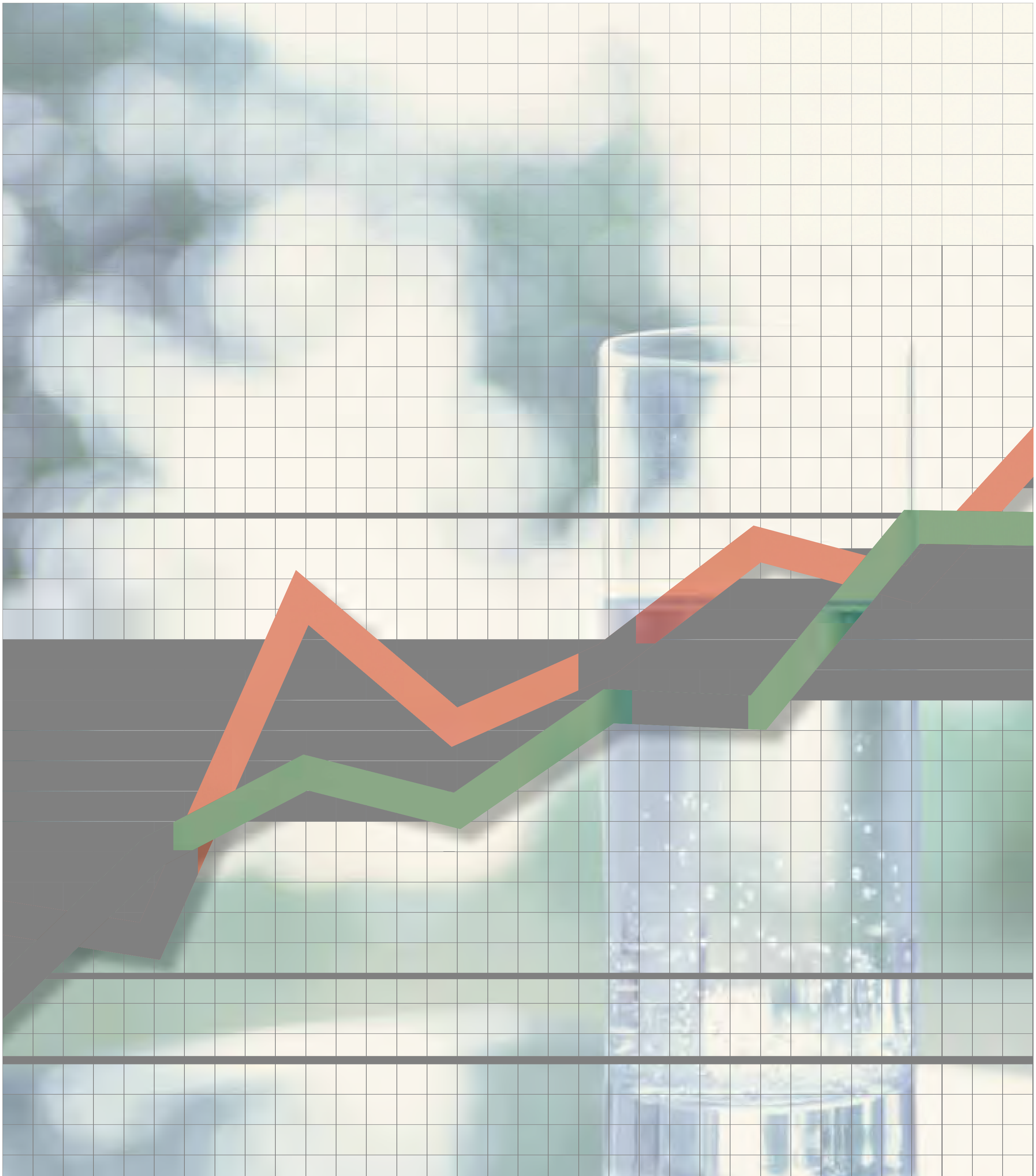
Case Studies

Project Name	Storm Sewer	Sludge Holding Tank Filter Building w/ UV	Storm Water Pump Station Improvement	Interceptor Replacement
County	**Jefferson**	**Lebanon**	**Lycoming**	**Mercer**
Total output of the region	**0.35 M**	**10.45 M**	**1.39 M**	**3.04 M**
Local business expenditures	0.26 M	7.07 M	0.91 M	2.07 M
Sales of suppliers	0.05 M	1.69 M	0.24 M	0.48 M
Household spending	0.04 M	1.69 M	0.24 M	0.50 M
Personal income	**0.12 M**	**4.02 M**	**0.54 M**	**1.16 M**
State & local tax revenue	**0.01 M**	**0.22 M**	**0.03 M**	**0.06 M**
Employment	**4**	**93**	**13**	**28**
Pipe construction	3	62	8	18
Other	1	31	5	10

Project Name	WWTP Renovation	Renovation of Primary Sed Tank	Water Distribution Lines	Sewer Lines & Appurtenances
County	**Montgomery**	**Philadelphia**	**Schuykill**	**Westmoreland**
Total output of the region	**5.42 M**	**6.05 M**	**8.73 M**	**7.41 M**
Local business expenditures	3.37 M	4.07 M	6.2 M	4.64 M
Sales of suppliers	1.02 M	0.98 M	1.29 M	1.48 M
Household spending	1.03 M	1.00 M	1.24 M	1.30 M
Personal income	**2.30 M**	**2.76 M**	**3.26 M**	**2.92 M**
State & local tax revenue	**0.13 M**	**0.13 M**	**0.15 M**	**0.17 M**
Employment	**41**	**43**	**79**	**65**
Pipe construction	27	28	56	40
Other	14	15	23	15

Project Name	**Sewage Coll Sys & Pump Station**	**Water Main Transmission**	**Underground Water Tanks**	**Water Filtration Plant Rehab**
County	**Westmoreland**	**Westmoreland**	**Westmoreland**	**Westmoreland**
Total output of the region	**7.36 M**	**4.58 M**	**4.22 M**	**4.11 M**
Local business expenditures	4.60 M	2.86 M	2.64 M	2.57 M
Sales of suppliers	1.47 M	0.91 M	0.84 M	0.82 M
Household spending	1.29 M	0.80 M	0.74 M	0.72 M
Personal income	**2.89 M**	**1.80 M**	**1.66 M**	**1.61 M**
State & local tax revenue	**0.17 M**	**0.10 M**	**0.10 M**	**0.09 M**
Employment	**64**	**40**	**37**	**36**
Pipe construction	40	25	23	22
Other	24	15	14	14

Project Name	**Wastewater Treatment Plant**	**Force Main and Trunk Sewer Upgrade**
County	**York**	**York and Adams**
Total output of the region	**4.91 M**	**1.18 M**
Local business expenditures	3.09 M	0.74 M
Sales of suppliers	0.92 M	0.22 M
Household spending	0.90 M	0.22 M
Personal income	**2.01 M**	**0.48 M**
State & local tax revenue	**0.11 M**	**0.03 M**
Employment	**41**	**10**
Pipe construction	25	6
Other	16	4



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Footnote 9 Document

U.S. Conference of Mayors, "*Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Value to the National Economy*", issued August 14, 2008.

THE U.S. CONFERENCE OF MAYORS
MAYORS WATER COUNCIL

LOCAL GOVERNMENT INVESTMENT IN MUNICIPAL WATER AND SEWER INFRASTRUCTURE: *Adding Value to the National Economy*

Washington, DC
August 14, 2008

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THE UNITED STATES CONFERENCE OF MAYORS

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Contents

Mayors Briefing

Public infrastructure is the foundation for economic development. Access to roads, water, sewer, communication technologies, and electricity are all essential to the economy. Investment in both the infrastructure (***i.e.,*** the purchase of physical plant and equipment) and the operation and maintenance (e.g., labor, supplies) of these structures can expand the productive capacity of an economy, by both increasing resources and enhancing the productivity of existing resources.

This paper summarizes estimates of direct economic impacts of water and sewer investment. The estimates exhibit a wide range, but the consensus is that public infrastructure investment yields positive returns, and investment in water and sewer infrastructure has greater returns than most other types of public infrastructure.

- A recent study estimates that one dollar of water and sewer *infrastructure investment* increases private output (Gross Domestic Product, GDP) in the *long-term* by $6.35.

- With respect to *annual general revenue and spending* on operating and maintaining water and sewer systems, the US Department of Commerce's Bureau of Economic Analysis estimates that for each additional dollar of *revenue (or the economic value of the output)* of the water and sewer industry, the increase in *revenue (economic output)* that occurs in all industries is $2.62 in that year.

- The same analysis estimates that adding 1 job in water and sewer creates 3.68 jobs in the national economy to support that job.

However, there are many factors to consider when interpreting the results. Measures of the return on public infrastructure investment vary geographically and are affected by past investment. For example, if public water and sewer infrastructure is adequate and of high quality, the rates of return on further investment may be lower than it would be if infrastructure were inadequate. Optimal levels of investment also depend on the method used to generate additional funding. For example, if greater investment in public infrastructure is going to be funded by increased taxes, the effect of those taxes on the economy must be taken into account.

These conclusions are based on a review of 310 economic studies, books, and government and non-government reports. Although a large body of literature estimates the return on investments in public infrastructure, only a sub-set of the literature focuses on the returns to investment in water and sewer infrastructure. Some early studies estimated that returns were very large, while others indicated no meaningful returns on investment in public infrastructure. Over time, the methodologies used by researchers have evolved and the results have become more consistent. It has become clear that water and sewer investment can foster specialization and complement labor and private capital within an economy.

Specific types of investment may also generate *secondary or indirect benefits* such as fire protection and the increased provisioning of ecosystem services such as climate regulation, disturbance regulation, habitat, and cultural and recreational services. These services also have a positive effect on the economy. For example, protecting one hectare (10,000 square meters, or

2.471 acres) of a wetland for source water protection may yield a primary benefit of $4,177 annually in avoided treatment costs. However, the same wetland may yield an additional $10,246 annually in other ecosystem services. These secondary benefits are reviewed briefly, but are not the focus of this paper.

As the largest investors in water and sewer, municipalities have an interest in knowing the return on this investment. Overall, the reviewed literature indicate that water and sewer investment by local government creates significant value-added to the economy.

A. Introduction: The Need for Investment

The nation has considerable resources invested in drinking water and sewer services. Although local governments are major investors in this sector, other capital intensive services (i.e., transportation, communication, and electricity) compete for limited local resources. Beyond providing safe drinking water and environmental protection, water and sewer investments also contribute to economic growth in the local and national economies.

Infrastructure investment contributes to economic growth by expanding the productive capacity of a locality, region, state, or the nation as a whole. A new highway, for example, allows for increased transportation of people, goods, and services. But it does more. It creates opportunities for increased commerce as businesses will locate near the new road, providing additional jobs and output. Investments can enhance the productivity of existing infrastructure resources and increase the resource base of an economy through the addition of new infrastructure. Therefore public investment lowers the total production costs for private companies (Munnell 1992). Infrastructure investment can also contribute to economic growth through the expenditures associate with purchasing, installing, operating, and maintaining the infrastructure itself.

The goal of this paper is to describe the value-added from investment in municipal water and sewer. This paper reviews the body of relevant literature estimating the economic impact of water and sewer investment and presents our findings in the following five sections:

- Returns to Public Infrastructure Investment
- Returns to Annual Operations and Maintenance Spending
- Additional Indirect Impacts
- Additional Factors to Consider
- Conclusions

Local governments are the primary investors in water and sewer systems. According the US Census, state and local governments spent $36 billion on sewers and another $46 billion on drinking water in 2004-2005. In 2004, public spending on infrastructure reached a cumulative total of just over $312 billion, of which states and localities spent $238.7 billion, or 76 percent.[1] Water supply and sewer treatment projects took 32 percent of total state and local infrastructure investment, or $28.3 billion, in 2004 alone (CBO 2007). Of these combined state and local investments, the local government share of spending on sewer is over 95 percent, and over 99 percent for water supply (Anderson 2007). For example, of the $15.3 billion invested in sewer infrastructure by state and local governments in 2006, $14.7 billion or 96% came from local governments (Census 2008).

Despite these considerable and ongoing investments, the US Environmental Protection Agency projects that the nation’s water systems will need to invest $276.8 billion through 2023 to

[1] In real dollars (i.e., adjusted for inflation), all types of infrastructure.

provide safe drinking water and $202.5 billion through 2028 to control wastewater pollution—figures that exclude needs related to growth (EPA 2005, EPA 2008).

Beyond investments in physical plant and equipment, spending on the operations and maintenance of water systems also is a major financial obligation for states and local governments. In 2004, spending by states and localities on water and sewer operations and maintenance was $51.2 billion. This represents a 34 percent share of their total operation and maintenance spending, second only to highway and roads (CBO 2007).

The research question in this paper focuses on defining the economic impact of investment in water and sewer systems, including investment in infrastructure, operations, and maintenance. Infrastructure investment can come from both the reinvestment and replacement of existing infrastructure (existing assets), and investment in new infrastructure (adding assets at the margin). Beyond the replacement or addition of infrastructure, there are also economic impacts associated with operations and maintenance (the provisioning of the service). Therefore, local decision makers may consider three ways that investment in water and sewer could create added value in the economy.

1. Capital reinvestment in existing infrastructure (replacement, rehabilitation, etc.)
2. Capital investment in new infrastructure
3. Operation and maintenance of existing infrastructure

From an economic perspective, the distinction between these categories is important, especially with regard to the methodology for estimating their impact. Existing infrastructure stocks affect the marginal productivity of new infrastructure. Assuming diminishing returns, a small increase in the stock of infrastructure would have a small economic impact if a large stock of infrastructure is already in place. Similarly, a large increase in the infrastructure stock is expected to have a large economic impact if the previous stock was small. Despite the importance of marginal impacts, many empirical studies focus on the average productivity of public infrastructure and cannot be used to assess whether the existing stock is efficient or if investment in new infrastructure is necessary (Romp and de Haan 2005).

How Does Infrastructure Affect the Economy?

Infrastructure investment can boost productivity by enhancing the productivity of existing infrastructure resources and by increasing the resource base of an economy by adding new infrastructure.

Existing Infrastructure

- On a periodic basis, infrastructure needs to be rehabilitated or replaced. This *reinvestment* maintains the value of the existing assets. Reinvestment is primarily spending on physical plant and equipment. It also involves labor costs for construction.

- On a daily basis, systems incur expenses to *operate* and serve customers and perform routine *maintenance* to prevent wear and tear. Beyond productivity gains, economic impacts primarily come from spending on labor and supplies.

New Infrastructure

- Periodically *new infrastructure* is added to the existing stock. This represents growth at the margin of the infrastructure stock. Beyond productivity gains, economic impacts result from payments for the new infrastructure and payments for its installation.

Models of Economic Output (What is a *Production Function*?)

To estimate the effects of infrastructure investment on the economy a conceptual model is needed to determine how they interact.

- A *production function* is a mathematical equation of the relationship between production inputs (e.g., capital and labor) and outputs (e.g. Gross Domestic Product).
    - The Cobb-Douglas production function is a specific production function (named for economists Charles Cobb and Paul Douglas) that assumes that output is an exponential function of inputs. In general, output (Q) is given by $Q = AK^{\alpha}L^{\beta}$, where:

        A represents technology or productivity

        K represents the amount of capital (K can be divided into several types of capital)

        L is the amount of labor (which also can be divided into several categories)

        α and **β** relate capital and labor to output. They are elasticities; i.e., they show the percentage change in output for a percentage change in inputs. These parameters often are estimated using regression models.

    - Water and sewer infrastructure are typically modeled as a type of capital, or technology. The *investment elasticity* describes the relationship between investment in water and sewer infrastructure and output.
- An *input-output model* maps out the economy as a whole. It measures how the output from each sector is used as an input in other sectors of an economy. It describes the inter-sector relationships through a series of *multipliers*.
- Other types of models have different basic assumptions and are analyzed using specific techniques.

Evolution of the Economic Literature

Since the late 1980s, academic interest in the role of public investment and economic growth has been revived. This was largely motivated by declines in public investment in the early 1970s and falls in economic productivity growth at roughly the same time. Arguments by Aschauer (1989) and others that there were significant linkages between economic growth and public infrastructure investments fueled the discussion. Many of these studies were estimations of *Cobb-Douglas production functions* with time series data. (*Production functions* describe how inputs are combined to produce outputs. See the text box "Models of Economic Output.") However, many of the early studies were controversial because of their sensitivity to small changes in data and methodological issues (CBO 2007; OECD 2006). The wide range of estimates made the results of older studies difficult to interpret from a policy perspective. Key points of concern in these early studies focused on methodological and econometric difficulties including causality and correlation (Romp and de Haan 2005; Gramlich 1994).

- *Direction of causality*: While public infrastructure may affect productivity and output, economic growth can also shape the demand and supply of public infrastructure services. This may cause an upward bias if feedbacks within the model are not addressed.

- *Spurious (false) correlation*: Output and public infrastructure data often have a *unit root*, meaning that the value tomorrow is its value today plus an unpredictable change. This unpredictable change can be viewed as the result of irregular policy decisions to start, stop, or change infrastructure projects to meet evolving priorities with respect to public infrastructure. If statistical models fail to account for this random process, they will misestimate the relationship between public infrastructure investment and output.

To address these issues, researchers have employed a number of statistical techniques, including testing variables for co-integration, using vector autoregression models, and using panel data approaches to estimate the relationships between public infrastructure and output (Gramlich 1994). Most recent estimates are significantly lower than previous estimates, possibly indicating that the earlier results did not account for some feedback effects (OECD 2006).

Major Methodological Approaches

Estimates of investment elasticites and of input-output (I-O) multipliers are two approaches used to capture how changes in the water and sewer industry affect the broader economy.

- Investment elasticities measure the relationship between inputs and output. In general, e*lasticities* give the percentage change in one variable for a percentage change in another. For example, *price elasticities of demand* show the percentage change in the quantity consumer's demand for a percentage change in price. In the public infrastructure literature, *investment elasticities* show the percentage change in output for a percentage change in the value of public infrastructure assets. Output usually is measured as gross state product or national GDP.

Interpreting Return on Investment and Spending

Investment

The relationship between infrastructure investment and economic output is captured by an *elasticity coefficient*. This represents what a one-percent change in infrastructure investment would have on economic output. For example, according to one estimate, a one percent increase in investment in water and sewer in Florida would increase output in Florida by approximately 0.2 percent. While that may seem small, it is in fact a very large impact. With annual gross state product (GSP) of $735 billion, the 0.2 percent increase in output is worth $1.4 billion.

Florida Economic Output (GSP)	Investment Elasticity	Impact of 1% Increase in the Stock of Water and Sewer Infrastructure
$ 734.5 billion	0.1959	$ 1.4 billion

Spending

One person's spending is another person's income. Therefore, when municipalities spend more on water and sewer infrastructure operations and maintenance these dollars contribute to workers wages and revenue for other businesses, which in turn spend the money in the economy.

This chain of spending results in a *multiplied* effect on the economy. These effects are captured by *multipliers* representing the impact of a one dollar investment on the economy. For example, for each additional dollar of water and sewer output in New Mexico there is $1.74 total increase in output that occurs in the economy as a whole.

- *Input-output multipliers* measure the economic impact of each sector of the economy on other sectors. The multiplier is the primary factor income to outside sectors (other industries) that sell to or buy from the water industry (direct beneficiaries of augmented water supply) (DOC 1997; Young 2005).

These two measures are used to quantify the impact that water and sewer infrastructure has on the economy. The elasticities show the effect that changes in investment have on the economy, while the I-O multipliers map out inter-industry interactions and capture the relationship between the water and sewer industry and other industries within a region, or the economy as a whole.

In a review of the theoretical and empirical literature on the link between public infrastructure investment and economic growth, Romp and de Haan (2005) identify the three major approaches economists have used to estimate elasticities.

- *Production-function approach*: An aggregated Cobb-Douglas production function is adapted to include the monetary value of the infrastructure stock. Most often infrastructure is a third factor in the production function (in addition to private capital and labor), or is incorporated into the production function as a part of the technological constraint (i.e., influences total factor productivity).

- *Cost-function approach*: The cost function for private sector firms are estimated assuming that public infrastructure is externally provided by the government as a free input. When firms optimize they decide the amount of the unpaid fixed input (public infrastructure) they want to use and the model satisfies the conditions of standard marginal productive theory – which the production-function approach violates.

- *Vector auto regression (VAR) models*: All variables are jointly determined with no *a priori* assumptions about causality (unlike the production function and cost-function approaches). VAR models test whether the causal relationship assumed in other approaches is valid, or whether feedback effects from output to infrastructure exist.

B. Returns to Public Infrastructure Investment

Effects of Investment in Public Infrastructure

Public infrastructure is the foundation for economic development. Access to roads, water, sewer, communication technologies, and electricity are all essential to the economy (Kemp 2005). Many different researchers have attempted to describe and quantify the effects that public infrastructure has on economic output. Most of this research was sparked by Aschauer's 1989 paper "Is Public Expenditure Productive," which concluded that reduced government spending on public infrastructure was one of the primary causes of the economic slowdown in the U.S. He used a production function in which state output is a product of labor, productivity, utilization, private capital, and public infrastructure. He found "core" public infrastructure (highways, mass transit, airports, electrical and gas facilities, water, and sewers) to have a profoundly positive effect on the productivity of state economies. The subsequent research on this topic builds on Aschauer's initial work, modifying the methodology, and either affirming or challenging the results. The economic output elasticities of public infrastructure are reported in Table 1, and other measures of the effect of public infrastructure on the economy are reported in Table 2.

Table 1: Investment Elasticities of Public Infrastructure

Source	Measure	Region	Investment Elasticity/ Range
Aschauer 1989	Output elasticity of net nonmilitary public infrastructure stock	National	0.39*
Munnell 1990	State output elasticity of public infrastructure stock	States	0.15*
Moomaw et al. 1995[1]	State output elasticities of aggregate public infrastructure	National	0.2398*
		Northeast	-0.1021 - 0.2612
		North Central	0.0652 - 0.1716
		South	0.0104 - 0.1918
		West	0.0006 - 0.2414
Tatom 1991	Business sector elasticity of public infrastructure	National	0.042[2]

* Statistically significant at the 5 percent level.
1. Only results for 1986 cross section are reported.
2. Not statistically different from 0.

Munnell (1990) uses a similar methodology as Aschauer to measure the effect of public infrastructure spending on state economic output. Her study confirms Aschauer's conclusions, that spending on public infrastructure has a positive effect on the productivity of the economy, but she finds slightly lower output elasticities of public infrastructure. Moomaw et al. (1995) expands on this technique to produce elasticities for all 50 states for 3 years. Again, the results support a positive correlation between public infrastructure and economic output in almost all cases.

Some researchers have since challenged the statistical method used to obtain these results. Tatom (1991) argues that Aschauer's study and those using similar methodologies ignore broken trends in productivity, fail to account for changes in energy prices, and contain non-stationary variables (i.e., they fail to account for trends in the data over time). Tatom concludes that if you take into account the above limitations the effect of public infrastructure stock on output is not statistically different from zero. (A statistically significant result is one that is unlikely to have occurred by chance. Statistical significance does not imply the difference is large or important; rather, it means it is not merely random noise.)

One way to address some of these concerns is to view public infrastructure as a technology that constrains the other inputs in the production function rather than as an independent input. Duggal et al. (1999) uses this approach and finds similar output elasticities of public infrastructure as Aschauer (1989). Bougheas et al. (2000) takes this technique one step further and views infrastructure as a technology that reduces the cost of intermediate inputs in the production of final goods. Bougheas et al. conclude that these reduced costs foster specialization, which increases productivity within the economy. Both these studies affirm that public infrastructure investment can expand the productive capacity of an economy, both by increasing resources and by enhancing the productivity of existing resources (Munnell 1992).

Over time, a consensus has emerged that public infrastructure stimulates economic growth; however most recent studies show that the impact is not as large as Aschauer first reported (Romp and de Haan 2005). Demetriades and Mamuneas (2000) concludes that in the long run, public infrastructure investment is positively correlated with input demands and output supply; in the short run the correlation is also positive but less powerful. This positive correlation has many possible causes. Public infrastructure is a gross-complement to both labor and private capital (Demetriades and Mamuneas 2000).

Table 2: Other Measures of the Effect of Public Infrastructure on the Economy

Source	Measure	Region	Investment Elasticity/ Range
Aschauer 1989	Total factor productivity of core infrastructure[1]	National	0.24[*]
Duggal et al. 1998	Output elasticity of core public infrastructure	National	0.27
Bougheas et al. 2000	Relationship between infrastructure and degree of specialization	National for manufacturing industry	2.8613
Demetriades & Mamuneas 2000	**Output supply** elasticity of public infrastructure	National Short - Run	1.000
		National Long-Run	1.030
Demetriades & Mamuneas 2000	**Input demand** elasticity of public infrastructure	National Short - Run	Labor: 1.129 Capital: 0.026
		National Long-Run	Labor: 0.798 Capital: 0.309

* Statistically significant at the 5 percent level.
1. Core infrastructure consists of highways, mass transit, airports, electrical and gas facilities, water, and sewers.

Public infrastructure expenditures provide cost-saving benefits that exceed the associated investment costs due to substitutability between public infrastructure and private input. This is especially true in the manufacturing industry (Morrison and Schwartz 1996). Public spending on infrastructure also has a positive effect on the productivity of private capital investment (Munnell 1990).

The fluctuations in the output elasticities that have been reported by these studies have several explanations. First and foremost, the rate of return depends on the level of previous investment in public infrastructure. If an economy has already made large investments in highways or water and sewer then the return on further investment will be lower than in an economy that has not spent as much developing this infrastructure (Moomaw et al. 1995). There is also a balance that needs to be struck between public infrastructure and private capital. Aschauer (1989) attempts to quantify this relationship; he reports that a ratio of $0.44 of core public infrastructure to $1.00 of private capital is optimal for growth in an economy (the ratio is $0.31 to $1.00 for all other public infrastructure).

Effects of Investment in Water and Sewer Infrastructure

A subset of the literature estimating the value-added of public infrastructure investment focuses on water and sewer infrastructure. These papers are not focused on answering questions related to the role of water and sewer per se; rather they are focused on presenting a disaggregated view of public infrastructure as a whole with water and sewer as one component of that whole. The literature provides insight into both the effect of water and sewer investment on the economy and how investment in water and sewer compares to other types of public infrastructure. The investment elasticities of water and sewer infrastructure are presented in Table 3.

In an effort to overcome some of the methodological problems associated with early studies, Evans and Karras (1994) used panel data and a production function approach to estimate how government capital and services contribute to private productivity. (Panel data track cross-sectional data of multiple localities over time). The authors find that educational services have positive productivity but no evidence that other services or capital (including water and sewer) are productive—the coefficient for the water and sewer infrastructure stock was not statistically significant. Using a pooled cross-section approach, Moomaw et al. 1995 estimate the relationship between the value of assets of water and sewer infrastructure and GSP both on a national and a state-by-state basis. The results indicate that, in general, states get greater returns from investing in water and sewer systems than from investing in highways. Table 3 shows the results for the nation, the high and low range of states in each of the four regions considered.

Several studies have found that the nature of variables could lead to misestimating the strength of the relationship among them. Unless special statistical techniques are used, correlations we observe among variables may be meaningless. (See the discussion of spurious correlation under "Evolution of the Economic Literature"). These studies employ VAR models to estimate the relationship between public infrastructure investment and output and use techniques to address spurious correlation. Batina (1998) examined the cointegration properties of aggregate data on output, labor, private and public infrastructure and used dynamic statistical models to test for effects over time and directionality. The author found that public infrastructure has a strong and long lasting effect on output and private sector variables, and vice versa. However, when public infrastructure is disaggregated into real spending on highways and streets and water and sewer systems the magnitude of the public infrastructure coefficients is much smaller.

Table 3: Investment Elasticities of Water and Sewer Infrastructure

Source	**Measure**	**Region**	**Investment Elasticity/ Range**
Evans & Karras 1994	Net stock of water an sewer infrastructure on GSP	48 States	0.011[1]
Moomaw et al. 1995[2]	Net stock of water an sewer infrastructure on GSP	National	0.1686*
		Northeast North Central South West	0.0003 to 0.2467 0.0567 to 0.2452 0.0434 to 0.3312 0.0991 to 0.3045
Batina 1998	Real spending on water and sewer on an Industrial Production Index	National	0.0004
Pereira 2000	Investment in sewage and water supply system infrastructure on (1) Private GDP (2) Private Investment (3) Private Employment	National	(1) 0.00856[3] [-0.00579 to 0.01074] (2) -0.01159[3] [-0.01233 to -0.00473] (3) 0.01239[3] [-0.05814 to 0.01673]
Pereira 2001	Investment in sewage and water supply system infrastructure on private investment	National	0.0129

* Statistically significant at the 5 percent level.
1. Not statistically significant at the 5 percent level.
2. Only results for 1986 are reported.
3. Central case and range presented. Elasticities represent total percentage-point changes in private sector variable for each long-term accumulated percentage-point change in public investment once all dynamic feedback effects among the different variables have been considered.

Periera (2000) used VAR models to examine the relationship between aggregate and decomposed types of public investment and private GDP, investment and employment. In general, Periera found that faster growth in private GDP yields greater public investment (more tax revenue) and negative growth in employment yields greater public investment (perhaps because it is used as a countercyclical tool). However, the opposite is true for water and sewage investment. When the economy slows down, public investment goes to infrastructure like streets, mass transit, and electric—not water and sewer. When private investment grows, public investment in water and sewer grows as well. The paper also focuses on the effect on public investment on the private sector. It found public investment has a positive effect on private output. Of the five sub-components considered (highways and streets, energy infrastructure and mass transit, water and sewer, public buildings, and conservation structures), water and sewer had the third greatest impact with respect to private GDP. It had the fourth greatest impact with respect to private employment and private investment. In all three cases, energy infrastructure and mass transit had the greatest positive impact. However, when the measures of elasticity are converted to marginal productivity (i.e., the dollar value of the increase in output) per dollar invested water and sewer has the second highest[2] marginal productivity (Table 4).

[2] Energy and mass transit infrastructure has a substantially larger marginal productivity.

Table 4: Effect of Public Investment on Private Output and Private Investment

Source	Measure	Marginal Productivity	Rate of Return
Pereira 2000	Effect of public sewage and water supply systems investment on private **output (GDP)**	\$6.35[1]	9.7%[2]
Pereira 2001	Effect of public sewage and water supply systems investment on private **investment**	\$0.25[2]	

1. Read long-term accumulated marginal productivity as: One dollar spent on sewage and water supply systems increases private output in the long-term by \$6.35.
   Calculated as Elasticity (0.00856) multiplied by the Output to Public Investment ratio for years 1988-1997. Designed to reflect the relative scarcity of the different types of public investment.
2. Rate of return assumes a life horizon of twenty years.

Building on the 2000 study, Periera (2001) examined the effects of different types of public investment on aggregated and disaggregated private investment. At the aggregated level, public investment in water and sewer infrastructure has lower long term elasticities than all other types of infrastructure except for highways and streets. However, when the elasticity is converted to measure marginal productivity its impact on private investment is greater than both highways and streets, and public buildings (Table 4). Like private output, the impact of public investment in energy and mass transit infrastructure yields higher returns than all other types of infrastructure.

The methodological variation among the studies helps explain the variation in elasticities and marginal products. Appendixes 1 and 2 summarize the variables and techniques used by the reviewed papers. Although this variation makes it impossible to summarize the elasticities using an average (i.e., to say the average effect is X), the finding of a small positive relationship between water and sewer infrastructure investment and economic activity should be considered robust explicitly because of the variability in methodologies used to produce this consistent result.

C. Returns to Annual Operations and Maintenance Spending

Infrastructure is not the only type of investment that municipalities can make in water and sewer. New infrastructure investment and reinvestment in existing infrastructure through replacement and rehabilitation are not constant expenditures for water and sewer systems. Rather they are likely to occur once a year, or every few years. On the other hand, the operation and maintenance of existing infrastructure is a continuous investment for water and sewer systems. As a municipal expenditure, the returns on annual operations and maintenance spending are also important to consider.

The US Department of Commerce Bureau of Economic Analysis (BEA) calculates input-output (I-O multipliers) for 473 industries, including the water and sewer industry.[3] The goal of I-O multipliers is to account for inter-industry relationships. BEA calculates the multiplier based on

[3] Defined as water, sewage and other systems by NAICS code 2213.

I-O benchmark data. These benchmark data estimate the goods and services purchased by an industry (water and sewer), and whether industry output (goods and services) are purchased by other industries (DOC 1997). The primary output of the water and sewer industry is clean water. Producing this output requires infrastructure (new and rehabbed), water treatment supplies, and labor (operating and maintaining infrastructure). Because output is used as an input for households (wages and water) and industry (water), increases in water and sewer output has a direct impact on other sectors of the economy. BEA estimates that across the United States as a whole, for each additional dollar's worth of output of the water and sewer industry in a year, the dollar value of the increase in output that occurs in all industries is $2.62 in the same year (final-demand output multiplier, Table 7).

Table 7: Input-Output Model Results

	Final-demand Output (dollars)[1]	**Direct-effect Employment (number of jobs)**[2]
United States	2.62	3.68
Low State	1.22	1.97
High State	2.19	3.06

Bureau of Economic Analysis, 2008

1. ***Final demand output is the increase in the economic value of the output of all industries due to a one dollar increase in the economic value of the output of the water and sewer industry.***
2. ***Direct effect employment is the increase in number of jobs in all industries due to the addition of one job in the water and sewer industry.***

The BEA I-O multipliers also breakdown effects in and among regions. A state-by-state comparison shows variation across states (Appendix 3). The lowest state multiplier is Washington DC, where output increase in all industries is $1.22 for each additional dollar of water and sewer output in a year. The highest state multiplier is Texas, with a multiplier of $2.19. The national multiplier is greater than the highest state multiplier because it captures spillovers among states and regions and therefore does not represent the average state but the whole nation.

Employment multipliers indicate another aspect of the direct impact of water and sewer investment. BEA estimates that for each additional job created in the water and sewer industry, 3.68 jobs are created in all industries (direct-effect employment multiplier, Table 7). Wyoming has the lowest multiplier of 1.97 jobs, while Pennsylvania has the highest, with 3.06 jobs created in all industries from one additional job in water and sewer.

D. Additional Indirect Impacts

Beyond the direct economic impacts already discussed, several indirect impacts should also be considered. With respect to drinking water, we consider additional indirect impacts as those beyond the delivery of potable water to the public (necessary for life) and business (necessary as a factor of production). Indirect economic impacts come in terms of fire suppression, public health gains, and the provisioning of ecosystem services. Most indirect impacts from sewer investment come from the improved provisioning of ecosystem services.

Fire suppression is a secondary benefit from drinking water distribution pipelines. From a water delivery perspective, hydrants are used to maintain water quality when regularly "flushing" pipelines to remove stagnant water. These hydrants can also be used as a local source of water by firefighters (instead of bringing water to the fire) with economic impacts stemming from minimized losses to property and wages from businesses that would otherwise be burned.

Although a system's water may be potable, investments focused on improving the quality of the drinking water itself are commonplace and are focused on protecting/improving public health. An indirect economic impact from improved public health is a reduction in lost wages (from workers taking unpaid sick days), and improved workplace productivity (because workers are not sick at work). To the extent better public health results in less treatment in hospitals and clinics**,** spending on health care sector will be reduced..

Table 8: Average Value of Ecosystem Services From Land Types (Costanza et al. 1997)

	Ecosystem Services (1994 US$ per hectare per year)							
	Gas & Climate Reg-ulation	**Distur-bance Reg-ulation**	**Water Reg-ulation** (flow)	**Water Supply** (storage)	**Water Purific-ation**	**Habitat**	**Rec-reation**	**Cultural**
Temperate/ boreal forests	$ 88		$ 0		$ 87		$ 36	$ 2
Grass/ rangelands	$ 7		$ 3		$ 87		$ 2	
Wetlands	$ 133	$ 4,539	$ 15	$ 3,800	$ 4,177	$ 304	$ 574	$ 881
Lakes/ rivers			$ 5,455	$ 2,177	$ 665		$ 230	

Note: Open cells indicate a lack of available information.

An additional positive indirect economic impact comes from protecting the quantity and quality of source water. Often, systems purchase land to create protection zones with the goal of keeping pollution sources away from the source of drinking water, or to capitalize on the water purification properties of the ecosystem itself. Regardless of the objective, land purchases have indirect benefits in terms of ecosystem services. Ecosystem services are defined as the benefits humans derive from ecosystem functions (including habitat, and biological properties or processes) of which water purification is just one. The economic value of these services can be estimated using a variety of techniques (NRC 2005). Costanza et al. (1997) calculated the average annual per hectare value of 17 ecosystem services for marine and terrestrial biomes.[4] Although source water protection land purchases could include any number of terrestrial biomes, biomes like temperate forests, grass/rangelands, and wetlands provide important services. In these biomes, important contributors to the total value of ecosystem services (in addition to water purification) can include climate regulation (CO_2 sequestration), flood/drought control, habitat, food production, and recreational and cultural services. For example, protecting one hectare of a wetland for source water protection can yield a primary benefit of $4,177 annually in avoided treatment costs. (The wetland effectively treats the water and thus reduces the need for

[4] Based on a survey of published studies and original calculations.

traditional treatment facilities. One hectare is 10,000 square meters or 2.471 acres.) However, the same hectare may yield an additional $10,246 annually in other services. (This is the sum of the wetlands row in Table 8, excluding waste treatment.) A sample of the average annual per hectare value of the services provided by these land types is listed in Table 8.

With respect to sewer investment, most indirect economic benefits come as a result of improved water quality. Improved water quality decreases negative pressures on ecosystems and can result in the provisioning of more ecosystem services (including those listed above), and in the case of freshwater, an economic benefit to drinking water systems through decreased treatment costs.

E. Additional Factors to Consider

The preceding sections have described literature examining the relationship between water and sewer investment and its value added in the economy. As a result of challenges to early results, methodologies have evolved and current studies yield more consistent results. However, several factors still need to be considered when interpreting the literature and its application to current policy decisions.

The economic impact of infrastructure is likely to depend on how additional investment is financed. Increases in taxes are widely considered to reduce the rate of economic growth. Therefore, an increase in public infrastructure stimulates economic growth only if the impact of public infrastructure outweighs the adverse impact of higher taxes needed to finance the investment, and outweighs the adverse impact of spending cuts in other area such as operations and maintenance (Romp and de Haan 2005).

Economic benefits also depend on the geographic source of the money and the geographic area of benefit under consideration. Young (2005) argues when the benefits of project investments are localized but costs are paid by the national government, total economic benefits across the national economy are zero. In a properly functioning competitive economy (fully employed resources) a new investment yields no net benefits beyond its own net income. Expansion in secondary sectors in one region is offset by a fall in activity and profits elsewhere over the long-run. Therefore, from a national perspective the multiplier effects of local water projects financed by federal dollars would be offset by the multiplier effects of foregone alternative public investment (Young 2005).

Despite the challenges associated with identifying the appropriate level of new infrastructure investment from an economic perspective, it may be desirable to fall back on estimates of need from an engineering perspective. As cited previously, the EPA Drinking Water Needs Survey and Assessment (2005) estimates that the nation’s water systems will need to invest $276.8 billion through 2023 to provide the same level of service to current customers—excluding costs solely for operation and maintenance, dams, reservoirs, future growth, and fire flow. However, Gramlich (1994) challenges the basic premise of these types of engineering needs assessments, arguing that studies of this type are based on an arbitrary initial period where infrastructure was presumed to be adequate. Without economic reasoning, there are no adjustments for excessive or underutilized initial infrastructure, and no recognition that citizens may want to trade off the benefits of greater infrastructure against the costs. These criticisms are not necessarily applicable to this survey, because it is not purely an engineering study; it is also a political statement and reflects tradeoffs and decisions made by federal, state, and local government. But studies that do not account for the economic value of the assets and tradeoffs stakeholders need to make may misstate the economic return to these assets.

F. Conclusions

The economic literature supports several conclusions about the returns to public spending on infrastructure. First, although not all studies find a growth-enhancing effect, there is a general consensus in the literature that spending often displays positive economic returns. Second, according to most studies the impact is much lower than the findings of earlier studies (e.g., Aschauer 1989). Third, both the average return and the range of return vary based on the type of infrastructure and the amount of infrastructure already in place. In other words, the larger the stock and the better its quality, the lower the impact of new infrastructure will be (CBO 2007; Romp and de Haan 2005).

Policymakers have a perverse incentive to invest in new public infrastructure projects that are politically more attractive than continuing or improving maintenance activities (Romp and de Haan 2005). However, the economic impacts of annual operations and maintenance spending should not be forgotten. Additionally, indirect impacts from some types of investment, especially benefits from ecosystems services, should be considered. Ultimately, understanding the full spectrum of investment options and the direct and indirect impacts of each type of investment can help inform municipal decision makers and help ensure that economic, environmental, and social goals are achieved.

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Appendix 1: Methodological Summary of Public Infrastructure Studies

Source	Dependent Variable (Units)	Independent Variables (Units)	Technique
Aschauer 1989	Private business economic output	• Private labor • Private capital • Nonmilitary public capital • Private business economy total factor productivity • Capacity utilization rate in manufacturing	Cobb-Douglas (log levels)
Munnell 1990	Gross state product	• The level of technology • Private capital stock • Employment on nonagricultural payrolls • Stock of state and local public capital • State unemployment rate	Cobb-Douglas (log levels)
Moomaw et al. 1995	Gross state product	• Labor (nonagricultural employment) • Private capital stocks • Public capital stocks	Cobb-Douglas (log levels)
Tatom 1991	Business sector production	• Public sector capital • Business sector hours • Relative price of energy	Cobb-Douglas with first difference regression (log levels)
Bougheas et al. 2000	Gross domestic product	• Number of manufacturing establishments • Core infrastructure • Twenty intercept dummies	Modification of the Romer specialization model (log levels)
Duggal et al. 1998	Gross Domestic Product (reduced by the portion originating from housing, adjusted upward by the portion of deflated government interest payments that can be attributed to the debt incurred due to government expenditures on new infrastructure)	• Core public infrastructure • Labor (total employee hours worked in nonagricultural establishments) • Capital stock (excluding military and infrastructure capital) • Interest rate • Real user cost of capital for equipment and structures • Comparative price variable (ratio of the GDP deflator and the nominal wage rate multiplied by the ratio of the GDP deflator to the nominal user cost of equipment) • Index of producer prices for 28 sensitive materials	Non-linear model (log levels)
Demetriades & Mamuneas 2000	Manufacturing Gross Domestic Product	• Technology • Fixed factors (capital) • Variable inputs	Non-linear SUR[1] with a system of simultaneous equations

Notes:
1. Seemingly Unrelated Regression (SUR)

Appendix 2: Methodological Summary of Water and Sewer Studies

Source	Dependent Variable (Units)	Independent Variables (Units)	Technique
Evans & Karras 1994	GSP[1]	• Number of workers in private industry • Net stock of private capital • State unemployment rate • Net stock of highway capital * • *Net stock of water and sewer capital* * • Net stock of other infrastructure capital * • Current educational services • Current highway services • Current health and hospital services • Current police and fire services • Current sewer and sanitation services	Cobb-Douglas, Translog; Panel Data (log dollars, fixed effects)
Moomaw et al. 1995	GSP	• Private capital • Aggregate public capital • Labor[1] • Net stock of highway capital * • *Net stock of water and sewer capital* * • Net stock of other infrastructure capital *	Production Function, Pooled Cross Section=*Panel Data* (log dollars, difference from mean=*fixed effects*)
Batina 1998	Industrial Production Index[2]	• Aggregate employment • Private Capital • Real spending on highways and streets • *Real spending on water and sewer*	VAR model; Error correction model (log dollars, difference from mean per std. dev.)
Pereira 2000[3]	Private GDP; private investment; private employment	• Aggregate public investment • Highways and street infrastructure • Electric and gas, transit system, airfield infrastructure • *Sewage and water system infrastructure* • Public buildings • Conservation and development structures, civilian equipment	VAR model (first-difference, log dollars; full time equivalents)
Pereira 2001	Private investment	• Aggregate public investment • Highways and street infrastructure • Electric and gas, transit system, airfield infrastructure • *Sewage and water system infrastructure* • Public buildings Conservation and development structures, civilian equipment	VAR model (first-difference, log dollars)

Note: Data transformations and units in parenthesis.
* Federal Reserve Bank of Boston data used by Munnell (1990)
1. Excluding agricultural industries.
2. Substantiate, Index is unit-less
3. First difference of log-levels estimates the growth rates of the original variables.

Appendix 3: Additional Data

Output Elasticities of Water and Sewer Capital

State	1970	1980	1986	Average
Northeast				
Maine	0.0193	0.0317	0.0510	0.0340
New Hampshire	-0.0182	0.0878	0.0309	0.0335
Vermont	-0.0431	0.0828	0.0003	0.0133
Massachusetts	0.1009	0.1156	0.1636	0.1267
Rhode Island	-0.0537	0.2165	0.0125	0.0584
Connecticut	0.0739	0.0950	0.1255	0.0981
New York	0.2036	0.1357	0.2467	0.1953
New Jersey	0.1456	0.0046	0.1964	0.1155
Pennsylvania	0.1969	0.1298	0.2323	0.1863
North Central				
Ohio	0.2029	0.1384	0.2291	0.1901
Indiana	0.1766	0.1957	0.2069	0.1931
Illinois	0.2084	0.2318	0.2452	0.2285
Michigan	0.1865	0.1312	0.2261	0.1813
Wisconsin	0.1235	0.1495	0.1815	0.1515
Minnesota	0.1448	0.2109	0.1667	0.1741
Iowa	0.1348	0.1635	0.1531	0.1505
Missouri	0.1357	0.1282	0.1769	0.1469
North Dakota	0.0862	0.1660	0.1399	0.1307
South Dakota	0.0530	0.1373	0.0567	0.0823
Nebraska	0.0925	0.1202	0.1358	0.1162
Kansas	0.1456	0.1720	0.1799	0.1658
South				
Delaware	-0.0099	0.0250	0.0434	0.0195
Maryland	0.0921	0.0317	0.1393	0.0877
Virginia	0.1111	0.1492	0.1735	0.1446
West Virginia	0.1235	0.1529	0.1620	0.1461
North Carolina	0.1334	0.2272	0.1912	0.1839
South Carolina	0.1010	-0.0319	0.1576	0.0756
Georgia	0.1332	0.1717	0.1924	0.1658
Florida	0.1563	0.2054	0.2259	0.1959
Kentucky	0.1205	0.1586	0.1689	0.1493
Tennessee	0.1304	0.0667	0.1761	0.1244
Alabama	0.1359	0.1743	0.1844	0.1649
Mississippi	0.1064	0.1615	0.1366	0.1348
Arkansas	0.0942	0.1307	0.1348	0.1199
Louisiana	0.2628	0.2623	0.2808	0.2686
Oklahoma	0.1611	0.2179	0.2020	0.1937
Texas	0.2979	0.2640	0.3312	0.2977
West				
Montana	0.1016	0.1650	0.1219	0.1295
Idaho	0.0448	0.0689	0.0682	0.0606
Wyoming	0.1348	0.1771	0.1815	0.1645
Colorado	0.0993	0.1492	0.1505	0.1330
New Mexico	0.1181	0.1694	0.1432	0.1436
Arizona	0.1155	0.1317	0.1457	0.1310
Utah	0.0402	0.3261	0.0991	0.1551
Nevada	0.0668	0.1293	0.1184	0.1048
Washington	0.1371	0.1713	0.1821	0.1635
Oregon	0.0933	0.1987	0.1359	0.1426
California	0.2349	0.2763	0.3045	0.2719

Moomaw, 1995

I-O Multipliers for NAICS#2213: Water, Sewage and Other Systems

State	Final-demand Output (dollars)	Direct-effect Employment (number of jobs)
Alabama	1.9208	2.2696
Alaska	1.6906	2.5252
Arizona	1.8694	2.6873
Arkansas	1.8188	2.1756
California	2.0954	3.0412
Colorado	2.0707	2.9177
Connecticut	1.7766	2.4339
Delaware	1.6951	2.4626
District of Columbia	1.2217	2.1049
Florida	1.8916	2.6769
Georgia	2.0499	2.8369
Hawaii	1.7905	2.3658
Idaho	1.7824	2.5363
Illinois	2.1203	2.9168
Indiana	1.9382	2.8644
Iowa	1.8188	2.4243
Kansas	1.8856	2.1848
Kentucky	1.8873	2.2695
Louisiana	1.9262	2.3918
Maine	1.7704	2.9238
Maryland	1.871	2.6308
Massachusetts	1.8345	2.6434
Michigan	1.8681	2.8475
Minnesota	1.9567	3.0231
Mississippi	1.8073	2.1563
Missouri	1.9458	2.7198
Montana	1.799	2.2744
Nebraska	1.7917	2.8904
Nevada	1.7068	1.9783
New Hampshire	1.799	2.5424
New Jersey	1.9422	2.7631
New Mexico	1.742	2.1527
New York	1.7388	2.3404
North Carolina	1.9456	2.391
North Dakota	1.7818	2.3501
Ohio	1.9808	2.7746
Oklahoma	1.9697	2.6782
Oregon	1.8572	2.3589
Pennsylvania	2.0715	3.0623
Rhode Island	1.6896	2.7112
South Carolina	1.8924	2.6654
South Dakota	1.7227	2.2269
Tennessee	1.9696	2.4195
Texas	2.1932	3.0116
Utah	2.0065	2.4586
Vermont	1.6734	2.1866
Virginia	1.8967	2.4436
Washington	1.9318	3.0085
West Virginia	1.6907	2.4267
Wisconsin	1.8986	3.0604
Wyoming	1.638	1.9736
United States	**2.6179**	**3.6772**

Bureau of Economic Analysis, 2008

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Footnote 10 Document

US EPA 2011 Drinking Water Infrastructure Needs Survey and Assessment Fifth Report to Congress

United States
Environmental Protection
Agency

Drinking Water Infrastructure Needs Survey and Assessment

Fifth Report to Congress

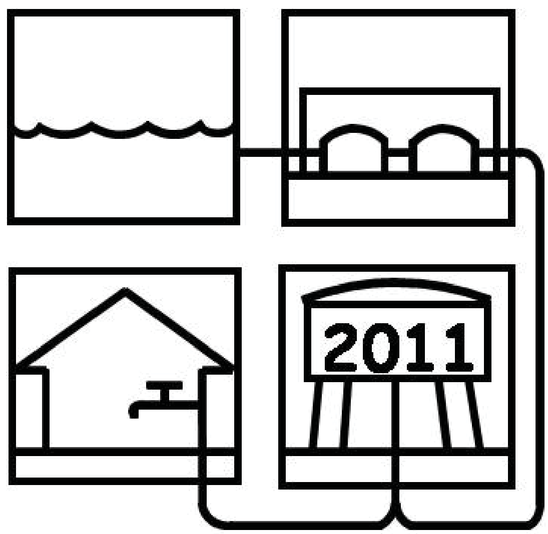



Cover photos (left to right): Water Supply Revolving Loan Account funded water treatment plant and storage in Deshler, OH, Ohio EPA; Child Drinking Water, Julie Blue; Bolted steel drinking water storage tank in the Alaska Native Village of Atka, Dennis Wagner, EPA Region 10; Laying water line in rural Arizona for Congress Domestic Water Improvement District, Water Infrastructure Finance Authority of Arizona

Office of Water (4606M)
EPA 816-R-13-006
April 2013

Drinking Water Infrastructure Needs Survey and Assessment

Fifth Report to Congress



U.S. Environmental Protection Agency
Office of Water
Office of Ground Water and Drinking Water
Drinking Water Protection Division
Washington, D.C. 20460

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Ohio EPA

Water Supply Revolving Loan Account funded project in Woodville, OH.

Executive Summary

Total National Need

The U.S. Environmental Protection Agency's (EPA's) fifth national assessment of public water system infrastructure needs shows a total twenty-year capital improvement need of $384.2 billion. This estimate represents infrastructure projects necessary from January 1, 2011, through December 31, 2030, for water systems to continue to provide safe drinking water to the public. The national total comprises the infrastructure investment needs of the nation's approximately 52,000 community water systems and 21,400 not-for-profit noncommunity water systems, including the needs of American Indian and Alaska Native Village water systems, and the costs associated with proposed and recently promulgated regulations. The findings are based on the 2011 Drinking Water Infrastructure Needs Survey and Assessment (DWINSA or Assessment) which relied primarily on a statistical survey of public water systems (approximately 3,165 responses).

$384.2 Billion is Needed

The nation's drinking water utilities need $384.2 billion in infrastructure investments over the next 20 years for thousands of miles of pipe as well as thousands of treatment plants, storage tanks, and other key assets to ensure the public health, security, and economic well-being of our cities, towns, and communities.

Authority, Purpose, and History

The 1996 Safe Drinking Water Act Amendments mandated that EPA conduct an assessment of the nation's public water systems' infrastructure needs every four years and use the findings to allocate Drinking Water State Revolving Fund (DWSRF) capitalization grants to states. The DWSRF was established to help public water systems obtain financing for improvements necessary to protect public health and comply with drinking water regulations. From 1997 to 2011, states loaned $21.7 billion to water systems for 9,188 projects.

The estimate covers infrastructure needs that are eligible for, but not necessarily financed by, Drinking Water State Revolving Fund (DWSRF) monies (note - DWSRF is designed to supplement, not replace, investment funding by states and localities as well as rate payers). Projects eligible for DWSRF funding include the installation of new infrastructure and the rehabilitation, expansion, or replacement of existing infrastructure. Projects may be needed because existing infrastructure is deteriorated or undersized, or to ensure compliance with regulations. Cost estimates assume comprehensive construction costs including engineering and design, purchase of raw materials and equipment, construction and installation labor, and final inspection.

EPA recognizes that there are legitimate and significant water system needs that are not eligible for DWSRF funding, such as raw water dams and reservoirs, projects related primarily to population growth, and water system operation and maintenance costs. However, because the Assessment is directly associated with the allocation of DWSRF capitalization grants to states and tribal set-aside funds to EPA Regions, needs ineligible for DWSRF funding are not included in the estimate.

National Need Compared to Previous Needs Assessments

Exhibit ES.1: DWINSA Comparison of 20-Year National Need (in billions of January 2011 dollars)

Year	1995	1999	2003	2007	2011
National Need	$227.3	$224.8	$375.9	$379.7	$384.2

EPA conducted four previous Assessments, in 1995, 1999, 2003, and 2007. Exhibit ES.1, which adjusts the findings to 2011 dollars, shows the 2011 Assessment's total national need to be comparable to the findings of previous surveys since 2003, indicating that we have continued our success in better capturing longer term needs that were underreported in the two earliest surveys. Outside of some clarifications of the factors considered in a weight of evidence determination for project acceptance (see Appendix C), the 2011 Assessment shared the same statistical and policy approach as the 2007 Assessment with similar total national need findings. Although there was no significant change in total need, the 2011 survey of American Indian and Alaska Native Village water systems is the first one conducted since 1999 (the 2003 and 2007 Assessments adjusted the 1999 findings to account for inflation in construction costs) and employed survey methods and policies substantially different than those used in 1999, reflecting the evolution in EPA's assessment methods.

Individual State Need

The 2011 Assessment shows significant changes in some states' needs from previous Assessments. These changes will result in modifications to individual states' DWSRF allotments. Most shifts in states' needs can be attributed to expected changes in the status of projects from one survey to the next.

Regulatory Need

The findings of the 2011 Assessment indicate that the need associated directly with Safe Drinking Water Act (SDWA) regulations remains a small percentage, 10.9 percent, of the total national need. Most water system needs are not directly related to violations of, or compliance with, SDWA regulations. Most needs are ongoing investments that systems must make to continue delivering safe drinking water to their customers.

Small System Need

The 2011 Assessment indicates a total national need of $64.5 billion for small systems in the states, Puerto Rico, and the U.S. Territories. Small systems are defined as serving 3,300 persons or fewer. For the 2011 Assessment, EPA estimated the infrastructure investment needs for these systems by adjusting the findings from the small system field survey which was done for the 2007 Assessment. In making the adjustment, EPA applied 2011 cost models using the current inventory of small systems.

Needs of American Indian and Alaska Native Village Water Systems

The needs of water systems serving American Indians and Alaska Native Villages total $3.3 billion. The findings presented in this report are based on a survey of these systems conducted for the first time since the 1999 Assessment. This need represents a small percentage of the nation's total drinking water infrastructure need. This need is, however, associated with higher average per household costs due to unique challenges that many of these water systems face. These public water systems are almost all small and often located in remote rural areas, some in areas with permafrost, and the communities served may have households that lack access to the public water supply. These conditions present special challenges for providing drinking water service.

Water Industry Capital Investment Planning and Documentation of Needs

Systems submitted a variety of planning documents and excerpts of documents in support of projects reported for the 2011 Assessment. These documents made clear that as our nation's infrastructure continues to age and deteriorate many water systems are using asset management strategies to better understand and address their infrastructure rehabilitation and replacement challenges. However, for many other systems, the information and documentation provided indicates that a significant gap still exists between information about their inventory of infrastructure and their knowledge of that infrastructure's condition or remaining useful life.

Water Infrastructure Finance Authority of Arizona

Constructing a solar array to power the city of Somerton's drinking water treatment facility in southwestern Arizona.

Chapter 1: Findings - National Need

2011 Total National Need

The 20-year national infrastructure need estimated by the 2011 Assessment is $384.2 billion. The breakout of the national need by system size and type is presented in Exhibit 1.1.

The assessment addressed community water systems[1] (CWSs) and not-for-profit noncommunity water systems[2] (NPNCWSs). The results for CWSs were derived from the responses to a probability sample of approximately 3,165 water systems including 220 American Indian and 86 Alaska Native Village water systems. The results for the NPNCWSs in states, Puerto Rico, and U.S. Territories were extrapolated from a similar assessment conducted in 1999. The total national need also includes the costs associated with meeting recently proposed or promulgated regulations that are too new to be a consideration in water systems' investment plans; those costs are derived from EPA's economic analyses (EAs) supporting each regulation.

Exhibit 1.1: Total National 20-Year Need (in billions of January 2011 dollars)

System Size and Type	Need
Large Community Water Systems* (serving over 100,000 persons)	$145.1
Medium Community Water Systems* (serving 3,301-100,000 persons)	$161.8
Small Community Water Systems (serving 3,300 and fewer persons)†	$64.5
Not-for-Profit Noncommunity Water Systems‡	$4.6
Total State Need	**$376.0**
Alaska Native Village Water Systems	$0.6
American Indian Water Systems	$2.7
Costs Associated with Proposed and Recently Promulgated Regulations	$4.9
Total National Need	**$384.2**

Note: Numbers may not total due to rounding.

* "Large" and "Medium" community water systems are defined the same as for the 2007 Assessment but are different than in the 2003 and previous Assessments. See Appendix A for more information.

† Based on 2007 Assessment findings adjusted to 2011 inventory and cost models.

‡ Based on 1999 Assessment findings adjusted to 2011 dollars.

Super Pulsator Water Treatment Plant at the Davis Municipal Authority in Oklahoma. Oklahoma Department of Environmental Quality

[1]A community water system is a public water system that serves at least 15 connections used by year-round residents or that regularly serves at least 25 residents year-round. Cities, towns, and small communities such as retirement homes are examples of community water systems.

[2]A noncommunity water system is a public water system that is not a community water system and that serves a nonresidential population of at least 25 individuals daily for at least 60 days of the year. Schools and churches are examples of noncommunity water systems.

John Taylor, Farr West Engineering

Construction of new municipal well in Hawthorne, NV.

The need reported in the Assessment includes projects for expanding, replacing, or rehabilitating existing infrastructure. It also includes projects to construct new infrastructure in order to preserve the physical integrity of water systems and to convey drinking water to existing residential, commercial, and industrial customers. Projects vary greatly in scale, complexity, and cost—from rehabilitating a small storage tank, to replacing an entire treatment plant, to constructing a high-capacity pipeline.

The results presented in this report will determine the allocation of DWSRF capitalization grants and also factor into the allocation of the tribal set-aside funding to EPA Regions for federal fiscal years 2014 through 2017. Therefore, the need does not include projects that are ineligible for DWSRF funding. The approach and methodologies for discerning needs are further detailed in Appendix A. A summary of the types of projects included in the Assessment, as well as specific types of unallowable projects, is presented in Appendix B. EPA recognizes that projects not eligible for DWSRF funding can be significant, if not critical, water system needs, but they are outside the scope of this Assessment. In addition, the Assessment does not seek to capture information on the financing alternatives being pursued or considered by systems for individual projects. The DWSRF is in fact intended as a supplement to, not a replacement for, funding by states, localities, and rate payers.

The $384.2 billion represents the need associated with thousands of miles of pipe, thousands of treatment plant and source projects, and billions of gallons of storage. Investments in water systems not only provide assurances of continued delivery of safe drinking water to our homes, schools, and places of business, they are key to local economies across our nation.

As stated in the 2008 report by the U.S. Conference of Mayors:

> "The estimates exhibit a wide range, but the consensus is that public infrastructure investment yields positive returns, and investment in water and sewer infrastructure has greater returns than most other types of public infrastructure.
>
> - A recent study estimates that one dollar of water and sewer infrastructure investment increases private output (Gross Domestic Product, GDP) in the long-term by $6.35.
> - With respect to annual general revenue and spending on operating and maintaining water and sewer systems, the US Department of Commerce's Bureau of Economic Analysis estimates that for each additional dollar of revenue (or the economic value of the output) of the water and sewer industry, the increase in revenue (economic output) that occurs in all industries is $2.62 in that year.
> - The same analysis estimates that adding one job in water and sewer creates 3.68 jobs in the national economy to support that job."

The U.S. Conference of Mayors. *Local Government Investment in Municipal Water and Sewer Infrastructure: Adding Value to the National Economy*. Richard A. Krop, Ph.D., Charles Hernick, and Christopher Frantz. The Cadmus Group, Inc. August 14, 2008.

Additional Source:
Pereira, A.M. "Is all public capital need created equal?" *Review of Economics and Statistics*, 82:3 (2000): 513–518.

2011 Total National Need Compared to EPA's Previous Assessments

The 2011 total national need of $384.2 billion is comparable to the 2007 estimate of $379.7 billion and the 2003 estimate of $375.9 billion (all adjusted to 2011 dollars), continuing those earlier Assessments' success in better capturing previously underreported longer term needs for infrastructure rehabilitation and replacement. All three Assessments clearly point to the nation's water systems having entered a "rehabilitation and replacement era" in which much of water utilities' existing infrastructure has reached or is approaching the end of its useful life.

Exhibit 1.2 compares the need from this Assessment to past Assessments. Cost indices were used to adjust previous needs to the 2011 Assessment's year. Although there are numerous cost indices available, EPA used the Construction Cost Index (CCI) compiled by McGraw Hill Construction because it includes adjustments for labor rates as well as the cost of materials. It is worth noting that the CCI shows cost increases of approximately 3 percent per year from 1995 through 2003, approximately 5 percent per year from 2003 through 2007, and approximately 3.4 percent per year from 2007 to 2011.

Exhibit 1.2: Total National 20-Year Need Comparison to Previous DWINSA Findings (in billions of dollars)

	1995	1999	2003	2007	2011
Total National Need (as listed in Assessment Year's Report to Congress)	$138.4	$150.9	$276.8	$334.8	$384.2
Cost adjustment factor to January 2011 dollars (based on Construction Cost Index)	64.2%	49.0%	35.8%	13.4%	—
Total National Need (adjusted to January 2011 dollars)	**$227.3**	**$224.8**	**$375.9**	**$379.7**	**$384.2**

The 2011 Assessment shares a similar approach and total national finding with the 2003 and 2007 Assessments. The 2011 effort clarified for survey participants the elements to be considered in a weight of evidence determination of project acceptance (see Appendix C) with the intent of facilitating project submittal and review rather than actually changing what projects were submitted and accepted into the Survey.

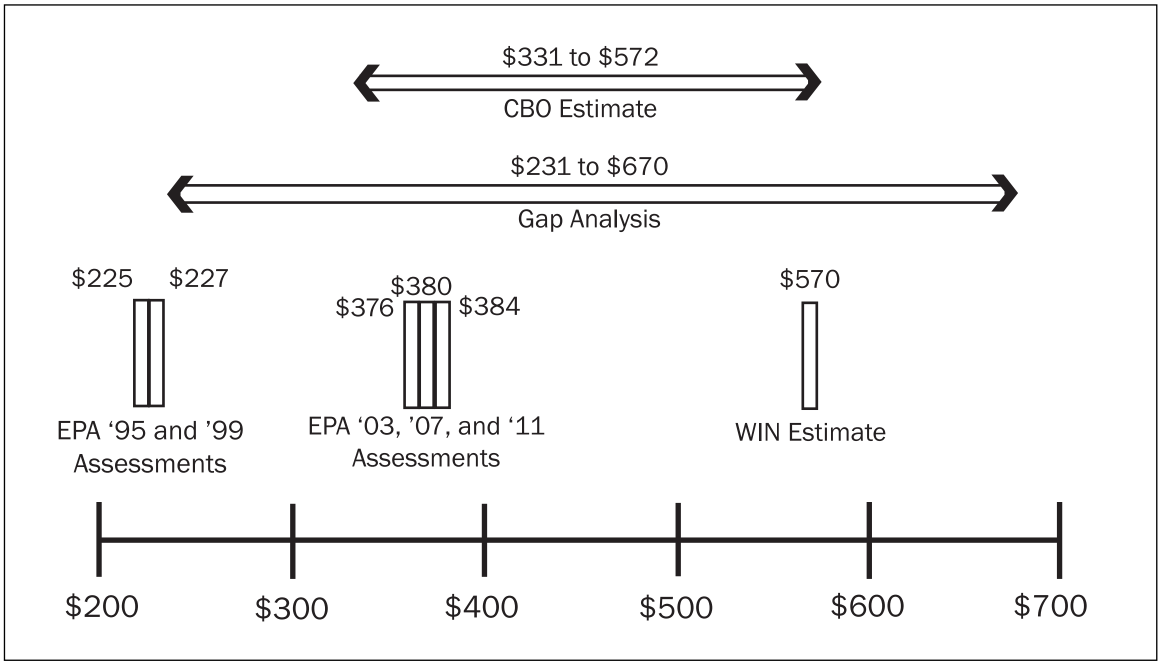
Exhibit 1.3 compares the EPA Assessments to other important assessment efforts. All estimates are presented in 2011 dollars. EPA's DWINSA continues to estimate a need within the range identified in these reports:

- The Congressional Budget Office (CBO) report "Future Investment in Drinking Water and Wastewater Infrastructure," which estimates annual water system needs of $16.6 billion to $28.6 billion. This extrapolates to a 20-year need in the range of $331.2 to $571.7 billion.[3]

[3]Congressional Budget Office, "Future Investment in Drinking Water and Wastewater Infrastructure," (November 2002), p. ix. Needs were reported in 2001 dollars and have been adjusted to January 2011 dollars for comparison purposes.

- EPA's "Clean Water and Drinking Water Infrastructure Gap Analysis," which estimated drinking water systems' 20-year capital needs in the range of $231 billion to $670 billion with a point estimate of $412 billion.[4]
- The Water Infrastructure Network's (WIN's) "Clean and Safe Water for the 21st Century - A Renewed National Commitment to Water and Wastewater Infrastructure," which estimates water system needs of $28.5 billion annually. This extrapolates to $570.4 billion over 20 years.[5]
- The American Water Works Association (AWWA) report "Buried No Longer: Confronting America's Water Infrastructure Challenge" recently estimated at least $1 trillion will be required over a 25 year period through 2035 in order to restore existing water system pipe that has reached the end of its useful life and to expand pipe networks to meet growing populations. This estimate is significantly higher than the transmission and distribution total for EPA's 2011 DWINSA, as it is based on a different set of assumptions about pipe replacement and investment and covers a longer period of time.[6]

Exhibit 1.3: Total 20-Year Need Comparison to Other Assessments (in billions of January 2011 dollars)

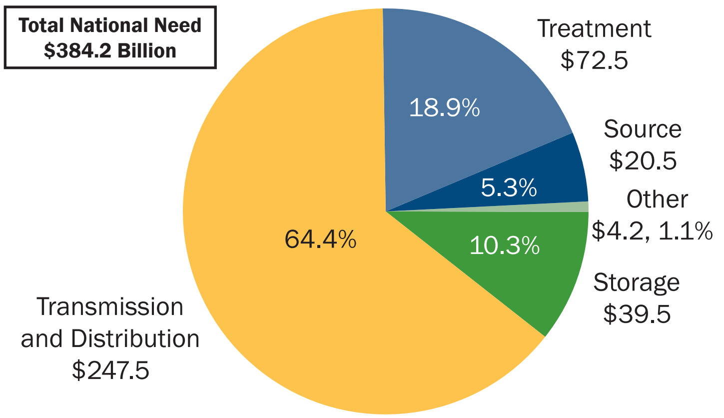


[4] U.S. Environmental Protection Agency, "Clean Water and Drinking Water Infrastructure Gap Analysis," (September 2002), p. 5. Needs were assumed to be in 1999 dollars based on the date of the report and planning period used. Needs have been adjusted to January 2011 dollars for comparison purposes.
[5] Water Infrastructure Network, "Clean and Safe Water for the 21st Century - A Renewed National Commitment to Water and Wastewater Infrastructure," (undated), p. 3-1. Needs were assumed to be in 1999 dollars based on the planning period and data used. Needs have been adjusted to January 2011 dollars for comparison purposes.
[6] American Water Works Association "Buried No Longer: Confronting America's Water Infrastructure Challenge," (February 2012), p. 9. Needs were reported in 2010 dollars and have been adjusted to January 2011 dollars for comparison.

Total National Need by Project Type

Infrastructure needs of water systems can be grouped into four major categories based on project type. These project types are source, transmission and distribution, treatment, and storage. Each category fulfills an important function in delivering safe drinking water to the public. Most needs were assigned to one of these categories. An additional "other" category is composed of projects that do not fit into one of the four categories. Exhibit 1.4 shows the total national need by project type. Exhibit 1.5 shows the total national need by water system size and type, as well as by project type.

Exhibit 1.4: Total 20-Year Need by Project Type (in billions of January 2011 dollars)



Note: Numbers may not total due to rounding.

Exhibit 1.5: Total 20-Year Need by System Size and Type and Project Type (in billions of January 2011 dollars)

System Size and Type	Distribution and Transmission	Treatment	Storage	Source	Other	Total Need
Large Community Water Systems (serving over 100,000 persons)**	$98.0	$27.5	$11.2	$6.7	$1.7	$145.1
Medium Community Water Systems (serving 3,301 to 100,000 persons)**	$108.1	$28.6	$16.2	$7.1	$1.9	$161.8
Small Community Water Systems (serving 3,300 and fewer persons)†	$38.7	$10.0	$9.5	$5.6	$0.7	$64.5
Not-for-Profit Noncommunity Water Systems‡	$0.6	$0.9	$2.2	$0.9	$0.0*	$4.6
Total States and U.S. Territories Need	**$245.4**	**$67.1**	**$39.1**	**$20.3**	**$4.2**	**$376.0**
American Indian Water Systems	$1.8	$0.3	$0.3	$0.2	$0.1	$2.7
Alaska Native Village Water Systems	$0.3	$0.2	$0.1	$0.0*	$0.0*	$0.6
Costs Associated with Proposed and Recently Promulgated Regulations§		$4.9				$4.9
Total National Need	**$247.5**	**$72.5**	**$39.5**	**$20.5**	**$4.2**	**$384.2**

Note: Numbers may not total due to rounding. *Actual "Other" need $1.04 million for NPNCWS; Alaska Native Village water system "Other" need $4.9 million and "Source" need $39 million.
** "Large" and "medium" community water systems are defined differently for this Assessment than in the 2003, 1999, and 1995 Assessments. See Appendix A for more information.
† Based on 2007 Assessment findings adjusted to 2011 inventory and cost models.
‡ Based on 1999 Assessment findings adjusted to 2011 dollars.
§ Taken from EPA economic analyses.

Transmission and Distribution Needs

Transmission and distribution projects are the largest category of need at $247.5 billion over the next 20 years (64.4 percent of the total need). This category of need increased the most since the 2007 Assessment.

Although the least visible component of a public water system, the buried pipes of a transmission and distribution network generally account for most of a system's capital value. Even small rural systems may have several hundred miles of pipe. In larger cities, replacement or rehabilitation of even small segments of the extensive underground networks of water supply pipes can be costly, both from the perspective of the cost of construction and the costs related to disruption to the city's commerce. Regardless of water system size, projects dealing with water mains and related infrastructure present challenges. Pipe projects are typically driven by a utility's need to continue providing potable water to its customers while preventing contamination of the water prior to delivery.

The majority of this $247.5 billion need is for replacing or refurbishing aging or deteriorating transmission and distribution mains. These projects are critical to the delivery of safe drinking water and can help ensure compliance with many regulatory requirements. Failures in transmission and distribution lines can interrupt the delivery of water and possibly allow contamination of the water.

Michelle Stamates, Nevada Division of Environmental Protection

Installation of 450 linear feet of 24-inch fusible PVC below existing utilities in Carson City, NV.

The rate at which water mains require replacement or rehabilitation varies greatly by pipe material, age of the pipe, soil characteristics, weather conditions, and construction methods. Systems that have been unable to rehabilitate or replace mains may have proportionally more aged infrastructure, and therefore a higher level of need. In addition, some pipe materials tend to degrade prematurely; galvanized pipe is particularly susceptible to corrosion in certain soils, and unlined cast iron pipe is susceptible to internal corrosion. Furthermore, health concerns associated with asbestos during pipe repair make asbestos cement pipe undesirable for some systems. Many water suppliers are replacing these types of mains with ductile iron or polyvinyl chloride pipe.

Other projects in the transmission and distribution category are: installing new pipe to loop dead end mains to avoid stagnant water, installing water mains in areas where existing homes do not have a safe and adequate water supply, and installing or rehabilitating pumping stations to maintain adequate pressure. This category also includes projects to address the replacement of appurtenances, such as valves that are essential for controlling flows and isolating problem areas during repairs, hydrants to flush the distribution system to maintain water quality, backflow-prevention devices to avoid contamination, and meters to record flow and water consumption.

Treatment Needs

The total 20-year national need for treatment is estimated to be $72.5 billion. This category includes the construction, expansion, and rehabilitation of infrastructure to reduce contamination through various treatment processes (e.g., filtration, disinfection, corrosion control). A large percentage of the regulatory need is in this category. Treatment facilities vary significantly depending on the quality of their source water and type of contamination present. Treatment systems range from a simple chlorinator for disinfection to a complete conventional treatment system with coagulation and flocculation (processes that cause particles suspended in the water to combine for easier removal), sedimentation, filtration, disinfection, laboratory facilities, waste handling, and computer automated monitoring and control devices.

Top Photo: State of Kentucky Department of Environmental Protection
Bottom Photo: Chad Kolstad, Minnesota Department of Public Health

Top: Filter controls from Madisonville, KY
Bottom: New surface water treatment plant in Fairmont, MN. The current plant was constructed in 1926 and needed to be replaced. The new plant will have biologically active GAC filters to help with taste and odor complaints.

Treatment technologies are used to remove or inactivate disease-causing organisms, or to remove or prevent the formation of harmful chemicals.

The treatment category also includes projects to remove contaminants that adversely affect the taste, odor, and color of drinking water. Treatment for these "secondary contaminants" often involves softening the water to reduce magnesium and calcium levels, or applying chemical sequestrants for iron or manganese contamination. Although not a public health concern, the aesthetic problems caused by secondary contaminants may prompt some consumers to seek more palatable, but less safe or affordable sources of water.

Source Needs

The total 20-year national need for source water infrastructure is estimated at $20.5 billion. The source category includes needs for constructing or rehabilitating surface water intake structures, drilled wells, and spring collectors. Needs for dams and raw water reservoirs are excluded from DWSRF funding and this Assessment.

Drought

An emerging need encountered in the 2007 Assessment, and now reiterated in the 2011 Assessment, is new source water infrastructure with associated piping and treatment to offset existing and anticipated drought conditions. In the past several years, water systems across the United States have been adversely affected by drought. EPA does not question that water systems are being affected by drought conditions. However, only a small percentage of the systems participating in the Assessment have completed plans to address drought impacts. When documentation was lacking or nonexistent, EPA had to decide whether a permanent solution or a less costly temporary solution should be considered for inclusion in the Assessment. EPA also investigated the drought-related projects to ensure they were primarily to provide drinking water to existing consumers and not for projected growth demand. EPA believes the drought-related needs reported in the 2007 and 2011 Assessments capture only a portion of the drought-related needs water utilities may face in the future.

Dave Westbrook

A leaking water tower in the city of Upper Sandusky, OH.

Drinking water comes from either ground water or surface water sources. Wells typically are considered ground water sources. Rivers, lakes, other open bodies of water, and wells under the direct influence of surface water are considered surface water sources. Whether drinking water originates from ground or surface water sources, its raw water quality is an important component in protecting public health. A high-quality water supply can minimize the possibility of microbial or chemical contamination and may not require extensive treatment facilities. Many source water needs involve construction of new surface water intake structures or drilling new wells to obtain higher quality raw water.

A water source should provide an adequate supply to enable the water system to maintain minimum pressures. Low water pressure may result in the intrusion of contaminants into the distribution system. The 2011 Assessment includes projects to expand the capacity of intake structures and add new wells to address supply deficiencies facing existing customers.

Storage Needs

The 20-year national need estimated for storage projects is $39.5 billion. This category includes projects to construct, rehabilitate, or cover finished water storage tanks, but it excludes dams and raw water reservoirs (unless the raw water basins are onsite and part of the treatment process) because they are specifically excluded from DWSRF funding. It is critical that water systems have sufficient storage to provide adequate supplies of treated water to the public, particularly during periods of peak demand. This storage enables the system to maintain the minimum pressure required throughout the distribution system to prevent the intrusion of contaminants into the distribution network.

Other Needs

Needs not included in the previous four categories are grouped as "other" needs. These needs account for $4.2 billion of the total 20-year national need. Examples of "other" projects are system-wide telemetry, supervisory control and data acquisition (SCADA) systems, and water system security measures that were not assigned to another category.

Need by System Size

Exhibit 1.6 shows the relationship between infrastructure need, population served, and the number of community water systems by size category in the states, the District of Columbia, Puerto Rico, and the U.S. Territories. As this exhibit demonstrates, large systems account for a small portion of the number of community water systems in the states, District of Columbia, Puerto Rico, and U.S. Territories, but they serve 46 percent of the population receiving water from community water systems and account for 39 percent of the drinking water infrastructure investment need. Small systems cannot take advantage of economies-of-scale like large systems and so have higher costs per customer. Small systems represent, by far, the largest number of systems, but they account for only 8 percent of the population served. In relation to population

Exhibit 1.6: State Community Water System 20-Year Need by Size and Population*
(in billions of January 2011 dollars)

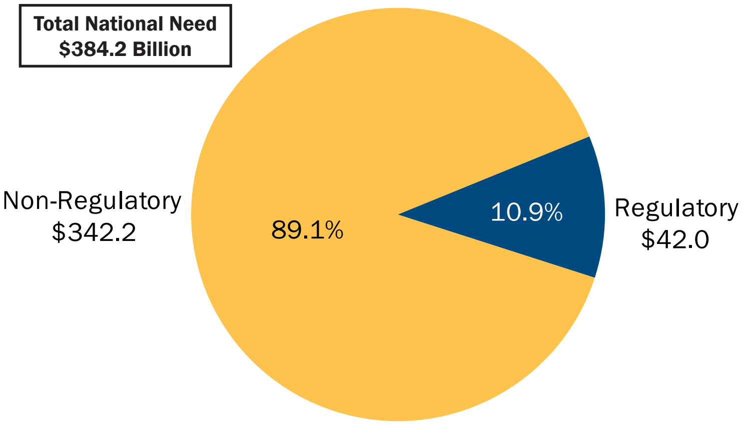
System Size	Need		Water Systems		Population Served	
	$ Billions	% of Need	Number of Systems‡	% of Water Systems‡	Population (millions)§	% of Population Served§
Large Community Water Systems (serving over 100,000 persons)**	$145.1	39.1%	611	1.2%	137.4	46.3%
Medium Community Water Systems (serving 3,301 to 100,000 persons)**	$161.8	43.6%	8,063	16.0%	135.2	45.6%
Small Community Water Systems (serving 3,300 and fewer persons)	$64.5	17.4%	41,801	82.8%	24.0	8.1%

Note: Numbers may not total due to rounding.
* This exhibit reports the need for community water systems in the states, Washington D.C., Puerto Rico, and the U.S. Territories. It does not discuss findings for not-for-profit noncommunity systems, needs associated with proposed or recently promulgated regulations, or needs for American Indian or Alaska Native Village water systems.
‡ Based on the DWINSA sample frame as discussed in Appendix A of this report.
§ Data on population served from EPA's *Annual Trends data, including summary inventory, violations and GPR*. June 2011 http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/pivottables.cfm#summary. Does not include populations for systems defined as "Federal Systems" or "Native American," but does include populations served by Alaska Native Village Water Systems. Database distinguished system sizes for "very small," "small," "medium," "large," and "very large," allowing direct comparisons to system size in the Assessment.
** "Large" and "medium" community water systems are defined differently for this Assessment than in the 2003, 1999, and 1995 Assessments. See Appendix A for more information.

served, they account for a disproportionate 17 percent of the community water system need. Medium systems represent the largest portion of the need, and their need is more proportional to the population served.

American Indian and Alaska Native Village communities are not included in Exhibit 1.6; those systems serve primarily small communities. For example, approximately 90 percent of the 791 American Indian water systems serve fewer than 3,300 people. Similarly, no Alaska Native Village systems serve over 10,000 people and all but 4 of the 165 systems serve 3,300 or fewer people.

Exhibit 1.7: Total Regulatory vs. Non-Regulatory 20-Year Need (in billions of January 2011 dollars)



Note: Numbers may not total due to rounding.

Needs Associated with SDWA Regulations

As shown in Exhibit 1.7, 10.9 percent of the total national need, $42.0 billion, is for compliance with the SDWA regulations. This need includes existing regulations as well as regulations which are proposed or recently promulgated (see below). Although all of the projects in the Assessment are needed to further the goals of the SDWA, most needs are not for obtaining or maintaining compliance with a specific regulation. Most infrastructure projects are needed to ensure continued provision of potable water to a utility's customers. Projects that are directly attributable to specific SDWA regulations are collectively referred to as the "regulatory need." Most of the regulatory need involves the upgrade, replacement, or installation of treatment technologies.

The Assessment divides the regulatory need into existing regulations and proposed or recently promulgated regulations. These needs are further identified as either microbial or chemical regulations. Exhibit 1.8 provides a matrix of the regulatory needs by these categories.

Exhibit 1.8: Total 20-Year National Regulatory Need (in billions of January 2011 dollars)

Regulation Type	Microbial Regulations	Chemical Regulations	Total Regulatory Need
Existing Regulations	$26.1	$10.9	$37.1
Proposed or Recently Promulgated Regulations	$1.1	$3.8	$4.9
Total Regulatory Need	**$27.3**	**$14.7**	**$42.0**

Note: Numbers may not total due to rounding.

Assigning Arsenic Needs to Small Systems in the 2011 Assessment

For the 2011 Assessment, small systems were not resurveyed, and therefore EPA adjusted the 2007 small system needs to 2011 dollars. Because EPA has information that some number of small systems have not yet addressed capital improvement needs related to meeting the arsenic standard, the needs associated with arsenic compliance have been carried over from the 2007 Assessment and adjusted to 2011 dollars. While this likely overestimates the need for small systems by continuing to include those that have addressed infrastructure needs since 2007 to achieve compliance with the arsenic standard, EPA's analysis indicates any overestimation is well within the 2011 Assessment's statistical margin of error with insignificant impact on either the total national need or the relative needs between states.

Existing Regulations

Microbial Contaminants.

The surface water treatment regulations (Surface Water Treatment Rule, Interim Enhanced Surface Water Treatment Rule, Filter Backwash Recycling Rule, Long Term 1 Enhanced Surface Water Treatment Rule, and Long Term 2 Enhanced Surface Water Treatment Rule), the Total Coliform Rule, and the Ground Water Rule are existing SDWA regulations that address microbial contamination. The Stage 1 Disinfectants/Disinfection Byproducts Rule regulates the maximum disinfectant and disinfection byproducts levels in distribution systems and is commonly grouped with the microbial rules.

Projects for compliance with existing regulations were reported by systems in the Assessment and account for almost 90 percent of the total regulatory need and almost all of the microbial contaminant-related need. This reflects the fact that the majority of the nation's large municipal systems use surface water sources. Under all of these regulations, systems using surface water sources must provide treatment to minimize microbial contamination. In most cases, this means installing, upgrading, or rehabilitating treatment plants to control pathogens such as the bacterium *E. coli*, the virus Hepatitis A, and the protozoans *Giardia lamblia* and *Cryptosporidium*. Disinfection also helps protect the system from Total Coliform Rule violations.

Chemical Contaminants.

This estimate includes projects attributable to the Nitrate/Nitrite Standard, the revised Arsenic Standard, the Lead and Copper Rule, and other regulations that set maximum contaminant levels (MCLs) or treatment techniques for organic and inorganic chemicals. Examples of projects are infrastructure that aerates water to remove volatile organic compounds such as tetrachloroethylene, or ion exchange units that remove contaminants from the water. This category includes regulations governing more than 80 inorganic or organic chemicals for which infrastructure projects may be needed.

Stew Thornley
New reverse osmosis plant in the city of St. Peter, MN to treat for nitrate, iron, manganese and hardness.

Proposed or Recently Promulgated Regulatory Needs

In general, water systems can readily identify the infrastructure needs required for compliance with existing regulations, but most systems have not determined the infrastructure needed to comply with proposed or recently promulgated regulations. Therefore, relying on systems to report the infrastructure needs for proposed or recently promulgated regulations might misstate the true need. Consequently, EPA derived the capital infrastructure estimates from the EA that the Agency published when proposing each regulation, or from the final EA if the regulation has been recently promulgated.

However, since the EAs rely on regional data, they are not appropriate predictors of state-specific needs. Therefore, the costs associated with the proposed or recently promulgated regulations are allocated at a national level, not apportioned to each state.

The proposed or recently promulgated regulations included in the 2011 Assessment are:

- Proposed Radon Rule
- Final Stage 2 Disinfectants/Disinfection Byproducts Rule
- Proposed Revisions to the 1989 Total Coliform Rule

The total cost of complying with these regulations is included in the 2011 Assessment as future regulatory needs. The capital cost estimates for the Proposed Radon Rule and the Final Stage 2 Disinfectants/Disinfection Byproducts Rule are provided in Exhibit 1.9. No capital costs are associated with the Proposed Revisions to the 1989 Total Coliform Rule, which would result in enhanced maintenance and operations rather than new infrastructure investments.

Exhibit 1.9: Total National 20-year Need for Proposed and Recently Promulgated Regulations (in billions of January 2011 dollars)

Proposed or Recently Promulgated Regulation*	Estimated Total Regulatory Need†
Stage 2 Disinfectants/Disinfection Byproducts Rule	$1.1
Radon Rule‡	$3.8
Total Proposed or Recently Promulgated Regulatory Need	**$4.9**

* The Economic Analysis for the Proposed Revisions to the 1989 Total Coliform Rule did not report capital costs.
† Estimates obtained from the appropriate Final or Proposed Rule "Economic Analysis." These estimates include only capital costs (i.e., they exclude operation and maintenance costs).
‡ The total capital costs were determined by averaging the capital costs from the Economic Analysis for the proposed Radon Rule.

Security Needs

Since the September 11, 2001 attacks, there has been a concentrated national focus on our vulnerabilities, and water systems are no exception. The Public Health Security and Bioterrorism Preparedness and Response Act of 2002 required any community water system that serves a population of more than 3,300 to prepare a vulnerability assessment. For many water systems, particularly the large systems, security measures have become fully integrated into the capital costs of major infrastructure improvements.

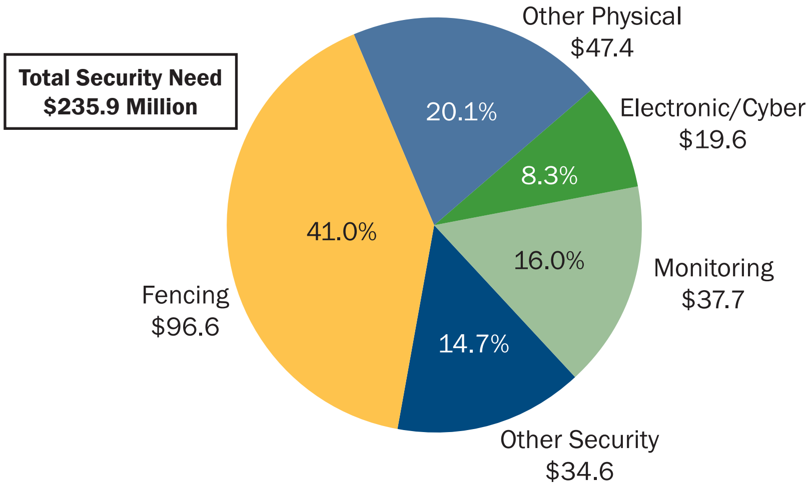
Projects in the 2011 Assessment that were specifically listed as security need account for $235.9 million. However, the total cost that systems incur to protect their infrastructure and their customers' water quality is likely far greater because many of these costs are now commonly incorporated into the construction cost of infrastructure projects rather than considered separately. The majority of security needs are mostly "hidden" in the other needs reported by this Assessment.

EPA Region 9

Storage tanks are equipped with caged ladders for safety and are secured to deter trespassers.

Exhibit 1.10 shows the breakdown of the stand-alone security needs by type of project, including fencing, electronic or cyber security, other physical security measures, monitoring equipment, and other projects listed as having multiple types of security needs. Note that these categories are the same as the 2007 Survey but slightly different from those reported in the 2003 Assessment. They were changed to align with the categories now used within the water supply industry.

Exhibit 1.10: Total National 20-Year Security Needs (in millions of January 2011 dollars)



Note: Numbers may not total due to rounding.

American Indian and Alaska Native Village Water System Needs

The combined American Indian and Alaska Native Village water system need estimated by the 2011 Assessment is $3.3 billion in capital improvements over the next 20 years. This need includes drinking water infrastructure to increase access to safe drinking water through compliance with EPA's drinking water regulations and connection of homes without piped water to existing public water systems. These infrastructure needs are based on surveys of statistically-selected water systems. The prior 2003 and 2007 Assessments estimated the need by adjusting the findings of the 1999 Assessment to current dollars.

As shown in Exhibit 1.11, the combined need of $3.3 billion for the 2011 Assessment is comparable to the $3.3 billion of the 1999 Assessment (adjusted to 2011 dollars); however, the mix of needs between the American Indian and the Alaska Native Village water systems has shifted significantly. These estimates are discussed further in Chapter 3.

Exhibit 1.11: American Indian and Alaska Native Village Reported Needs by Survey Year (20-year need in millions of 2011 dollars)

	1995 Results in 2011 Dollars	1999 Results in 2011 Dollars	2011 Results
American Indian Systems	$920.6	$1,715.8	$2,695.6
Alaska Native Village Systems	$1,267.7	$1,589.8	$593.4
American Indian and Alaska Native Village Total	**$2,188.3**	**$3,305.6**	**$3,296.4**

Sara Ziff, EPA Region 9

The Whiteriver Surface Water Treatment Plant allows the White Mountain Apache Tribe to supplement a declining well field with water from the White River. The innovative design of the treatment plant will annually save 85 million gallons of water.

Sara Ziff, EPA Region 9

This water main connects the village of Sikul Himatk on the Tohono O'odham Nation to a nearby community with an arsenic treatment plant. The Sikul Himatk well exceeded the EPA maximum contaminant level for arsenic, and the project provides water with arsenic meeting the EPA standard.

Climate Readiness

The drinking water industry has increased efforts dedicated to anticipating and proactively addressing the potential effects of climate change at the water utility level. For the 2011 Assessment, EPA did not create a new category of need, but captured voluntary, additional information to estimate, in very general terms, the extent to which projects that are included in the survey are also related to climate change adaptation – referred to as climate readiness. Identifying a project as related to climate readiness did not affect project allowability for the DWINSA.

What is Climate Readiness?

For the purposes of this report, climate readiness refers to adapting to and addressing climate change impacts on drinking water system infrastructure.

The method used for capturing data on DWINSA projects that are related to climate readiness is described in Appendix A. For the DWINSA, EPA has not defined what constitutes a climate readiness project or what is appropriate rationale or data to support the consideration of climate readiness during the planning of a project. EPA has captured data on climate readiness projects to report the findings to the industry and others to help facilitate communications on this emerging issue.

The 2011 DWINSA found few climate readiness projects, with just 164 projects from 44 systems related to climate readiness – less than 1.5 percent of the responding systems. Respondents cited climate change data from a variety of sources including state-specific models, region-specific models, state environmental agencies, National Oceanic and Atmospheric Administration (NOAA), energy companies, supply contracts, and the condition of current infrastructure.

Survey responses that reported needs with climate readiness considerations are summarized in Exhibit 1.12. As shown in the exhibit, one state accounts for over half the reported climate readiness needs. The low level of identification of climate readiness projects may have been due to such identification being voluntary, not having any bearing on estimating infrastructure needs, and lack of definition of climate readiness. However, this aspect of the survey served to increase dialogue within the DWINSA regarding climate readiness and could serve as baseline data for future surveys.

Exhibit 1.12: Climate Readiness Needs by State (As a percentage of Total Reported Climate Readiness Need)

State	Percent of Total Reported Climate Readiness Need*
North Carolina	50.8%
Connecticut	17.8%
Tennessee	6.9%
Iowa	4.1%
West Virginia	3.5%
Colorado	3.1%
South Carolina	3.1%
California	2.8%
Kentucky	2.5%
Texas	1.4%
Indiana	1.4%

*In addition to the states listed above, systems in Florida, Georgia, Maine, Michigan, Delaware, Oklahoma, Massachusetts, Illinois, and American Indian systems in EPA Region 8 reported climate readiness need which totaled less than 1 percent of the total reported climate readiness need.

Green Projects

Similarly, while EPA did not create a new category of need, the survey questionnaire requested responders to voluntarily identify projects that included green components for the 2011 DWINSA. While EPA did not specifically define green projects, a guide to identifying projects that might include a green component was provided with the questionnaire package (see Appendix A). The Assessment did not collect information on the specific cost of the green component, and identifying a project as including a green component did not affect project allowability for the DWINSA.

What is Green Infrastructure?

Green infrastructure includes products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. Categories of green infrastructure include water efficiency, energy efficiency, and environmentally innovative projects.

Exhibit 1.13: Entities with More Than 5 Percent of Total Reported Green Need

State	Percentage of Total Reported Green Need
California	28.7%
Georgia	8.4%
Illinois	7.0%
North Carolina	5.3%
Oregon	5.6%
Puerto Rico	5.6%

As with climate readiness, few "green" projects were reported in the survey (3,137 projects, or about 3.2 percent of the total number of projects that were submitted). Like "climate readiness" projects, the low level of identification of "green" projects is likely due to such identification being voluntary and not having any bearing on estimating infrastructure needs. However, this aspect of the survey served to increase dialog within DWINSA regarding "green" projects being considered and could serve as baseline data for future studies.

Of the reported projects, 55 percent were for water efficiency, 42.4 percent for energy efficiency, and the remaining 2 percent were identified as either "other green infrastructure" or environmentally innovative or a combination of these categories.

The total cost of projects that included a green component or purpose is estimated at $4.79 billion. Relatively few states and systems reported such information. Exhibit 1.13 shows all entities (five states and Puerto Rico) which accounted for more than 5 percent of the total reported green projects. These six entities account for 61 percent of the reported green projects.

Data collected by the 2011 DWINSA indicate that systems are considering diverse applications for green initiatives. Exhibit 1.14 presents the most common types of need that included green applications.

Exhibit 1.14: Top Five Project Types Representing Green Need (As a percentage of Total Reported Green Need)

Project Type	Percentage of Total Reported Green Need
Meters	69.4%
Pump Stations	9.9%
Distribution Mains	3.2%
Well Pumps	2.6%
Conventional Filter Plants	2.6%

Chapter 2: Findings - State Need

State-Specific Needs

Since federal fiscal year 1998, the SDWA has required EPA to allot DWSRF grants to each state based on the findings of the most recent DWINSA. Because of this Assessment's role in determining DWSRF capitalization grant allocations, obtaining highly credible and statistically valid estimates of each state's need is crucial. Exhibits 2.1 and 2.2 show the total DWSRF-eligible need for states, Puerto Rico, the District of Columbia, and the U.S. Territories by project type and system size. Exhibit 2.3 is a map indicating each state's 20-year total need.

DWSRF capitalization grants for fiscal years 2014 through 2017 will be allocated to states based on the findings of the 2011 Assessment. The funding is allocated by first setting aside a percentage allotment, recently 2.0 percent, to American Indian and Alaska Native Village water systems and a percent allotment, recently 1.5 percent, to the U.S. Territories (the U.S. Virgin Islands, Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa); the Assessment findings are used to help divide these set-asides among these entities. The remaining funds are then divided among the states, Puerto Rico, and the District of Columbia based on the Assessment's determination of each state's relative percentage of the total "state need" with each receiving no less than the one percent minimum allotment.

States that received the minimum allocation of one percent in the most recent allocation were given the option of a lower level of participation in the Assessment. These states' needs are reported as one group referred to as "partially surveyed" states. This option is explained later in this chapter.

The state need does not include costs associated with proposed or recently promulgated regulations or the need of American Indian or Alaska Native Village water systems.

Partnership for Determining State Need

The substantial effort involved in collecting data and calculating water systems' 20-year needs relies on a partnership between EPA, the states, and the utilities themselves. Each partner makes a valuable contribution to estimating the DWSRF-eligible needs of drinking water systems.

Water System. Operators and managers of water utilities have on-the-ground knowledge of their system's infrastructure and condition. These personnel are in the best position to assess their infrastructure needs.

States. State personnel often have considerable knowledge of the systems in their state, and states have the staffs that are trained to assist systems in completing this Assessment. The states work with EPA towards consensus development of Assessment policies and methods to ensure consistency across the states.

EPA. EPA's primary roles are to serve as the quality assurance agent for the data collection effort, to ensure that survey policies and methodologies are met, and to serve as a technical resource to assist with capturing complete and accurate 20-year needs. EPA provides oversight for survey submittals to encourage full reporting, to ensure consistency and fairness between states, and to control for any state bias.

Gordon Cole, Shaw Engineering

Installation of more than 35,000 linear feet of new 14-in PVC transmission line in Tonopah, NV.

Exhibit 2.1: State 20-year Need Reported by Project Type (in millions of January 2011 dollars)

State	Transmission and Distribution	Source	Treatment	Storage	Other	Total
Alabama	$6,115.2	$142.7	$918.8	$639.8	$133.2	$7,949.8
Arizona	$4,974.6	$334.7	$1,416.9	$684.9	$29.6	$7,440.7
Arkansas	$4,391.6	$195.5	$857.0	$574.3	$79.9	$6,098.4
California	$26,752.1	$2,564.5	$8,467.3	$6,403.9	$325.3	$44,513.0
Colorado	$4,136.4	$223.6	$1,915.4	$816.5	$32.2	$7,124.0
Connecticut	$2,584.3	$146.6	$545.1	$267.3	$35.0	$3,578.3
District of Columbia	$1,448.7	$0.0	$43.3	$104.4	$10.2	$1,606.7
Florida	$10,153.6	$1,348.2	$3,561.8	$1,060.5	$346.8	$16,471.0
Georgia	$6,732.1	$297.0	$1,371.8	$813.8	$53.5	$9,268.2
Illinois	$12,673.7	$1,575.5	$2,786.2	$1,551.1	$398.4	$18,984.9
Indiana	$4,522.3	$334.5	$1,036.7	$618.2	$35.3	$6,546.9
Iowa	$4,189.7	$294.9	$900.1	$509.6	$35.9	$5,930.2
Kansas	$3,066.7	$190.7	$572.9	$351.8	$12.5	$4,194.7
Kentucky	$4,848.5	$96.8	$708.6	$524.3	$50.4	$6,228.6
Louisiana	$3,458.2	$279.7	$1,084.7	$455.1	$45.0	$5,322.6
Maine	$737.6	$73.8	$190.7	$165.8	$11.9	$1,179.7
Maryland	$4,895.0	$180.8	$1,199.4	$469.1	$168.7	$6,913.1
Massachusetts	$5,641.4	$276.4	$981.0	$737.5	$64.6	$7,701.0
Michigan	$9,504.6	$639.3	$2,511.8	$1,073.8	$84.4	$13,813.9
Minnesota	$4,603.3	$457.7	$1,383.5	$845.6	$72.5	$7,362.6
Mississippi	$2,110.6	$279.0	$780.2	$499.5	$17.2	$3,686.6
Missouri	$6,120.3	$316.5	$1,269.3	$752.4	$22.2	$8,480.7
Nevada	$2,880.7	$1,043.5	$1,291.7	$331.1	$44.2	$5,591.3
New Jersey	$5,025.2	$377.5	$1,595.4	$842.9	$73.4	$7,914.5
New York	$13,760.4	$1,779.8	$3,814.2	$2,531.2	$155.6	$22,041.1
North Carolina	$6,673.5	$482.0	$1,803.9	$936.0	$150.4	$10,045.8
Ohio	$8,057.5	$548.5	$2,194.5	$1,169.3	$221.3	$12,191.1
Oklahoma	$4,380.4	$366.7	$1,202.2	$513.1	$31.3	$6,493.8
Oregon	$3,189.9	$285.9	$1,031.2	$1,001.8	$54.3	$5,563.0
Pennsylvania	$9,290.8	$610.7	$2,498.5	$1,645.6	$181.7	$14,227.3
Puerto Rico	$2,058.3	$84.3	$665.6	$379.7	$25.2	$3,213.2
Tennessee	$1,816.4	$78.1	$550.4	$218.1	$29.0	$2,692.0
Texas	$22,181.6	$1,353.3	$6,663.4	$3,266.5	$427.0	$33,891.8
Utah	$2,225.7	$242.5	$588.0	$649.0	$20.4	$3,725.6
Virginia	$4,490.9	$207.8	$1,239.2	$715.2	$62.6	$6,715.7
Washington	$5,770.4	$628.2	$1,607.5	$1,252.0	$261.9	$9,520.0
Wisconsin	$4,381.3	$433.1	$1,436.7	$850.3	$39.5	$7,140.8
Partially Surveyed States*	$15,255.4	$1,431.4	$4,276.5	$2,697.3	$301.8	$23,962.4
Subtotal	**$245,099.1**	**$20,201.7**	**$66,961.4**	**$38,918.3**	**$4,144.4**	**$375,325.0**
American Samoa	$48.0	$7.0	$11.3	$15.4	$0.3	$81.9
Guam	$125.1	$30.8	$6.8	$48.6	$24.1	$235.4
North Mariana Is.	$62.4	$29.6	$42.1	$40.2	$3.5	$177.7
Virgin Islands	$99.0	$0.0	$34.5	$39.0	$2.0	$174.6
Subtotal	**$334.5**	**$67.4**	**$94.7**	**$143.1**	**$29.9**	**$669.7**
Total	**$245,433.6**	**$20,269.1**	**$67,056.2**	**$39,061.4**	**$4,174.4**	**$375,994.7**

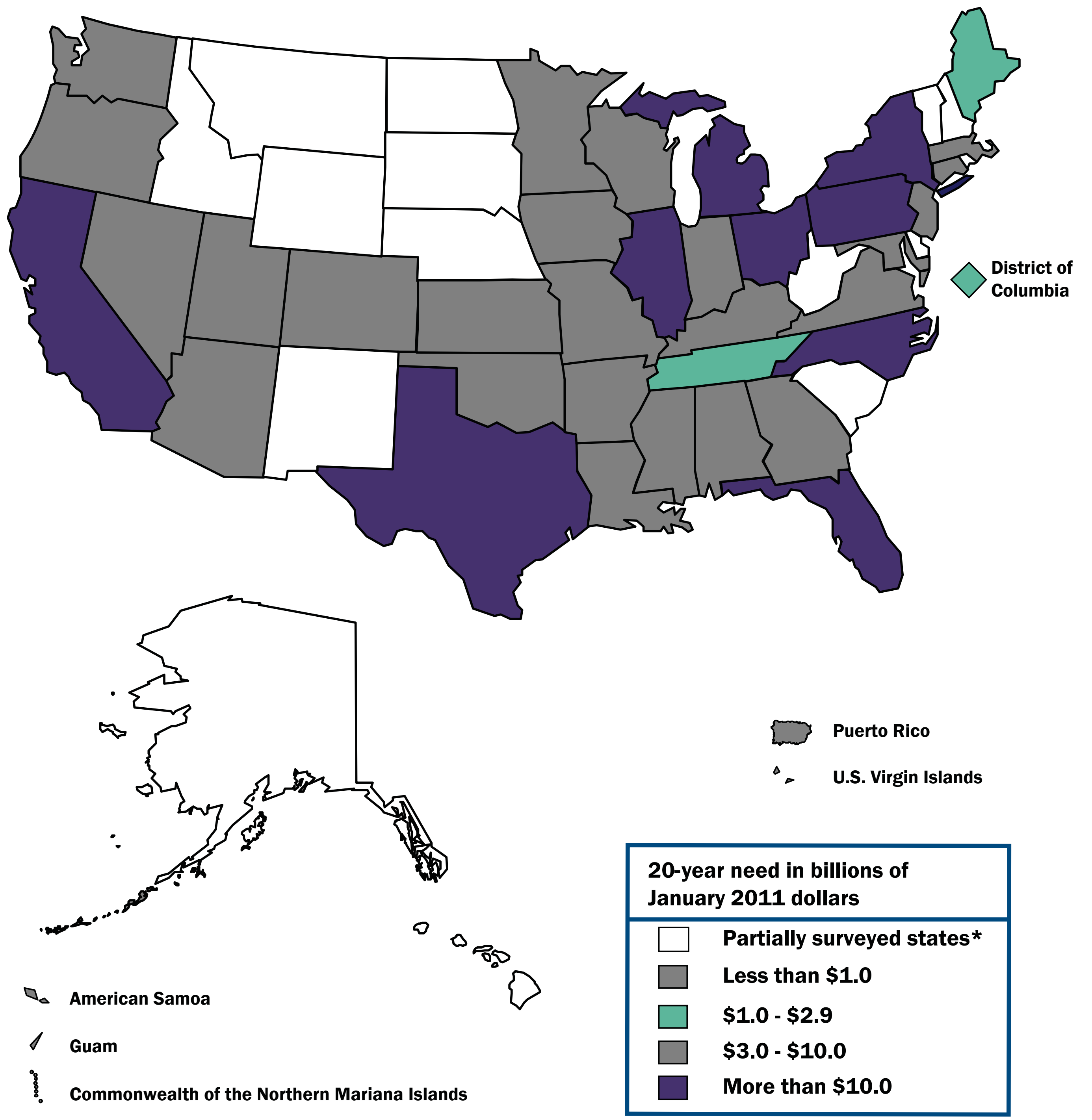
*The need for states that opt out of the medium system portion of the survey is presented cumulatively and not by state. The list of 15 partially surveyed states can be seen in Exhibit 2.4.

Exhibit 2.2: State 20-year Need Reported by System Size (in millions of January 2011 dollars)

State	Large	Medium	Small	NPNCWSs	Total
Alabama	$1,570.2	$5,951.9	$423.3	$4.3	$7,949.8
Arizona	$3,987.1	$2,463.9	$968.7	$21.0	$7,440.7
Arkansas	$696.0	$4,354.9	$1,039.2	$8.3	$6,098.4
California	$27,369.9	$13,317.8	$3,710.3	$115.0	$44,513.0
Colorado	$2,708.2	$3,222.5	$1,191.8	$1.5	$7,124.0
Connecticut	$1,735.3	$1,137.7	$674.1	$31.2	$3,578.3
District of Columbia	$1,606.7	$0.0	$0.0	$0.0	$1,606.7
Florida	$8,258.6	$6,147.8	$1,919.7	$144.8	$16,471.0
Georgia	$3,283.0	$4,197.4	$1,772.2	$15.6	$9,268.2
Illinois	$8,640.7	$7,135.7	$3,083.7	$124.9	$18,984.9
Indiana	$1,791.2	$3,416.3	$1,139.3	$200.0	$6,546.9
Iowa	$447.9	$3,821.2	$1,640.3	$20.9	$5,930.2
Kansas	$1,045.3	$1,762.7	$1,382.8	$3.9	$4,194.7
Kentucky	$1,206.2	$4,662.0	$359.1	$1.2	$6,228.6
Louisiana	$1,196.1	$2,713.7	$1,395.9	$16.9	$5,322.6
Maine	$149.6	$501.6	$489.4	$39.1	$1,179.7
Maryland	$5,276.1	$939.7	$585.8	$111.4	$6,913.1
Massachusetts	$2,106.2	$5,104.4	$453.0	$37.3	$7,701.0
Michigan	$5,796.9	$5,649.7	$1,831.6	$535.6	$13,813.9
Minnesota	$738.7	$4,798.4	$1,521.1	$304.3	$7,362.6
Mississippi	$147.0	$1,648.5	$1,880.2	$10.9	$3,686.6
Missouri	$2,055.4	$4,365.6	$2,015.3	$44.4	$8,480.7
Nevada	$4,555.2	$726.3	$293.6	$16.2	$5,591.3
New Jersey	$3,402.9	$3,600.3	$680.5	$230.9	$7,914.5
New York	$13,801.7	$4,144.4	$3,951.9	$143.1	$22,041.1
North Carolina	$2,831.3	$4,983.4	$1,811.7	$419.4	$10,045.8
Ohio	$4,719.4	$5,432.9	$1,718.8	$320.1	$12,191.1
Oklahoma	$1,507.7	$3,418.8	$1,542.0	$25.3	$6,493.8
Oregon	$1,274.4	$3,088.8	$1,136.8	$63.1	$5,563.0
Pennsylvania	$5,065.4	$6,052.3	$2,790.0	$319.6	$14,227.3
Puerto Rico	$779.9	$1,823.6	$608.3	$1.4	$3,213.2
Tennessee	$259.6	$1,971.5	$428.3	$32.7	$2,692.0
Texas	$12,746.6	$15,172.7	$5,918.4	$54.1	$33,891.8
Utah	$861.3	$2,286.2	$563.4	$14.7	$3,725.6
Virginia	$2,531.6	$2,738.1	$1,342.0	$104.0	$6,715.7
Washington	$2,538.9	$4,272.3	$2,577.2	$131.7	$9,520.0
Wisconsin	$1,733.9	$3,386.8	$1,471.8	$548.4	$7,140.8
Partially Surveyed States*	$4,424.7	$11,043.7	$8,096.6	$397.5	$23,962.4
Subtotal	**$144,847.0**	**$161,455.5**	**$64,408.1**	**$4,614.4**	**$375,325.0**
American Samoa	$0.0	$52.1	$29.8	$0.0	$81.9
Guam	$235.4	$0.0	$0.0	$0.0	$235.4
North Mariana Is.	$0.0	$118.5	$59.2	$0.0	$177.7
Virgin Islands	$0.0	$174.6	$0.0	$0.0	$174.6
Subtotal	**$235.4**	**$345.2**	**$89.0**	**$0.0**	**$669.7**
Total	**$145,082.4**	**$161,800.8**	**$64,497.1**	**$4,614.4**	**$375,994.7**

*The need for states that opt out of the medium system portion of the survey is presented cumulatively and not by state. The list of 15 partially surveyed states can be seen in Exhibit 2.4.

Exhibit 2.3: Overview of 20-Year Need by State



*** The list of the 15 partially surveyed states can be seen in Exhibit 2.4.**

- Does not include needs for American Indian and Alaska Native Village water systems.

- The needs for American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Virgin Islands are less than $1 billion each.

States that received the minimum DWSRF allotment of one percent in the most recent allocation were given the option of surveying only the large systems in their state, and not collecting data for medium-sized systems. (Small system data were collected by EPA in the 2007 Assessment.) This option was provided to reduce the burden on these states and allow for resources to be focused on the large systems. Of the 22 states (including the District of Columbia and Puerto Rico) that received the minimum allocation based on the 2007 DWINSA findings, 15 chose this "partially surveyed" option. For these states, the medium system need was estimated based on data from fully surveyed states. Because this method does not meet the Assessment's stringent data quality objectives at the state level, the needs of these states contribute to the estimate of the total national need but are not reported individually by state. Exhibit 2.4 shows the large and small system need estimated by state, and the total medium system need for the partially surveyed states.

Exhibit 2.4: State 20-year Need Reported for Partially Surveyed States (in millions of January 2011 dollars)

State	Large CWSs	Medium CWSs*	Small CWSs	NPNCWSs †	Total
Alaska	$311.7		$392.6	$69.3	$773.7
Delaware	$73.5		$291.6	$3.7	$368.8
Hawaii	$898.5		$154.6	$1.1	$1,054.2
Idaho	$142.1		$776.9	$42.8	$961.8
Montana	$72.0		$755.8	$57.5	$885.3
Nebraska	$713.3		$888.7	$18.1	$1,620.2
New Hampshire	$56.7		$708.0	$70.2	$834.9
New Mexico	$427.2		$720.0	$17.4	$1,164.7
North Dakota	$0.0		$443.6	$6.0	$449.7
Rhode Island	$49.5		$80.3	$18.3	$148.2
South Carolina	$1,260.8		$560.3	$18.4	$1,839.4
South Dakota	$212.9		$519.4	$5.8	$738.1
Vermont	$0.0		$510.6	$0.2	$510.8
West Virginia	$206.4		$898.1	$54.7	$1,159.2
Wyoming	$0.0		$396.1	$13.9	$409.9
Total	**$4,424.7**	**$11,043.7**	**$8,096.6**	**$397.5**	**$23,962.4**

* The medium community water system need was estimated cumulatively based on data from fully surveyed states.

† The non-for-profit noncommunity system need is based on 1999 Assessment findings adjusted to 2011 dollars.

More of the need of the partially surveyed states is for small and medium systems than among the rest of the nation. Large system need makes up a relatively small share of the total among partially surveyed states because these states generally do not have as many systems serving more than 100,000 persons as other states.

Unique Needs of Water Systems in U.S. Territories

Under SDWA and through appropriations, 1.5 percent of DWSRF monies is allocated to the U.S. Territories (American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, and the U.S. Virgin Islands) to be used as grants for water systems. For the 2011 Assessment, EPA mailed questionnaires to all large systems and to a probability sample of medium-sized systems in the U.S. Territories to assess the needs of water systems on these islands.

Exhibit 2.5: 20-Year Need Reported by U.S. Territories (in millions of January 2011 dollars)

Territory	Total Need
American Samoa	$81.9
Guam	$235.4
Commonwealth of the Northern Mariana Islands	$177.7
U.S. Virgin Islands	$174.6

Exhibit 2.5 shows the 20-year need reported for each of the U.S. Territories in millions of January 2011 dollars. The DWINSA Assessments have consistently demonstrated that water systems in the territories face unique challenges in providing safe drinking water to their citizens. While drinking water issues can vary from island to island, the overall challenges for all of the U.S. Territories include:

- **Rapidly Deteriorating Infrastructure**. In many island climates, corrosive soils and years of delivering previously untreated water have contributed to a prematurely deteriorated distribution system. Inadequate storage and lack of redundancy in the water systems make it difficult to take infrastructure off line for required maintenance or replacement.
- **Seasonal, Transient Customers**. A high volume of tourists creates considerable fluctuations in seasonal water demand that are difficult to design for. Cruise ships and other forms of tourism present huge peak demands on water systems already working at capacity.
- **Limited Source Options**. The ability to serve existing homes as well as a growing population is limited by a lack of quality sources of water. The islands' water supplies are dependent upon limited fresh water sources, ground water aquifers which are susceptible to contamination, and the use of rainwater catchments.
- **Ground Water Contamination**. Aquifer contamination from waste and sediment runoff, on-site wastewater treatment systems, illegal dumping, and salt water intrusion threatens the quality and quantity of water pumped from aquifers.

Changes in State-Specific Need through Assessment Cycles

As shown in Exhibit 2.6, the state-specific results of the 2011 Assessment, when compared to previous Assessments, show that states' needs change, and some change more significantly than others during the four-year intervals between Assessments. Changes in relative needs of states from one Assessment to the next can be attributed to two primary factors:

Exhibit 2.6: Historic State Need Reported for Each DWINSA (20-year need in millions of 2011 dollars)

State	1995	1999	2003	2007	2011
Alabama	$2,724.6	$1,610.2	$2,293.7	$4,649.8	$7,949.8
Alaska	$1,266.4	$871.8	$925.5	$921.4	*
Arizona	$2,222.9	$2,416.8	$12,386.1	$8,405.6	$7,440.7
Arkansas	$3,324.4	$2,285.2	$4,806.1	$5,987.2	$6,098.4
California	$30,894.6	$26,053.0	$37,853.7	$44,288.8	$44,513.0
Colorado	$3,200.6	$3,769.5	$7,230.1	$7,259.4	$7,124.0
Connecticut	$2,227.8	$1,499.7	$887.0	$1,581.1	$3,578.3
Delaware	$610.2	$452.9	$327.1	*	*
District of Columbia	$216.1	$616.8	$202.9	$991.6	$1,606.7
Florida	$7,119.0	$5,548.0	$20,427.6	$14,544.8	$16,471.0
Georgia	$5,410.4	$3,584.7	$12,247.2	$10,137.8	$9,268.2
Hawaii	$707.6	$218.5	$1,103.5	*	*
Idaho	$969.2	$768.5	$987.3	*	*
Illinois	$8,784.8	$9,160.8	$18,330.7	$17,033.4	$18,984.9
Indiana	$2,750.0	$2,522.8	$5,475.9	$6,742.6	$6,546.9
Iowa	$3,704.4	$4,240.5	$4,758.9	$6,933.8	$5,930.2
Kansas	$3,245.6	$2,451.8	$2,622.5	$4,571.3	$4,194.7
Kentucky	$3,652.4	$2,635.6	$3,814.8	$5,646.5	$6,228.6
Louisiana	$3,207.9	$1,896.1	$5,577.6	$7,826.5	$5,322.6
Maine	$1,421.2	$742.7	$1,129.7	*	$1,179.7
Maryland	$2,109.6	$2,489.2	$5,382.7	$6,174.2	$6,913.1
Massachu-setts	$9,762.5	$8,753.9	$11,618.6	$7,701.7	$7,701.0
Michigan	$7,285.7	$10,112.4	$15,362.2	$13,432.9	$13,813.9
Minnesota	$4,002.8	$4,617.1	$7,416.1	$6,792.4	$7,362.6
Mississippi	$2,588.1	$2,027.0	$2,233.5	$3,678.8	$3,686.6
Missouri	$3,085.4	$3,247.2	$8,092.2	$8,037.0	$8,480.7
Montana	$1,088.1	$1,298.8	$1,072.0	*	*
Nebraska	$1,564.8	$1,239.5	$1,839.0	$2,015.1	*
Nevada	$861.9	$897.4	$1,238.8	$3,052.7	$5,591.3
New Hamp-shire	$1,177.4	$744.0	$808.9	*	*
New Jersey	$5,933.3	$5,450.5	$9,392.4	$9,030.6	$7,914.5
New Mexico	$1,712.2	$1,552.2	$1,252.5	*	*
New York	$16,556.6	$19,597.0	$20,117.6	$30,780.9	$22,041.1
North Caro-lina	$4,456.8	$4,032.7	$14,912.7	$11,405.3	$10,045.8
North Dakota	$963.8	$729.7	$824.2	*	*
Ohio	$8,056.7	$7,387.2	$13,152.4	$14,290.6	$12,191.1
Oklahoma	$3,335.8	$3,487.0	$6,524.8	$4,664.2	$6,493.8
Oregon	$3,527.6	$4,035.6	$5,796.0	$3,159.3	$5,563.0
Pennsylvania	$7,809.9	$7,832.9	$14,926.5	$12,907.2	$14,227.3
Puerto Rico	$3,701.3	$2,937.4	$3,095.0	$2,878.2	$3,213.2
Rhode Island	$1,078.4	$859.7	$546.8	*	*
South Caro-lina	$2,398.8	$1,222.3	$1,691.7	$1,846.9	*
South Dakota	$933.9	$655.0	$1,344.4	*	*
Tennessee	$3,072.7	$2,100.6	$3,762.7	$4,023.9	$2,692.0
Texas	$20,304.0	$19,465.9	$38,258.5	$29,639.2	$33,891.8
Utah	$1,716.7	$765.5	$960.1	*	$3,725.6
Vermont	$754.2	$457.2	$536.2	*	*
Virginia	$4,834.2	$3,061.9	$3,891.2	$6,875.8	$6,715.7
Washington	$6,619.0	$5,880.2	$9,061.2	$11,065.9	$9,520.0
West Virginia	$1,790.2	$1,519.4	$1,170.7	*	*
Wisconsin	$3,066.1	$4,615.0	$8,064.9	$7,016.6	$7,140.8
Wyoming	$641.6	$658.8	$405.0	*	*
Partially Surveyed States*				$19,500.7	$23,962.4
Subtotal	**$224,450.4**	**$207,076.3**	**$358,139.3**	**$367,491.8**	**$375,325.0**
American Samoa	$36.9	$54.2	$43.8	$105.3	$81.9
Guam	$175.2	$170.8	$378.9	$299.4	$235.4
North Mariana Is.	$57.6	$111.4	$268.7	$328.1	$177.7
Virgin Islands	$366.4	$240.8	$245.0	$287.4	$174.6
Subtotal	**$636.0**	**$577.3**	**$936.4**	**$1,020.1**	**$669.7**
Total	**$225,086.4**	**$207,653.6**	**$359,075.7**	**$368,511.9**	**$375,994.7**

*For the 2007 and 2011 DWINSA, the need for paritally surveyed states that opted out of the medium system portion of the survey is presented cumulatively and not by state.

- **Changes in Projects Planned, Initiated, and Completed.** Congress specified that the DWINSA be repeated at 4-year intervals to capture changes in system infrastructure needs. Changes in the reported needs of individual systems from one survey period to the next can have a significant effect on the overall state need. For instance, in one Assessment a state may have a large system that has identified a project with very substantial costs. During that Assessment cycle, that state's need may be increased due to this large project. However, if construction of this project begins prior to the next Assessment cycle, those needs would no longer be included, and this state's need may be lower. In addition, conditions within a state may change significantly over a four-year period and have an impact on that state's need.
- **Changes in National and State Assessment Approaches**. State-specific needs will be affected by how the Assessment has evolved since the first Assessment was conducted in 1995. The Assessment's "bottom-up" approach of submitting and accepting documented needs on a project-by-project basis for each individually sampled system has remained essentially unchanged. However, since the first effort in 1995, significant changes that can have an impact on individual states needs have been implemented regarding the parties responsible for data collection, the type of documentation required to support acceptance of an identified need, and policies and approaches implemented to ensure complete and quality data collection by the states. While these changes in survey processes and policies likely had significant impacts on states' relative needs in the 2003 and 2007 Assessments, the 2011 Assessment was conducted with little difference from that of the previous 2007 effort (the exception being the surveying of American Indian and Alaska Native Village water systems) and impacts on relative state needs are likely insignificant. The 2011 Assessment provided some clarifications of the weight of evidence determination for accepting certain types of needs (see Appendix C), but these clarifications were intended only to facilitate the processing of project submissions and approvals, and were not intended to alter a project's allowability.


Water Infrastructure Finance Authority of Arizona
Drilling a well for the city of Winslow in northern Arizona.

Continuing Evolution of the DWINSA

Each DWINSA's approach, policies, and guidelines influenced the total national need and individual state needs reported for that effort. In all cases, specific project documentation requirements and data quality objectives were set by a workgroup including states and other stakeholders and maintained by EPA. If the 2003 Assessment represented a success in better capturing longer term needs than the 1995 and 1999 efforts, the 2007 Assessment's achievement was in helping guide states toward a more consistent methodology in assessing those types of needs. The 2011 Assessment maintains the improvements made in 2003 and 2007; EPA believes any changes in results reflect actual changes in needs rather than any change in surveying approaches or policies (note the exception being the first survey since 1999 of water systems serving American Indians and Alaska Native Villages). EPA's quadrennial Assessment will continue to evolve, with each cycle providing valuable input as to how the next Assessment can be improved. In addition, it is possible that challenges which were not significant in previous Assessments may arise and affect water utilities. EPA will work with the states to improve each survey while maintaining the integrity of the Assessment.

HUB Engineering

Tahlequah Water Treatment Plant in Oklahoma

City of Somerton, AZ

Solar array powering the city of Somerton's drinking water treatment facility in southwestern Arizona.

Key Observations on Each Assessment's Approach

1995

For the first survey, conducted in 1995, the DWSRF was not yet in existence and EPA worked directly with many utilities to complete the survey with limited involvement from the states. A state/EPA workgroup helped plan and design the Assessment. Some states participated in data collection; however, many were unable to invest resources beyond encouraging system cooperation. In addition, the 1995 Assessment included needs for raw water dams and reservoirs, projects that were later determined to be DWSRF-ineligible for future Assessments. (Note – while needs for dams and reservoirs were included in 1995 Assessment, these needs were removed in the calculation for the 1998 through 2001 DWSRF allotments.)

1999

For the 1999 Assessment, the federal DWSRF program had been established and project-eligibility criteria were defined that specifically excluded raw water dams and reservoirs. Therefore these infrastructure needs were not included in the 1999 Assessment. The DWINSA workgroup established Assessment policies regarding water meters, backflow-prevention devices, and service lines. Although these needs were considered allowable for the Assessment, constraints were placed on documentation of ownership and whether projects for their replacement could be included. New to the 1999 Assessment was the inclusion of the need of not-for-profit noncommunity water systems. Also, state programs were expected to participate in data collection for this Assessment.

2003

Refinements made to the survey instrument in 2003 encouraged systems and states to think more broadly about systems' existing infrastructure condition and deficiencies, particularly in regard to long-term needs for replacing or rehabilitating their existing infrastructure assets. Considerable effort was invested in promoting a comprehensive approach to inventorying existing assets and estimating the needs for likely rehabilitation or replacement over the next 20 years. EPA provided flexibility to surveyed water systems and their states to forecast these longer term needs. In the 2003 Assessment, states and systems responded with varying means of determining asset inventories and with different assumptions about the life cycles of those assets (e.g., estimates of when buried pipe would need to be replaced or rehabilitated). In addition, the workgroup amended policies regarding the replacement of water meters as an allowable need. In 1999, meter replacements were allowed only if documentation was provided indicating that the system owned the meter. In 2003, documentation of ownership was not required. These changes resulted in a significant increase in the total national need and an increase in most states' individual state needs. EPA's objective to better capture the true 20-year need was met, but the states and EPA agreed that a more consistent methodology should be pursued in the next Assessment effort.

2007

For the 2007 Assessment, EPA and the states came to a consensus that more consistency was needed across the states in regard to both methods for determining needs and each state's approach to capturing those needs. Building on the methods and approaches used by the states in the 2003 effort, consensus was reached on consistent policies regarding replacement and rehabilitation assumptions and documentation requirements to support survey-allowable projects. EPA's quality assurance reviews included significant efforts to ensure the policies were followed by all states.

2011

In planning for the 2011 Assessment, EPA and the states came to a consensus that the 2007 Assessment's weight of evidence approach used to determine the acceptance of needs for more unique and often large-scale projects needed more clarification and definition to better facilitate project submission and review. The weight of evidence approach was further defined as having three elements which must be supported by documentation: necessity, feasibility, and an indication of commitment to the project. Special emphasis was given to these terms, and examples from the 2007 Assessment were used in training provided to state and EPA Regional survey coordinators in preparation for the 2011 Assessment. These elements of the weight of evidence determinations are further described in Appendix C.

Chapter 3: Findings - American Indian and Alaska Native Village Need

American Indian and Alaska Native Village-Specific Needs

The 2011 Assessment is based on a statistically-designed survey of American Indian water systems and Alaska Native Village water systems. It is the first actual survey of these systems since 1999 and incorporates the many changes to EPA's approach and policies for estimating infrastructure needs that have evolved for the survey of non-tribal systems in 2003 and 2007.

Sara Ziff, EPA Region 9

The new elevated water storage tank at the Shungopavi village on the Hopi Tribe reservation. The community experienced water shortages prior to construction of the new tank.

Data were submitted for the American Indian and Alaska Native Village portion of the survey by tribal water systems in coordination with the Navajo Nation, EPA Regions, and Indian Health Service (IHS) Areas. Exhibit 3.1 presents the American Indian and Alaska Native Village water system need by EPA Region and by type of need.

Exhibit 3.1: 20-Year Need for American Indian and Alaska Native Village Systems by EPA Region (in millions of January 2011 dollars)*

EPA Region	Transmission and Distribution	Source	Treatment	Storage	Other	Total Need
Region 1	$2.5	$0.6	$0.9	$0.8	$0.4	$5.2
Region 2	$18.2	$1.4	$1.9	$2.4	$1.3	$25.2
Region 3†	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Region 4	$25.2	$4.7	$7.8	$5.6	$2.2	$45.4
Region 5	$111.2	$14.1	$25.2	$22.8	$11.0	$184.2
Region 6	$105.9	$11.4	$26.6	$24.1	$8.6	$176.6
Region 7	$21.4	$1.9	$4.3	$4.1	$1.7	$33.5
Region 8	$284.6	$22.2	$57.1	$63.9	$9.5	$437.3
Region 9‡	$1,185.8	$68.8	$153.2	$135.3	$53.4	$1,596.6
Region 10§	$118.3	$13.3	$27.4	$22.4	$10.3	$191.7
Alaska Native Village Systems	$272.0	$39.0	$170.7	$106.8	$4.9	$593.4
Total	**$2,145.1**	**$177.4**	**$475.1**	**$388.1**	**$103.3**	**$3,289.0**

* Numbers may not total due to rounding.
† There are no American Indian water systems in EPA Region 3.
‡ Navajo water systems are located in EPA Regions 6, 8, and 9, but for purposes of this report, all Navajo water system needs are reported in EPA Region 9.
§ Needs for Alaska Native Village water systems are not included in the EPA Region 10 total.

Exhibit 3.2 presents the historic need by EPA Region for the three Assessments in which data were collected for the American Indian and Alaska Native Village systems.

Exhibit 3.2: American Indian and Alaska Native Village Needs Reported by Survey Year (20-year need in millions of 2011 dollars)*

EPA Region	1995 Results in 2011 Dollars	1999 Results in 2011 Dollars	2011 Results
Region 1	$0.5	$5.9	$5.2
Region 2	$3.0	$8.9	$25.2
Region 3†	$0.0	$0.0	$0.0
Region 4	$25.6	$26.5	$45.4
Region 5	$67.7	$234.3	$184.2
Region 6	$56.7	$226.3	$176.6
Region 7	$9.4	$21.3	$33.5
Region 8	$156.8	$198.7	$437.3
Region 9‡	$526.3	$817.6	$1,596.6
Region 10§	$74.7	$176.2	$191.7
American Indian Subtotal	**$920.6**	**$1,715.8**	**$2,695.6**
Alaska Native Village Systems	$1,267.7	$1,589.8	$593.4
American Indian and Alaska Native Village Total	**$2,188.3**	**$3,305.6**	**$3,289.0**

* Numbers may not total due to rounding.
† There are no American Indian water systems in EPA Region 3.
‡ Navajo water systems are located in EPA Regions 6, 8, and 9, but for purposes of this report, all Navajo water system needs are reported in EPA Region 9.
§ Needs for Alaska Native Village water systems are not included in the EPA Region 10 total.

The 2011 DWINSA estimated 20-year needs are based on data that included asset inventories and planned infrastructure projects. Approximately 14 percent of the total projects submitted and approved in the survey were taken from the Indian Health Service (IHS) Sanitation Deficiency System (SDS). The SDS is a cumulative inventory of the sanitation deficiencies of American Indian and Alaska Native communities; IHS updates this inventory annually. These annual updates result in new projects and revisions to previous years' unfunded projects. The total weighted need associated with the SDS projects included in the 2011 DWINSA was $882 million or approximately 27 percent of the total American Indian and Alaska Native Village need. SDS projects were reviewed for acceptance to the survey based on the requirements of the Drinking Water State Revolving Fund (DWSRF) program and the policies of the 2011 DWINSA; no projects were removed from the survey data based on IHS's economic feasibility unit cost per home thresholds. However, some SDS projects submitted were not included because they were for a public water system not included in the survey sample, were for wastewater facilities, or no project description was provided. Projects were also removed if the need did not meet the eligibility criteria of the DWSRF program (e.g., if a project was deemed primarily for growth or for surface water intake impoundment construction).

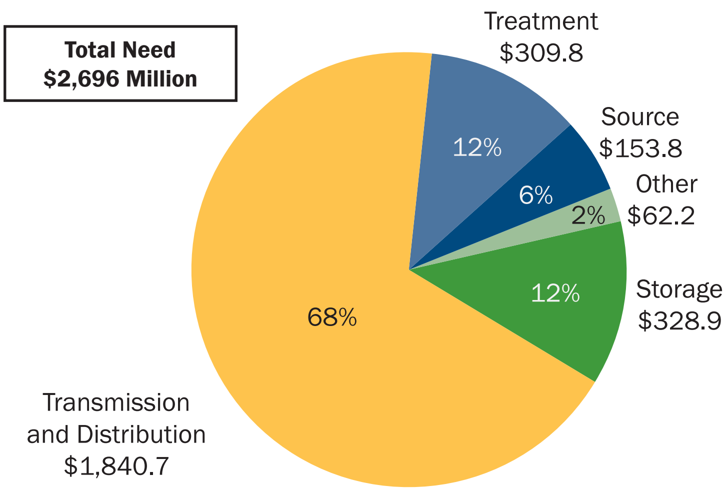
American Indian Needs

The total 20-year need for American Indian water systems is estimated to be $2.7 billion, significantly higher than the 1999 estimate of $1.7 billion. The increased American Indian water system need is most attributable to the changes in the survey methods and policies to better capture long term need underreported in previous surveys, primarily rehabilitation and replacement of distribution system piping based on infrastructure inventory. The 2011 American Indian water system survey also included a large regional project need on Navajo lands that was not yet planned during the 1999 survey. These results are an indication of likely improved asset inventory and project data from American Indian Tribes and other federal agencies, including IHS and the Bureau of Reclamation.

Additionally, this 2011 need includes more infrastructure to increase access to safe drinking water though connection of homes without water to existing public water systems. In 2011, according to the Indian Health Service data, while 91 percent of American Indian and Alaska Native Village homes had access to safe drinking water, 28,537 of the 32,900 (86.7 percent) tribal homes without access to safe drinking water were associated with American Indian Tribes. The remaining 4,356 of the 32,900 (13.3 percent) were located in the Alaska Native Villages.

Exhibit 3.3 shows the total American Indian water system need by project type. As would be expected for these systems, transmission and distribution is the largest category of need, representing 68 percent of the total need. This high percentage reflects the significant infrastructure and logistical challenges associated with American Indian water systems that must serve widely dispersed populations in remote locations.

Exhibit 3.3: Total 20-Year Need by Project Type For American Indian Water Systems (in millions of January 2011 dollars)



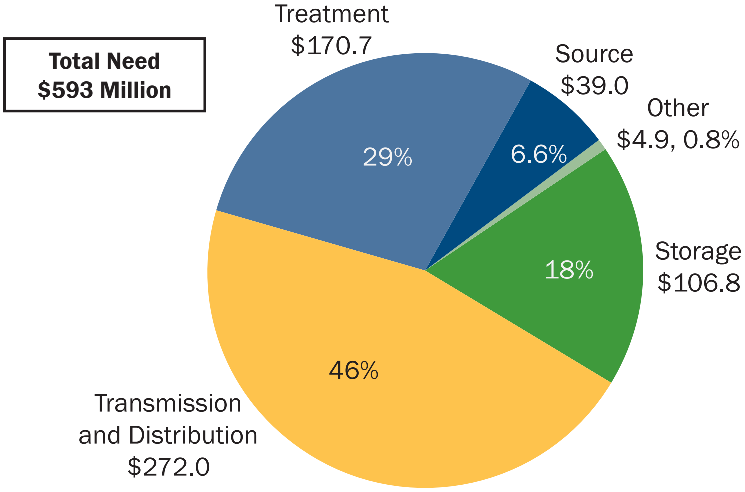
Note: Numbers may not total due to rounding.
(Excludes needs for proposed and recently promulgated regulations)

Alaska Native Village Needs

The 2011 total 20-year need for Alaska Native Village water systems is estimated to be $0.59 billion, significantly lower than the previous 1999 estimate of $1.59 billion. This difference is attributable in part to investments (an estimated $680 million in federal funding) that have been made over a fourteen year period (1999 to 2012) in Alaska Native Villages to improve access to safe drinking water.

Exhibit 3.4 shows the total Alaska Native Village water system need by project type. The need for Alaska Native Village water systems differs from more typical community water systems in that costs for piping in Alaska Native Village water systems make up less than half the need, with storage and treatment comprising a greater percentage of the total. These smaller communities with homes in close proximity typically have lower relative costs for piping and face higher treatment and storage costs. Both types of costs are higher than typical because of their remote or arctic conditions.

Exhibit 3.4: Total 20-Year Need by Project Type For Alaska Native Village Water Systems (in millions of January 2011 dollars)



Note: Numbers may not total due to rounding.
(Excludes needs for proposed and recently promulgated regulations)

Appendix A - Survey Methods


Chad Kolstad, Minnesota Department of Public Health

New surface water treatment plant in Fairmont, MN. The current plant was constructed in 1926 and needed to be replaced. The new plant will have biologically active GAC filters to help with taste and odor complaints.

The 1996 Safe Drinking Water Act (SDWA) Amendments direct the U.S. Environmental Protection Agency (EPA) to assess the needs of water systems and to use the results of the quadrennial Assessment to allocate Drinking Water State Revolving Fund (DWSRF) monies. The DWSRF monies are allocated based on each state's share of the total state need with a minimum of 1 percent of the state allotment guaranteed to each state, Puerto Rico, and the District of Columbia. The results of the Assessment are also used to allocate the percentage (recently 1.5 percent) of the DWSRF appropriation designated for the U.S. Territories. Therefore, the Assessment was designed to generate separate estimates of need for the U.S. Virgin Islands and the Pacific island territories (Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands). Further, the results of the Assessment are used, in part, to allocate the DWSRF appropriation (recently 2 percent) designated for the American Indian and Alaska Native Villages to nine EPA Regional Offices for grants to these water systems (EPA Region 3 does not have any federally recognized tribes). The DWINSA estimates the need for both community water systems and not-for-profit noncommunity systems.

The 20-year period captured by the 2011 Drinking Water Needs Survey and Assessment (DWINSA) runs from January 1, 2011, through December 31, 2030. The Assessment is based on a survey of approximately 3,165 water systems including 2,859 in states, Puerto Rico, the District of Columbia, and U.S. Territories and 306 American Indian and Alaska Native Village water systems. The 2011 Assessment also included an adjustment of findings from the 2007 Assessment for small water systems in states and the 1999 Assessment for the needs of not-for-profit noncommunity water systems in states. The survey of American Indian and Alaska Native Village water systems was conducted for the first time since the 1999 Assessment.

The assessment was developed in consultation with a workgroup consisting of the states, EPA regional coordinators and the Navajo Nation. The workgroup met several times by conference call and in person and reached a final consensus on the assessment's policies and processes. EPA also consulted with the Indian Health Service and through a consultation process provided the opportunity to all federally recognized American Indian Tribes and Alaska Native Villages to comment on the process for conducting the survey of public water systems in Indian Country.

Chad Kolstad, Minnesota Department of Health

10 Million Gallon Dale Street Reservoir for St. Paul Regional Water Service in Minnesota. The reservoir is a wire wrapped reservoir. Once the base was poured, the elaborate framing for forming the roof was done by local carpenters. Then the wall panels, which were poured on site, were set into place followed by the pouring of the roof. Finally, wire is wrapped around the wall panels and shotcrete is applied to the outside to protect the wires and waterproof the reservoir. The old reservoir was demolished and used as base material and fill for the project site.

Except where noted, the basic statistical and survey methodologies of the 2011 Assessment are nearly identical to those used in previous Assessments. Of particular note, the 2011 Assessment utilized the same survey method for the large and medium size systems as the 2007 Assessment, which is described in more detail later in this Appendix. The questionnaire used in the 2011 Assessment was essentially the same as the 2003 and 2007 Assessments' questionnaires.

In compliance with the Paperwork Reduction Act (PRA) (44U.S.C. 3501 et seq.), the survey design and instrument were reviewed and approved by the Office of Management and Budget (OMB). The Information Collection Request (ICR) for the survey can be accessed in the Federal Register/Vol. 76, No.45/Tuesday, March 8, 2011/Notices p12728.

Assessing the Needs of Water Systems in States and U.S. Territories

Frame

The frame is a list of all members (sampling units) of a population from which a sample will be drawn for a survey. For this Assessment, one frame consisted of all large and medium community water systems in each state, Puerto Rico, the District of Columbia, and the U.S. Territories. As discussed below, this Assessment used the result of the 2007 Assessment for small community water systems and therefore these were not included in this survey's sample frame. Also, separate sample frames were used for systems serving American Indians and for those serving Alaska Native Villages.

To ensure that the survey accounted for all community water systems in the nation, the universe of water systems was obtained from the federal Safe Drinking Water Information System (SDWIS-FED). SDWIS-FED is EPA's centralized database of public water systems. It includes the inventory of all public water systems and provides information regarding population served and whether a system uses ground water, surface water, or both.

Each state was asked to review the frame and verify or correct all information on each system's source water type and population served. EPA used this updated information to create a database of the universe of community water systems. A sample of systems was then selected from this updated frame.

Stratified Sample

Because there are thousands of medium and large community water systems in the nation, EPA must rely on a random sampling of these systems identified in the frame. EPA set a precision target of ± 10 percent with 95 percent confidence. To meet this target, all large systems were surveyed and a random sample of medium systems was selected in each fully surveyed state.

To determine aggregated needs, water systems are grouped (stratified) by size (population served) and by source (surface or ground water). Exhibit A.1 shows the possible population and source water strata for the state survey.

Exhibit A.1: Stratification of the State Community Water System Survey

<table>
<tr><th></th><th colspan="2">Population</th><th>Surface Water</th><th>Ground Water</th></tr>
<tr><td>Large</td><td colspan="2">> 100,000</td><td colspan="2">Sampled with certainty - All systems receive questionnaire</td></tr>
<tr><td rowspan="4">Medium</td><td colspan="2">50,001 - 100,000</td><td colspan="2" rowspan="4">State-specific samples for fully surveyed states</td></tr>
<tr><td>25,001 - 50,000</td><td rowspan="2">or 10,001 - 50,000*</td></tr>
<tr><td>10,001 - 25,000</td></tr>
<tr><td colspan="2">3,301 - 10,000</td></tr>
<tr><td colspan="5">*In some states, systems serving 10,001 - 50,000 can be considered one stratum and precision targets can be met. The most efficient sample is drawn from each state.</td></tr>
</table>

For the purposes of assigning a population to each system, consecutive populations are included in the system population because of the assumption that, in general, critical infrastructure of the selling-system would need to be sized to accommodate the demand of the population directly served by the system and the consecutive population.

Systems are categorized as surface water if they have at least one source that is surface water or ground water under the direct influence of surface water (GWUDI). Systems are categorized as ground water if they do not have a surface water or GWUDI source. The ground water category includes ground water systems and systems that do not have a source of their own and purchase finished water from another system (regardless of whether the purchased water comes from a surface water or ground water source). The decision to include purchased water systems in the ground water systems category was based on the 1995 Assessment's findings that, in general, indicated the needs of purchased water systems more closely resemble those of ground water systems than of surface water systems with source water treatment.

Conducting the Survey of Large Systems

For the 2011 Assessment, a large system is defined as serving more than 100,000 persons, either through direct connections or as a wholesale water system. Because of the unique nature of systems in this size category and because they represent a large portion of the nation's need, these systems are sampled with certainty, meaning that all systems receive a questionnaire. The 100,000 persons cut-off was the same as used in the 2007 Assessment; in the previous Assessments (1995, 1999, 2003), the large system category was defined as systems serving populations of more than 40,000 or 50,000.

Each large system was asked to complete the questionnaire and return it along with accompanying documentation to its state coordinator. The state coordinators reviewed the

Exhibit A.2: Medium and Large Community Water System Sample Size

State	Total Number of Systems in Inventory			Number of Systems Selected in Sample		
	Population Served			Population Served		
	3,301 - 100,000	More Than 100,000	Total Number Medium and Large Systems	3,301 - 100,000	More Than 100,000	Total Number Medium and Large Systems
Alabama	332	16	348	115	16	131
Alaska	-	1	1	-	1	1
Arizona	120	10	130	29	10	39
Arkansas	177	4	181	77	4	81
California	554	133	687	58	111	169
Colorado	148	11	159	48	11	59
Connecticut	51	6	57	30	6	36
Delaware	-	2	2	-	2	2
District of Columbia	-	1	1	-	1	1
Florida	307	49	356	73	49	122
Georgia	213	24	237	43	22	65
Hawaii	-	2	2	-	2	2
Idaho	-	1	1	-	1	1
Illinois	435	25	460	79	19	98
Indiana	205	9	214	73	9	82
Iowa	135	3	138	46	3	49
Kansas	109	6	115	56	6	62
Kentucky	252	5	257	134	5	139
Louisiana	223	8	231	57	8	65
Maine	34	1	35	24	1	25
Maryland	54	5	59	20	5	25
Massachusetts	244	9	253	63	9	72
Michigan	279	14	293	48	14	62
Minnesota	176	3	179	87	3	90
Mississippi	198	1	199	103	1	104
Missouri	204	9	213	110	8	118
Montana	-	1	1	-	1	1
Nebraska	-	2	2	-	2	2
Nevada	30	5	35	10	5	15
New Hampshire	-	1	1	-	1	1

questionnaires to ensure that the systems included all their needs, the information entered on the questionnaire was correct, and the projects were eligible for DWSRF funding. During their state reviews, states often contacted systems to obtain additional information. The states then submitted the questionnaire and all documentation to EPA for a final review.

Of the 606 large systems that received a survey for the 2011 Assessment, 598 completed the questionnaire—a response rate of 98.6 percent. Exhibit A.2 shows the number of large systems in the frame as well as the medium and large system sample size for each state.

Exhibit A.2: Medium and Large Community Water System Sample Size, cont.

State	Total Number of Systems in Inventory			Number of Systems Selected in Sample		
	Population Served			Population Served		
	3,301 - 100,000	More Than 100,000	Total Number Medium and Large Systems	3,301 - 100,000	More Than 100,000	Total Number Medium and Large Systems
New Jersey	225	17	242	45	16	61
New Mexico	-	1	1	-	1	1
New York	333	25	358	24	25	49
North Carolina	257	17	274	63	17	80
North Dakota	-	-	-	-	-	-
Ohio	305	15	320	75	15	90
Oklahoma	161	4	165	81	4	85
Oregon	109	5	114	43	5	48
Pennsylvania	326	23	349	58	23	81
Puerto Rico	101	5	106	48	5	53
Rhode Island	-	1	1	-	1	1
South Carolina	-	8	8	-	8	8
South Dakota	-	1	1	-	1	1
Tennessee	241	8	249	75	8	83
Texas	915	65	980	90	47	137
Utah	100	9	109	41	9	50
Vermont	-	-	-	-	-	-
Virginia	130	20	149	36	19	55
Washington	200	13	213	45	13	58
West Virginia	-	1	1	-	1	1
Wisconsin	175	6	181	52	6	58
Wyoming	-	-	-	-	-	-
Subtotal	**8,059**	**610**	**8,669**	**2,159**	**560**	**2,719**
American Samoa	1	-	1	1	-	1
Guam	-	1	1	-	1	1
North Mariana Is.	1	-	1	1	-	1
Virgin Islands	2	-	2	2	-	2
Subtotal	**4**	**1**	**5**	**4**	**1**	**5**
Total	**8,063**	**611**	**8,674**	**2,163**	**561**	**2,724**

*A dash indicates the state had no systems in that population category or was a partially surveyed state.

Conducting the Survey of Medium Systems

Medium systems, as defined for the 2007 Assessment, serve between 3,301 and 100,000 persons. Exhibit A.2 shows the number of medium systems in the frame and sample by state. States with a dash in the medium system sample column opted not to collect data for these systems.

For the 2011 Assessment, states that received the minimum one-percent DWSRF allotment in the 2007 Assessment were given the option of not participating in data collection for medium-sized systems. This option was provided in order to reduce burden on the small states that receive the same allotment regardless of the findings of the survey. Of the minimum allocation states, 15 chose not to participate in this portion of the survey. The medium system need for states that chose this option was estimated based on data from participating states. Because this method does not meet the Assessment's formal precision targets at the state level, the needs of these partially surveyed states contribute to the estimate of the total national need, but medium system need is not reported individually by state.

For states that participated in the medium system portion of the survey, the data collection process was similar to that of large systems with the system completing the survey, the state providing input, and the final review conducted by EPA.

Once the need for systems in the fully surveyed states was calculated, it was used to determine the need for the partially surveyed states. An average need per stratum from fully surveyed states was calculated and applied to the inventory of systems in the partially surveyed states.

Of the 2,234 medium systems that were randomly selected and received a survey, 2,159 completed the questionnaire for a response rate of 96.6 percent.

Conducting the Assessment for Small Systems

The infrastructure need reported for small systems serving 3,300 persons or fewer is based on the findings of the 2007 Assessment. Because of the high level of confidence in the findings from 2007 field survey of small water systems and resource constraints, EPA did not survey these systems again in 2011. Instead, EPA used the projects reported for the 2007 Assessment, applied the 2011 cost models, used the 2011 inventory of small systems, and converted all costs to 2011 dollars to estimate the 2011 needs for these systems.

System Weight

For the large and medium sized systems surveyed, the 2011 Assessment assigned weights to the findings from each surveyed water system to determine total state needs. Because all large systems are included in the survey, each large system has a weight of one. The state need for large systems was determined by summing the cost of each project for each system and then summing the need for each large system in the state. Systems were not re-weighted for non-response.

For medium systems, EPA determined the number of water systems that must be included in each stratum in order to achieve the desired level of precision. The surveyed systems were selected and assigned an initial weight for their specific state equal to the total number of systems in that stratum divided by the number of systems in that stratum's sample. A final weight was recalculated for each stratum with adjustments for non-response and systems changing stratum (population or source changes). Each fully surveyed state's need for medium systems was determined by summing the cost of each project for each system, and then multiplying each system's need by the system's final weight.

The number of medium sized water systems selected from each stratum was determined by the total number of systems in that stratum (shown in Exhibit A.1), the percentage of that state's need represented by that stratum in the most recent Assessment, and the relative variance of the need within that stratum in the most recent Assessment. The sample is allocated among the strata in a manner that lets the survey achieve the desired level of precision with the smallest sample size for each state.

Assessing the Need of Not-for-Profit Noncommunity Systems in the State Survey

Not-for-profit noncommunity water systems (NPNCWS) are eligible for DWSRF funding. The 2011 need for NPNCWSs was based on the findings of the 1999 Assessment in which a statistical survey of these systems was conducted. These findings were adjusted to January 2011 dollars using the Construction Cost Index (CCI).

During the 1999 Assessment, EPA collected data from a national sample of 100 NPNCWSs through site visits. Unlike the sampling design for community water systems, the NPNCWS sample was not stratified into size and source categories because EPA lacked the empirical information on variance necessary for developing strata. The sample used for the 1999 Assessment for NPNCWSs was designed to provide a 95 percent confidence interval that is within a range of ± 30 percent of the estimated need.

The national need for NPNCWSs was allocated among the states in proportion to the 1999 inventory of NPNCWSs in each state in a manner similar to that used for small systems.

EPA Region 2

Hydrants were recently upgraded in Seaford, DE along with the associated water mains, service lines, and meter pits.

Assessing the Need of American Indian and Alaska Native Village Water Systems

Frame

Similar to the state survey, a frame was established for all water systems identified as serving federally-recognized American Indian community and not-for-profit noncommunity water systems for which EPA and the Navajo Nation have primacy under SDWA. Another frame was established of community and not-for-profit noncommunity water systems serving Alaska Native Villages. The universe of water systems was obtained from SDWIS-FED, and EPA Regional Offices and the Navajo Nation primacy agency were asked to review the American Indian and the Alaska Native Village frames and verify or correct all information on these systems as well. EPA used this verified information to create a database of the universe for these two frames and a sample of systems for each of these frames was then selected for surveying.

Stratified Sample

Because there are hundreds of American Indian and Alaska Native Village water systems, EPA relied on a random sampling of the systems identified in the frame. EPA set a precision target of ± 10 percent with 95 percent confidence, the same as used for the state survey. To meet this target, all American Indian and Alaska Native Village systems serving a population of over 3,301 were surveyed. A national random sample of small (serving populations of 3,300 or fewer) American Indian systems was selected as well as a random sample of small Alaska Native Village systems.

To determine aggregated needs, water systems are grouped (stratified) by size (population served) and by source (surface or ground water). Procedures for defining population served and the source water categorization were the same as for the state survey. Exhibit A.3 shows the possible population and source water strata for the American Indian and Alaska Native Village water system survey. Exhibit A.4 shows the frame and sample size for the American Indian and Alaska Native Village water system surveys.

For the 2011 Assessment, the infrastructure needs reported for American Indian water systems were based on the statistically-determined sample of 220 water systems and needs for Alaska Native Villages were based on the statistically-determined sample of 86 water systems. Survey data were collected from 178 American Indian water systems for which EPA has primacy and 40 American Indian water systems for which the Navajo Nation has primacy for a response rate of 99 percent. Survey data were collected from 84 of the public water systems that have been designated as serving Alaska Native Villages, for a 98 percent response rate. The data collected from these systems were then used to estimate the overall need for the total 791 American Indian and 165 Alaska Native Village public water systems.

Exhibit A.3: Stratification of the American Indian and Alaska Native Village Survey

American Indian and Alaska Native Village Survey	Population	Surface Water	Groundwater
Medium	>3,301	Sampled with certainty - All systems receive a questionnaire	
Small	1,001-3,300	National Sample of American Indian Systems and Sample of Alaska Native Village Systems	
	501-1000		
	25-500		

Exhibit A.4: American Indian and Alaska Native Water System Sample Size

EPA Region	Total Number of Systems in Inventory			Number of Systems Selected in Sample		
	Population Served			Population Served		
	3,300 and Fewer	3,301 - 100,000	Total Number Small and Medium Systems	3,300 and Fewer	3,301 - 100,000	Total Number Small and Medium Systems
Region 1	6	-	6	-	-	-
Region 2	7	2	9	2	2	4
Region 3	-	-	-	-	-	-
Region 4	18	1	19	6	1	7
Region 5	80	11	91	16	11	27
Region 6	61	11	72	12	11	23
Region 7	13	-	13	6	-	6
Region 8	102	10	112	15	8	23
Region 9	333	35	368	71	34	105
Region 10	93	8	101	19	6	25
Alaska Native Systems	161	4	165	82	4	86
Total	**874**	**82**	**956**	**229**	**77**	**306**

Conducting the Survey

As with the systems surveyed by the states, these systems completed the survey questionnaire facilitated by the EPA Regional Office or by the Navajo Nation primacy agency. Assistance was also provided by the Indian Health Service Areas as described in Chapter 3. The EPA Regions and Navajo Nation primacy agency then submitted the questionnaire and all documentation to EPA Headquarters for a final review.

System Weight

The 2011 Assessment assigned weights to the findings from each surveyed water system to determine the total American Indian and the total Alaska Native Village needs.

Because all medium size systems (serving 3,301 or more) are included in the survey, each of these systems has a weight of 1. Their need was determined by summing the cost of each project for each system and then summing the need for each system in each survey. Medium systems were not re-weighted for non-response.

For small American Indian or Alaska Native Village systems, EPA determined the number of systems that must be included in each stratum in order to achieve the desired level of precision. These surveyed systems were selected and assigned an initial weight for their specific survey equal to the total number of systems in that stratum divided by the number of systems in that stratum's sample. A final weight was recalculated for each stratum with adjustments for non-response and systems changing stratum (population or source changes). The need for these systems was determined by summing the cost of each project for each system and then multiplying each system's need by the system's final weight.

After data collection, the needs of systems in the American Indian Survey were assigned to each EPA Region by multiplying the average small system need per stratum by the number of small systems in that stratum (from the inventory of small systems) and adding the medium system need that is specific to that EPA Region. It is important to note that conducting a survey in this manner allows for consistent estimation of project needs across all surveyed systems.

Climate Readiness

Although EPA did not create a new category of need to capture data for projects that are related to climate readiness, EPA provided a "Regulatory or Secondary Purpose" code that the system could enter on the survey questionnaire to identify a project as being related to climate readiness. For projects identified as related to climate readiness, the system was also asked to identify the concern (e.g. source water quality, source water quantity, and infrastructure vulnerability) and to describe the type of information driving the concern (e.g. meteorological models, scientific reports, staff analysis).

EPA requested this information to indicate the general extent to which water systems have currently incorporated climate change readiness strategies into their capital infrastructure projects. EPA did not specify criteria for identifying these projects; projects were identified as being related to climate readiness based on the professional judgment of the water system.

Green Projects

Similarly, although not a new category of need, to capture data for projects that include one or more components that are considered green, EPA provided multiple "Regulatory or Secondary Purpose" codes. Systems would enter the applicable code on each project that was identified as including a green component or purpose. Instructions to survey participants made clear that coding a project as having a green component or purpose will not affect current or future SRF eligibility or requirements.

A list of possible projects for each green category that was provided with the survey packages to participants is provided in Exhibit A.5.

Exhibit A.5: Examples of Project Components that may be Considered "Green"[1]

Green Infrastructure	• Pervious or porous pavement, bioretention, green roofs, rainwater harvesting/cisterns, and xeriscape that are included as part of a larger capital infrastructure project

Water Efficiency	• Installing any type of water meter in previously unmetered areas
	• Replacing existing broken/malfunctioning water meters or upgrading existing meters with:
	  ◦ Automatic meter reading systems (AMR) such as:
	    ▪ Advanced metering infrastructure (AMI)
	    ▪ Smart meters
	  ◦ Meters with built-in leak detection
	• Pressure reducing valves (PRVs)
	• Internal plant water reuse (such as backwash water recycling)

Energy Efficiency	• Renewable energy generation which is part of a larger capital infrastructure project • Energy efficient retrofits and upgrades to pumping systems and treatment processes • Pump refurbishment to optimize pump efficiency • Projects that result from an energy efficiency related assessment (such as an energy audit, energy assessment study, etc) • Installation of variable frequency drives (VFDs) • Automated and remote control systems (such as SCADA) that achieve substantial energy efficiency improvements • Upgrade of lighting to energy efficient sources for security or as part of a larger project
Environmentally Innovative Activities	• US Building Council LEED certified water system facilities that are part of an eligible DWSRF project.

[1]States may have included other types of green projects or components.

Cindy McDonald , State of Kentucky Department of Environmental Protection

Generator in Madisonville, KY.

Appendix B - Data Collection

To determine the scope of water systems' 20-year need, data are collected in the form of capital improvement projects. States and other agencies work with the surveyed systems to identify applicable projects. To be included in EPA's Assessments, each project had to meet each of the following four criteria:

- The project must be for a capital improvement.
- The project must be eligible for Drinking Water State Revolving Fund (DWSRF) funding.
- The project must be in furtherance of the public health protection goals of the Safe Drinking Water Act (SDWA).
- The project must be submitted with supporting information that documents the three other criteria are met.

Projects included in the Assessment generally fall into one of two categories that describe the reason for the project:

- Replacement or rehabilitation of existing infrastructure due to age or deterioration.
- New or expanded infrastructure to meet an unmet need for the current population or to comply with an existing regulatory requirement.

Projects for infrastructure generally expected to need rehabilitation or replacement in the 20-year period covered by the Assessment were accepted with minimal documentation describing their scope and the reason for the need. However, other types of projects required independently generated documentation that not only identified the need but also showed clear commitment to the project by the water system's decision-makers. Exhibit B.1 summarizes the types of projects that were included and the types that were unallowable.

For the purposes of assigning a cost to each need, the survey required that the water system either provide an existing documented cost estimate or the information necessary for EPA to assign a cost. This information was referred to as the "design parameter" and is discussed in more detail in this Appendix.

Survey Instrument

As with previous Assessments, the 2011 questionnaire was the survey instrument for reporting all needs. All large water systems and a random sample of medium systems were mailed a survey package, which included the questionnaire, instructions for completing the

American Water Works Association

Exhibit B.1: DWINSA Allowable and Unallowable Projects

DWINSA Allowable Projects	DWINSA Unallowable Projects
Criteria: • Eligible for DWSRF funding • Capital improvement needs • In furtherance of the public health goals of the SDWA • Within the Assessment time frame • Adequate documentation Project Types: • New or expanded/upgraded infrastructure to meet the needs of existing customers • Replacement or rehabilitation of existing undersized or deteriorated infrastructure	• Raw water reservoir- or dam-related needs • Projects needed primarily to serve future population growth • Projects solely for fire suppression • Projects for source water protection • Non-capital needs (including studies, operation and maintenance) • Needs not related to furthering the SDWA's public health objectives • Acquisition of existing infrastructure • Projects not the responsibility of the water system • Needs associated with compliance with proposed or recently promulgated regulations (Derived instead from EPA's economic analyses and added to the national total) • Projects or portions of projects started prior to January 1, 2011 • Projects or portions of projects needed after December 31, 2030

questionnaire, and a list of codes used to convert the information to a database format. These documents were also used by the site visitors for recording small system needs in the 2007 survey, as well as for all American Indian and Alaska Native Village water systems in the 2011 survey.

The instructions provided to the water systems included information on the background and purpose of the Assessment as well as how to identify projects that should be included in the questionnaire. In addition to infrastructure needs, the survey also requested basic information from the water systems such as the size of the population served, the number of service connections, the production capacity, the source water type, and the system's ownership type. This information was compared to the information used for the sample frame. Discrepancies in source and population were investigated to ensure accurate information was used for the statistical sample.

Project Documentation

Each project listed on the questionnaire was required to have accompanying written documentation of its scope and why it was needed. Written documentation included master plans, capital improvement plans, sanitary survey reports, and other sources of project information. Whether the documentation could be written for the 2011 Assessment or had to be pre-existing depended on the type of project that was described. All documentation for every project was reviewed by EPA to ensure that the project met the allowability criteria for the Assessment. See Appendix C for more information on the project allowability policies.

Cost Estimates and Modeling

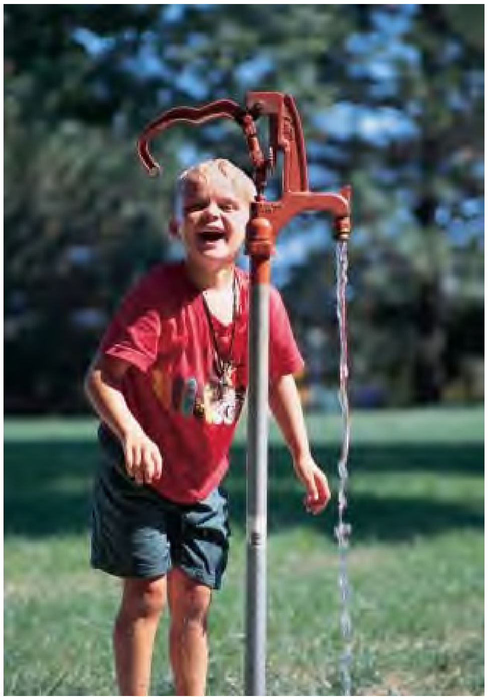
As with previous Assessments, costs assigned to projects were obtained in one of two ways. If the system had an existing documented cost estimate that met the documentation criteria of the survey, this cost was adjusted to 2011 dollars and used for that system's need. This is the preferred approach for assigning a cost to a project. If no cost estimate was available, the system was asked to provide information (design parameters) necessary for EPA to model the cost of the project. Cost models were built from the documented cost estimates provided by other survey respondents.

Acceptable forms of documentation for cost estimates were capital improvement plans, master plans, preliminary engineering reports, facility plans, bid tabulations, and engineer's estimates that were not developed for the 2011 Assessment. Each project with an associated cost was required to provide the month and year of the cost estimate in order to allow an adjustment of the cost to January 2011 dollars.

Systems that had cost estimates were encouraged to submit design parameters regarding size or capacity of the infrastructure. For example, a tank is described in terms of volume in millions of gallons, treatment plants are based on capacity in millions of gallons per day, and pipe parameters are in diameter and length. Over 70 project types of need were used to describe projects and link design parameters to cost. This combination of the specific type of project, costs, and parameters was used as input to develop cost models. Prior to input to the cost models, the cost estimates were normalized for both time frame and location. Cost estimates prior to January 2011 were adjusted to January 2011 dollars using the Construction Cost Index (CCI). Regional variations in construction costs were normalized by location using the RS Means "Location Factors Index." RS Means is a subsidiary of Reed Construction which publishes an annual index used to calculate construction costs for a specific location. The factor multiplier is expressed as a relationship to the national average of one.

Although over 70 different types of need were used, a few project types could not be modeled. These types of need were unique to individual systems and did not lend themselves to modeling (examples include de-stratification of a surface water source, pump controls and telemetry, and security features other than fencing).

Ultimately some projects were not able to be assigned a cost because a cost estimate from the system was not provided and project information submitted on the survey did not include the necessary design parameters required for modeling.

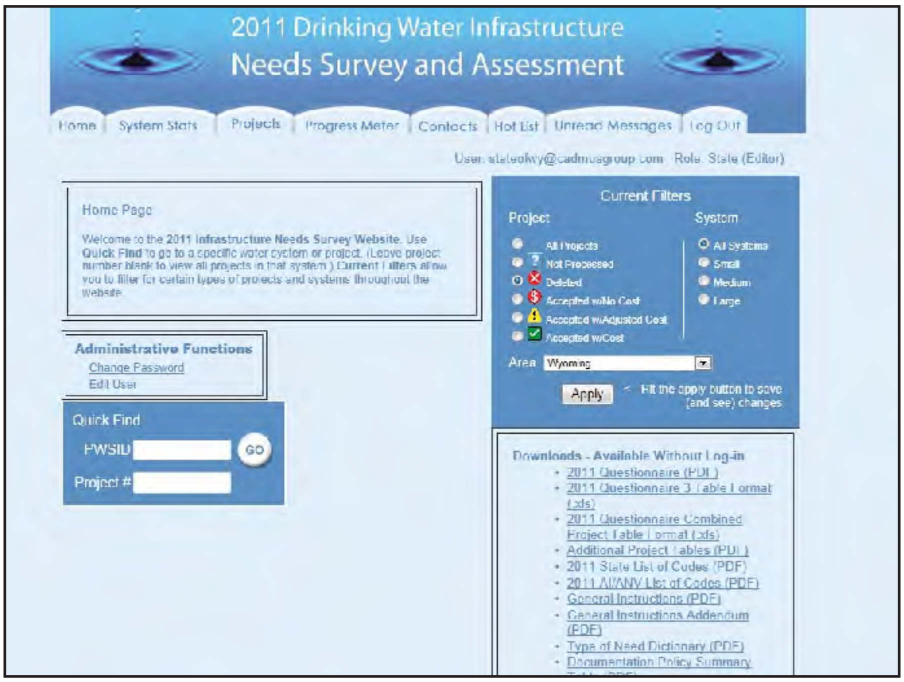


American Water Works Association

Web Site and Database

EPA used a 2011 survey-specific Web site to provide an efficient method of tracking and monitoring questionnaire responses for survey coordinators. The Web site allowed controlled viewing of survey information and provided a means to provide additional project information if needed. Water systems, state contacts, Navajo Nation, and EPA had secure login access to the Web site. The Web site was a modification of the one used successfully for the 2003 and 2007 Assessments.

Once logged into the Web site, water systems had access to their own project data, states had access to all project data for the water systems in their state, and EPA regional offices had access to the project data of states within their region. Web site users were given "read only" or "read/write" access depending on whether information posted to the Web site could be changed by that entity. This created a transparent process and open communication between systems, states, and EPA while also maintaining a secure environment so that persons without reason to see the data did not have access.



A screen shot from the DWINSA Web site.

The Web site also served as a means of communication between survey coordinators and EPA. As EPA completed the quality assurance reviews of each questionnaire, the information was uploaded to the Web site database along with specific indications of any changes that had been made to the projects and why the changes were implemented.

Each survey coordinator was able to view all its systems' projects and submit additional information for projects that had been changed or deemed unallowable through EPA's quality assurance review.

Quality Assurance

As with all four earlier Assessments, the findings of the 2011 Assessment are reinforced by adherence throughout the project to the principles embodied in the EPA Guidelines for Ensuring and Maximizing Information Quality. The most fundamental assurance of the high degree of information quality is the implementation of the Agency's Quality System. EPA implements the system through the development of a quality assurance project plan (QAPP) for each project, which details the specific procedures for quality assurance and quality control.

Because the Agency uses the results of this Assessment to allocate DWSRF capitalization grants to states, this Assessment (like those that preceded it) sought to maximize the accuracy of the state-level and American Indian and Alaska Native Village estimates of infrastructure needs. Decisions about precision levels, policies, and procedures were established by a survey coordinators workgroup that met regularly during the 2011 Assessment.

Accuracy was maximized at the national, state, system, and project levels through the following steps. First, since this was a sample survey, the workgroup established targets for precision of estimates in the sampling to shape the national sample design. These precision targets are discussed in Appendix A.

Second, EPA used quality assurance procedures from the QAPP to ensure that "eligible infrastructure" was clearly defined and that documentation standards were rigorously enforced. As noted previously, for a project to be included in the 2011 Assessment, documentation had to be submitted describing the purpose and scope of each project. The documentation was reviewed by EPA to determine whether each project met the eligibility criteria. The workgroup established the documentation requirements so that uniform criteria were applied to all questionnaires.

Of the 97,092 projects submitted to the survey, EPA accepted 85 percent. The 15 percent that were not allowed failed to meet the documentation criteria or appeared to be ineligible for DWSRF funding. Some projects were adjusted to correct a variety of measurement problems, such as overlap between two projects (raising the issue of double-counting), inconsistency of recorded data with project documentation, and the use of overly aggressive (short) infrastructure life cycles by states where system planning documents were not used or available.

Third, after the survey review process, the project data were entered into a database using dual data entry procedures to ensure the information was correctly transferred. The uploaded data then went through a systematic verification process to identify any outliers or data-entry errors. Each project, the systems' source water type, total pipe length, population, and number of connections were reviewed for any unusual entries. The data were then compared at the state and national levels to identify any outliers in the data. EPA investigated the outliers by reviewing the system's project documentation. If the documentation did not provide enough information to verify the project, EPA contacted the survey coordinator or the system for confirmation.

Oklahoma Department of Environmental Quality

High Service Pump Station at Washington RWD #3 in Oklahoma.

Appendix C - Policies

EPA recognizes that it is critical to the credibility of the 2011 Assessment and fairness to the states that EPA work with the DWINSA workgroup to set clear and well-defined data collection policies and for EPA to apply these policies consistently to all systems. The policies are aimed at ensuring that the Assessment meets its Congressional intent, maintains the credibility of the findings, and establishes a level playing field. To this end, the policies developed ensure two essential criteria — that only allowable needs be included, and that all needs be adequately documented according to Assessment criteria.

Oklahoma Department of Environmental Quality

Clearwell at the Broken Arrow Municipal Authority in Oklahoma.

Project Allowability

Because the findings of the Assessment are used to allocate DWSRF monies, only needs associated with DWSRF-eligible projects are included in the findings. Eligibility criteria for the DWSRF are established in the Safe Drinking Water Act. SDWA Section 1452(a)(2) states that DWSRF funds may be used:

> *"only for expenditures (not including monitoring, operation, and maintenance expenditures) of a type or category which the Administrator has determined, through guidance, will facilitate compliance with national primary drinking water regulations applicable to the system under Section 1412 or otherwise significantly further the health protection objectives of this title...."*

Needs are submitted in the form of capital infrastructure projects. To be considered an allowable need, a project must be eligible for DWSRF funding, be in furtherance of the public health protection objectives of SDWA, fall within the prescribed 20-year time frame (January 1, 2011, through December 31, 2030), and be adequately documented.

Projects Must Be for a Capital Improvement Need

Projects that do not address a specific, tangible capital infrastructure need are not included. Non-capital needs include operational and maintenance costs, water rights or fee payments, conducting studies, computer software for routine operations, and employee wages and other administrative costs.

Projects Must Be Eligible for DWSRF Funding

Projects ineligible for DWSRF funding are identified in the DWSRF regulation and include:

- Dams or the rehabilitation of dams.
- Water rights.
- Raw water reservoirs or rehabilitation of reservoirs (except for finished water reservoirs and reservoirs that are part of the treatment process and are on the property where the treatment facility is located).
- Projects needed primarily for fire protection.
- Projects needed primarily to serve future population growth. (Projects needed to address a deficiency affecting current users must be sized only to accommodate a reasonable amount of population growth expected to occur over the useful life of the facility.)

Projects Must Be in Furtherance of the Public Health Goals of the SDWA

Projects that are driven by objectives not based on public health protection and the goals of the SDWA are not included in the survey. These needs can include projects for improving appearances, infrastructure demolition, buildings and parking facilities not essential to providing safe drinking water, acquisition of land for an unallowable project, and infrastructure needed to extend service to homes that currently have an adequate safe drinking water supply.

Projects Must Fall Within the 20-Year Period of the Assessment

Projects for which construction began prior to January 1, 2011, and projects that are not needed until after December 31, 2030, fell outside the time frame for the Assessment and were not included.

Projects Must Be Adequately Documented

Project documentation is a critical piece of the Assessment's credibility and fairness. It is described in more detail later in this Appendix.

Other Unallowable Needs

Besides the project criteria discussed above, other limitations established by the workgroup were:

- Infrastructure needs that occur more than once during the 20-year survey period could be listed only once on the survey.
- Multiple projects meeting the same need, such as rehabilitating a tank and later replacing the same tank, could not all be included.

- Projects for compliance with specific proposed or recently promulgated regulations were not accepted from water systems. These costs were instead estimated and added to the national total by EPA directly.
- Projects driven solely by a non-water-related issue such as highway relocation were not included.
- Projects to acquire existing infrastructure were not considered capital infrastructure costs.
- Most vehicles and tools were considered operation and maintenance costs.
- Projects that are not the responsibility of the public water system, such as homeowners' portions of service line replacements, were not included.

If projects associated with an unallowable need were submitted, they were excluded from the Assessment by EPA. EPA understands that these projects often represent legitimate and even critical needs that a water system must pursue to continue to provide service to its customers. However, because they do not meet the allowability criteria they are not the subject of the DWINSA.

Documentation Requirements

The 2011 Assessment essentially maintained the documentation requirements established for the 2003 Assessment and improved upon by the 2007 Assessment effort. In particular, EPA and the workgroup came to consensus to incorporate the same improvements used by the 2007 Assessment to ensure a consistent approach to data collection and to the assessment of need applied by each survey coordinator.

High-quality documentation is required to justify the need for a project, defend cost estimates provided by the water system, provide a defensible assessment of national need, and ensure fair allotment of DWSRF monies. The documentation of need and cost for each project was carefully reviewed to ensure that the criteria set in the DWINSA approach and established by consensus of EPA and the workgroup were met.

For the assessment of infrastructure needs for systems serving American Indian and Alaska Native Villages, it should be noted that the 2011 documentation requirements were considerably different than those employed in 1999, but were consistent with all other documentation requirements for the 2011 survey.

Cindy McDonald, Kentucky Division of Water

Deteriorated ground storage tank in Kentucky.

Types of Documentation

In an effort to ensure more consistency in each state's approach to the assessment of its water systems' needs, the workgroup defined for the 2007 Assessment, and retained for the 2011 effort, three types of documentation that could be provided to describe a need or provide a cost:

Independent Documentation. A document or report generated through a process independent of the Assessment. Because these documents were not generated specifically for the Assessment, it is assumed that there is no intentional bias of over reporting of need.

Survey-generated Documentation. A statement or document discussing the need for a project generated specifically for the Assessment by the system, the state, the EPA Region (for American Indian and Alaska Native Village water systems), or Navajo Nation.

Combination Documentation. A combination of independent and survey-generated documentation to justify project need or cost. Independent documentation does not always directly address the reason a project is being pursued by a system and therefore may not fully establish that the project meets the survey's allowability criteria. Systems often added survey-generated documentation to independent documents to clarify the need for the project.

Documentation of Need

Documentation explains the scope of the project, explains why the project is needed, and gives an indication of the public health need that would be addressed by the project. In order for the project to be accepted, the documentation of need must:

- Provide sufficient information for EPA to review the allowability of the project.
- Provide adequate data to check the accuracy of the data entered on the questionnaire.
- Be dated and be less than 4 years old.

The type of documentation required varied by the specific project type. Minimum requirements were set to

Weight of Evidence

Documentation must include adequate system-specific and project-specific details to verify that the project meets the allowability criteria and that the project is needed. For the 2011 Assessment, three specific weight of evidence criteria had to be supported by documentation. The project had to be shown to be:

- Necessary to meet the requirements of the Safe Drinking Water Act and for public health purposes;
- Feasible by being typical of today's water engineering standards and practices; and
- Committed to by relevant decision-makers as specified in supporting documents or by a standing history of such commitment to similar projects, as common practice by the industry, or made evident in the documentation as a standing policy by the specific water system, state, or other relevant authority.

allow a minor level of effort by states, EPA, Navajo Nation, and water systems to document straight-forward projects. Doing so made more resources available to identify and document projects for which allowability was more questionable. Projects fell into the following levels of documentation requirements:

- Projects that required independent documentation of need.
- Projects for which survey-generated documentation were permitted but to which a weight of evidence review was applied.
- Projects accepted with any forms of documentation.

The level of documentation required depended on the type of project and whether the project was for new infrastructure or for the replacement, rehabilitation, or expansion/upgrade of existing infrastructure. Any of the three forms of documentation were acceptable for projects to rehabilitate or replace infrastructure assumed to have a life-cycle of 20 years or less.

Projects likely to be driven by a need that is not DWSRF-eligible (such as to accommodate growth or meet fire suppression needs) generally required independent documentation. Most projects for the installation of new infrastructure fell into this category. For those projects, such as the construction of a new treatment system or new storage tank, the independent documentation was reviewed and EPA applied a "weight of evidence" approach to determine whether the project could be included in the Assessment.

Projects for Which Independent Documentation was Required

Generally, projects that required independent documentation of need were likely to be unallowable needs (such as projects to meet anticipated growth) or for infrastructure likely to have an expected life of more than 20 years (such as a water main). EPA and the workgroup assumed that systems pursuing needs in this category are often in the process of formal planning and therefore independent documents are likely to exist. Projects requiring independent documentation for the 2011 Assessment included:

- Sources – installation of new surface water intakes, off-stream raw water storage, or new aquifer storage and recovery wells.
- Treatment – installation, replacement, or expansion/upgrade of a complete treatment plant or new treatment components.
- Storage – installation of new elevated or ground level finished water or treated water storage.
- Pipe – installation of new water mains, rehabilitation and replacement of a substantial portion (in excess of 10 percent of the total) of the system's existing water mains.
- Pumping – installation of new pump stations.

Projects for Which Survey-Generated Documentation was Allowed, but a Weight of Evidence Review was Applied

Needs that were subject to a weight of evidence review included projects that were significant in scope or that may be for unallowable need (such as anticipated growth), but are not necessarily likely to be included in a planning document. For these projects, systems were asked to provide enough information for the reviewer to ascertain whether the project was for an allowable need. These projects included:

- Sources – construction of new wells or springs, new well pumps or raw water pumps, and replacement or rehabilitation of any source; new, rehabilitation, or replacement of a well house.
- Treatment – installation of a new treatment monitor or analytical device such as streaming current monitors, particle counters, or chlorine residual monitors.
- Storage – replacement of a finished water elevated or ground level storage tank or installation of a new hydropneumatic storage tank.
- Pipe – a significant amount of new water main appurtenances such as valves, hydrants, or backflow prevention devices, or replacement of over 10 percent of the existing inventory of those items.
- Pumping – replacement of an existing pump station or installation of a new finished water pump.
- Security and Emergency Power – motion detector, in-line monitoring devices, or other sophisticated security system components and new emergency power generators.

Projects for Which All Forms of Documentation Were Accepted

Projects for infrastructure that is generally expected to require rehabilitation or replacement within a 20-year period were accepted with minimum documentation of need. Survey-generated documentation was sufficient for these projects, which included:

- Sources – replacement or rehabilitation of well pumps, raw water pumps, and other miscellaneous source projects.
- Treatment – rehabilitation of a complete treatment plant, or rehabilitation or replacement of treatment components, or replacement of treatment monitors.

Sarah Hudson, Indiana DWSRF

Elevated storage tank in Greensburg, Indiana.

- Storage – rehabilitation of any finished water storage tank or cistern, cover of finished water storage tank, replacement of hydropneumatic tanks, and installation or replacement of cisterns.
- Pumping – replacement or rehabilitation of any pump, or rehabilitation of any pump station.
- Pipe – rehabilitation or replacement of water mains up to 10 percent of the system's existing total pipe inventory.
- Other infrastructure such as replacement of lead service lines and installation of control valves, backflow prevention, meters, controls, and replacement of emergency power.

Documentation of Cost

To estimate a 20-year national, American Indian, Alaska Native, and individual state need, every project must have an estimated cost. There were two primary methods for assigning costs to a project:

- Systems provided an independent cost estimate.
- Systems provided adequate information for EPA to estimate a cost using a cost model.

For systems that provided a cost estimate, the documentation must:

- Include the date the estimate was derived.
- Be generated through a process independent of the Assessment.
- Be no more than 10 years old (earlier than January 1, 2001).
- Not include loan origination fees, finance charges, bond issuance fees or costs, interest payments on a loan, or inflationary multipliers for future projects.

Since projects with adequately documented costs were the basis of the cost models, systems were encouraged to provide both cost and design parameters for as many projects as possible so that the data could be used to update existing 2007 Survey cost models.

If a cost was not provided, key information on design parameters and project type was required for EPA to assign a cost to the project using a cost model. However, EPA was unable to model a few types of infrastructure projects (e.g., projects that were too unique or site-specific). In those cases, a documented cost estimate was required in order for the cost to be included in the Assessment.

As with previous Assessments, EPA will publish a document detailing the costs models used in the 2011 Assessment. The publication should be available by mid-2013.

Appendix D - Accuracy, Precision, and Uncertainty

Uncertainty, precision, and bias affect the accuracy of an estimate based on a statistical sample. While a sample can be designed to meet certain precision targets, other sources of uncertainty and potential biases may diminish the accuracy of estimates.

Ohio EPA

Water Supply Revolving Loan Account funded clarifier cover in Fostoria, OH.

Uncertainty

There are two types of uncertainty at play in the DWINSA. Real uncertainties are created as survey respondents predict future needs. EPA is asking systems not only to provide their existing needs, but also to anticipate what their future needs will be. It is difficult to predict future needs. Since no one knows, for example, when a pump will fail or exactly what it will cost to fix or replace it when it does fail, there is real uncertainty about the accuracy of estimates of future investment needs.

A second source of uncertainty is the use of a probability sample to estimate need. Uncertainties are created due to the inherent limitations of statistical analyses. The use of a random sample and cost models create such stochastic (i.e., random or arising from chance) uncertainties in the survey. In assessing the impact that the sample has on the estimate, EPA distinguishes between two sources of stochastic uncertainty: precision and bias.

Precision

Precision is the degree to which additional measures would produce the same or similar results. Two factors affect the precision of sample-based estimates. First is the inherent variability of the data. If systems' needs are similar, the margin of error will be smaller than if needs vary greatly across systems. The second factor is the size of the sample. Larger samples produce more precise estimates than smaller ones.

The use of a random sample introduces uncertainty in the estimate. A different sample would lead to a different estimate of each state's need, since there will always be some variability among different systems selected in a sample. Because the DWINSA relies on a random sample, the sample should provide an unbiased estimate of the total need. The level of confidence in the estimate is reflected in the confidence interval.

EPA's goal is to be 95 percent confident that the margin of error for the survey is ± 10 percent of the total need for systems serving more than 3,300 persons for each fully surveyed state and for all American Indian and Alaska Native Village public water systems, assuming that the data provided are unbiased. (The estimates for individual partially surveyed states do not meet these precision targets. DWINSA also has separate precision targets for systems in the state survey serving 3,300 or fewer persons.)

If the systems that responded to the survey reported the cost of their investment needs for all projects, sampling error would be the only stochastic source of uncertainty. But systems do not have cost estimates for most of the projects they reported. EPA imputed the cost of these projects using cost models based on cost estimates submitted for other projects. As with sampling, there is a degree of predictable error associated with such modeling.

Bias

Sampling error is random. It is as likely to lead to an estimate that is greater than the true value as it is lower than the true value. Bias, however, is not random. An estimator is biased if its expected value is different from the true value. An estimator is upwardly biased if it consistently leads to an estimate that is greater than the true value. It is downwardly biased if it consistently leads to an estimate that is less than the true value. The DWINSA has both upwards and downward biases. EPA implemented policies and procedures to mitigate the impact of these biases.

Downward bias

Past DWINSAs and studies of these Assessments have shown that systems are likely to underestimate their needs. There is little theory or empirical evidence to suggest that systems overstate their needs. This understatement is brought on for two primary reasons. One is that the bulk of a system's infrastructure is underground in the form of transmission and distribution mains. It is difficult to assess the need for addressing these out-of-sight assets. The second is that the survey assesses systems' 20-year need. Many systems have not undertaken the long-term planning necessary to identify future infrastructure needs.

Kentucky Department of Environmental Protection

Service line test in Hardinsburg, KY.

Upward bias

In part to help address the downward bias introduced by systems' underestimating their needs, EPA enlisted the help of states, EPA Regions, and the Navajo Nation in the data collection effort. However, because these entities are the recipients of the capitalization grants determined by the Assessment, there is an incentive for them to overestimate their systems' needs. This situation introduces a possible upward bias in the estimate of the needs generated by systems with this type of input.

This bias likely does not apply to the DWINSA estimate of small system need in the state survey. The small system survey is conducted by EPA, without states' direct involvement. For this reason, there is no upward bias in this portion of the survey. In addition, because these small system surveys are conducted by trained professionals, EPA expects very little downward bias.

Approximately 22 states, the U.S. Territories, and the District of Columbia have needs of less than one percent of the national need. These states receive the minimum DWSRF allocation regardless of the need reported (one percent for states, Puerto Rico, and the District of Columbia; 1.5 percent for U.S. Territories). For this reason, there is likely no upward bias in the allocation for these states, and only the downward bias discussed above influences need in these states.

With input from states, EPA Regions, and the Navajo Nation, as well as a peer-review process for the 2007 Assessment, EPA implemented policies to help address both upward and downward bias. These policies included:

- Projects to rehabilitate or replace infrastructure generally considered in need of attention within a 20-year period were allowed based on system- or other entity-signed statements and project descriptions. Systems were encouraged to consider their entire inventory and document all such needs if legitimate.
- Projects to rehabilitate or replace infrastructure not necessarily considered in need of attention within a 20-year period were allowed with documentation independent of the Assessment or a system or other entities' statement if it included additional project-specific information such as an assessment of age, current condition, and maintenance history.
- Projects that include the installation/construction of new infrastructure generally received a high degree of scrutiny to ensure that they met allowability criteria.
- Some infrastructure was only allowed if independent documentation was provided. This included new surface water sources, new treatment plants or components, the replacement or expansion of an existing treatment plant, new storage tanks, and widespread replacement or rehabilitation of the distribution system (defined as more than 10 percent of the existing pipe inventory).

Appendix E - Summary of Findings for State Systems Serving 10,000 and Fewer Persons

Community Water Systems in States Serving 10,000 People and Fewer

The SDWA requires that states use at least 15 percent of their DWSRF funding for financial assistance to community water systems (CWS) serving populations of 10,000 and fewer. Of the $ 371.4 billion in need for all CWS in states, those serving 10,000 and fewer persons represent 29.8 percent or approximately $110.5 billion of needs (includes CWSs in U.S. Territories). Exhibit E.1 presents the 20-year needs for these smaller community systems by state and project type. It also compares the reported need of these systems to the state's total community water system need. All data in Exhibit E.1 exclude needs related to not-for-profit noncommunity water systems.

Exhibit E.1: State Need Reported by Project Type for CWSs Serving a Population of 10,000 and Fewer (20-year need in millions of 2011 dollars)

State	CWSs Serving 10,000 or Fewer People						Total 20-Year Need of All CWS*	% of CWS Need Related to Systems Serving 10,000 or Fewer Persons.*
	Transmission and Distribution	Source	Treatment	Storage	Other	Total 20-Year Need of CWS Serving 10,000 or Fewer People*		
Alabama	$1,910.2	$57.8	$174.5	$221.2	$37.5	$2,401.2	$7,945.4	30.2%
Arizona	$921.0	$104.7	$267.4	$243.7	$9.6	$1,546.4	$7,419.7	20.8%
Arkansas	$1,630.4	$111.9	$280.5	$284.5	$29.2	$2,336.4	$6,090.1	38.4%
California	$3,035.5	$417.2	$1,012.6	$718.6	$63.2	$5,247.1	$44,398.1	11.8%
Colorado	$1,268.3	$126.4	$496.1	$361.8	$17.0	$2,269.7	$7,122.6	31.9%
Connecticut	$472.9	$87.1	$125.5	$114.0	$11.7	$811.2	$3,547.2	22.9%
District of Columbia	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$1,606.7	0.0%
Florida	$1,587.4	$442.6	$415.0	$338.6	$45.4	$2,829.0	$16,326.2	17.3%
Georgia	$2,245.0	$226.7	$403.7	$454.6	$27.1	$3,357.0	$9,252.6	36.3%
Illinois	$3,156.0	$333.7	$736.7	$702.3	$54.6	$4,983.3	$18,860.0	26.4%
Indiana	$1,513.8	$120.4	$279.5	$263.5	$13.1	$2,190.4	$6,346.9	34.5%
Iowa	$1,416.0	$193.0	$396.1	$322.7	$27.0	$2,354.8	$5,909.4	39.8%
Kansas	$1,725.3	$134.2	$296.7	$261.2	$12.5	$2,430.0	$4,190.7	58.0%
Kentucky	$1,117.5	$52.0	$115.8	$152.7	$13.6	$1,451.6	$6,227.4	23.3%
Louisiana	$1,812.9	$176.8	$393.5	$327.3	$18.4	$2,728.9	$5,305.7	51.4%
Maine	$395.0	$52.8	$106.7	$105.6	$10.0	$670.0	$1,140.6	58.7%
Maryland	$441.1	$78.5	$120.3	$117.2	$6.3	$763.4	$6,801.7	11.2%
Massachusetts	$743.6	$120.2	$192.2	$175.2	$14.9	$1,246.2	$7,663.7	16.3%
Michigan	$1,943.6	$254.5	$502.8	$364.2	$44.3	$3,109.3	$13,278.3	23.4%
Minnesota	$1,782.4	$189.2	$410.6	$344.8	$28.0	$2,754.9	$7,058.3	39.0%
Mississippi	$1,644.0	$216.8	$469.5	$390.0	$17.2	$2,737.3	$3,675.7	74.5%
Missouri	$2,985.7	$227.8	$553.6	$448.0	$20.6	$4,235.8	$8,436.3	50.2%
Nevada	$388.4	$39.1	$149.4	$92.1	$3.3	$672.4	$5,575.1	12.1%
New Jersey	$779.7	$102.0	$157.2	$174.5	$7.4	$1,220.8	$7,683.6	15.9%

* Excludes NPNCWS

Exhibit E.1: State Need Reported by Project Type for CWSs Serving a Population of 10,000 and Fewer (20-year need in millions of 2011 dollars)

State	CWSs Serving 10,000 or Fewer People						Total 20-Year Need of All CWS*	% of CWS Need Related to Systems Serving 10,000 or Fewer Persons.*
	Transmission and Distribution	Source	Treatment	Storage	Other	Total 20-Year Need of CWS Serving 10,000 or Fewer People*		
New York	$2,819.0	$381.0	$916.0	$680.2	$42.9	$4,839.2	$21,898.0	22.1%
North Carolina	$1,789.0	$242.9	$476.9	$422.6	$52.3	$2,983.6	$9,626.4	31.0%
Ohio	$1,876.8	$220.7	$585.1	$418.5	$51.7	$3,152.8	$11,871.1	26.6%
Oklahoma	$2,103.3	$142.8	$742.9	$342.8	$18.5	$3,350.3	$6,468.5	51.8%
Oregon	$1,069.7	$123.6	$404.8	$274.9	$18.0	$1,891.0	$5,500.0	34.4%
Pennsylvania	$2,629.3	$292.6	$829.2	$673.7	$59.6	$4,484.5	$13,907.7	32.2%
Puerto Rico	$898.3	$46.8	$221.7	$149.3	$7.6	$1,323.7	$3,211.8	41.2%
Tennessee	$545.1	$36.3	$98.2	$103.1	$6.6	$789.3	$2,659.3	29.7%
Texas	$7,906.2	$728.1	$1,994.4	$1,622.6	$164.7	$12,416.0	$33,837.7	36.7%
Utah	$628.9	$81.2	$167.4	$179.0	$6.6	$1,063.2	$3,710.9	28.7%
Virginia	$1,191.4	$129.9	$351.0	$301.9	$37.6	$2,011.9	$6,611.7	30.4%
Washington	$2,083.2	$355.5	$614.4	$506.7	$54.0	$3,613.7	$9,388.4	38.5%
Wisconsin	$1,249.0	$194.2	$447.7	$315.7	$15.4	$2,222.0	$6,592.4	33.7%
Partially Surveyed States**	$7,286.2	$900.5	$1,989.9	$1,590.5	$143.1	$11,910.2	$23,565.0	50.5%
Subtotal	**$68,990.9**	**$7,741.8**	**$17,895.6**	**$14,559.8**	**$1,210.4**	**$110,398.5**	**$370,710.6**	**29.8%**
American Samoa	$17.3	$2.3	$5.6	$4.3	$0.3	$29.8	$81.9	36.4%
Guam	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$235.4	0.0%
North Mariana Is.	$34.8	$5.7	$9.6	$8.4	$0.8	$59.2	$177.7	33.3%
Virgin Islands	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$174.6	0.0%
Subtotal	**$52.1**	**$8.0**	**$15.2**	**$12.7**	**$1.1**	**$89.0**	**$669.7**	**13.3%**
Total	**$69,043.1**	**$7,749.8**	**$17,910.8**	**$14,572.5**	**$1,211.4**	**$110,487.6**	**$371,380.3**	**29.8%**

* Excludes NPNCWS
** The need for states that opted out of the medium portion of the survey is presented cumulatively and not by state. The list of partially surveyed states can be seen in Exhibit 2.4

Glossary

Capital Improvement Plan (CIP): a document produced by a local government, utility, or water system that thoroughly outlines, for a specified period of time, all needed capital projects, the reason for each project, and the projects' costs.

Coliform bacteria: a group of bacteria whose presence in a water sample indicates the water may contain disease-causing organisms.

Community water system (CWS): a public water system that serves at least 15 connections used by year-round residents or that regularly serves at least 25 residents year-round. Examples include cities, towns, and communities such as retirement homes.

Current infrastructure needs: new facilities or deficiencies in existing facilities identified by the state or system for which water systems would begin construction as soon as possible to avoid a threat to public health.

Engineer's report: a document produced by a professional engineer that outlines the need and cost for a specific infrastructure project.

Existing regulations: drinking water regulations promulgated by EPA under the authority of the Safe Drinking Water Act; existing regulations can be found at Title 40 Part 141, the Code of Federal Regulations (40 CFR 141).

Finished water: water that is considered safe to drink and suitable for delivery to customers.

Future infrastructure needs: infrastructure deficiencies that a system expects to address in the next 20 years because of predictable deterioration of facilities. Future infrastructure needs do not include current infrastructure needs. Examples are storage facility and treatment plant replacement where the facility currently performs adequately but will reach the end of its useful life in the next 20 years. Needs solely to accommodate future growth are not included in the DWINSA.

Ground water: any water obtained from a source beneath the surface of the ground, which has not been classified as ground water under the direct influence of surface water.

Growth: The expansion of a water system to accommodate or entice future additional service connections or consumers. Needs planned solely to accommodate projected future growth are not included in the Assessment. Eligible projects, however, can be designed for growth expected during the design-life of the project. For example, the Assessment would allow a treatment plant needed now and expected to treat water for 20 years. Such a plant could be designed for the population anticipated to be served at the end of the 20-year period.

Infrastructure needs: the capital costs associated with ensuring the continued protection of public health through rehabilitating or constructing facilities needed for continued provision of safe drinking water. Categories of infrastructure need include source development and rehabilitation, treatment, storage, and transmission and distribution. Operation and maintenance needs are not considered infrastructure needs and are not included in this document.

Large water system: in this document, this category comprises community water systems serving more than 100,000 persons.

Medium water system: in this document, this category comprises community water systems serving from 3,301 to 100,000 persons.

Microbiological contamination: the occurrence of protozoan, bacteriological, or viral contaminants in a water supply.

Noncommunity water system: a public water system that is not a community water system and that serves a nonresidential population of at least 25 individuals daily for at least 60 days of the year. Examples of not-for-profit noncommunity water systems include schools and churches.

Public water system: a system that provides water to the public for human consumption through pipes or other constructed conveyances, if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year.

Regulatory need: a capital expenditure required for compliance with Safe Drinking Water Act regulations.

Safe Drinking Water Act (SDWA): a law passed by Congress in 1974 and amended in 1986 and 1996 to ensure that public water systems provide safe drinking water to consumers (42 U.S.C.A. §300f to 300j-26).

Small water system: in this document, this category comprises community water systems serving up to 3,300 persons.

Source rehabilitation and development: a category of need that includes the costs involved in developing or improving sources of water for public water systems.

State: in this document, state refers to all 50 states of the United States plus Puerto Rico, the District of Columbia, American Samoa, Guam, the Commonwealth of Northern Mariana Islands, and the U.S. Virgin Islands.

Storage: a category of need that addresses finished water storage for public water systems.

Supervisory Control and Data Acquisition (SCADA): an advanced control system that collects all system information and allows an operator, through user-friendly interfaces, to view all aspects of the system from one place.

Surface water: all water that is open to the atmosphere and subject to surface run-off, including streams, rivers, and lakes.

Transmission and distribution: a category of need that includes installation, replacement, or rehabilitation of transmission or distribution lines that carry drinking water from the source to the treatment plant or from the treatment plant to the consumer.

Treatment: a category of need that includes conditioning water or removing microbiological or chemical contaminants. Filtration of surface water, pH adjustment, softening, and disinfection are examples of treatment.

Watering point: a central source from which people who do not have piped water can obtain drinking water for transport to their homes.

Kentucky Department of Environmental Protection

Intake at the Licking River Dam in Salyersville, KY.

Footnote 11 Document

U.S. Department of Education, National Center for Education Statistics.

FAST FACTS

Back to school statistics

Question:
What are the new back to school statistics for 2018?

Response:

Elementary and Secondary Education

Enrollment

In fall 2018, about 56.6 million students will attend elementary and secondary schools, including 50.7 million students in public schools and 5.9 million in private schools. Of the public school students, 35.6 million will be in prekindergarten through grade 8 and 15.1 million will be in grades 9 through 12. The fall 2018 public school enrollment is expected to be slightly higher than the 50.6 million enrolled in fall 2017 and is higher than the 49.5 million students enrolled in fall 2010 (source). Total public elementary and secondary enrollment is projected to increase between fall 2018 and fall 2027 to 52.1 million.

Of the projected 50.7 million public school students entering prekindergarten through grade 12 in fall 2018, White students will account for 24.1 million. The remaining 26.6 million will be composed of 7.8 million Black students, 14.0 million Hispanic students, 2.6 million Asian students, 0.2 million Pacific Islander students, 0.5 million American Indian/Alaska Native students, and 1.6 million students of Two or more races. The percentage of students enrolled in public schools who are White is projected to continue to decline through at least fall 2027 along with the percentage of students who are Black, while the percentage of students who are Hispanic Asian, and of Two or more races are projected to increase (source).

In fall 2018, about 1.4 million children are expected to attend public prekindergarten and 3.6 million are expected to attend public kindergarten (source).

About 4.0 million public school students are expected to enroll in 9th grade in fall 2018 (source). Students typically enter American high schools in 9th grade.

Teachers

Public school systems will employ about 3.2 million full-time-equivalent (FTE) teachers in fall 2018, such that the number of pupils per FTE teacher —that is, the pupil/teacher ratio—will be 16.0. This ratio has remained consistent at around 16.0 since 2010. A projected 0.5 million FTE teachers will be working in private schools this fall, resulting in an estimated pupil/teacher ratio of 12.3, which is similar to the 2017 ratio of 12.2, but lower than the 2010 ratio of 13.0 (source).

Expenditures

Current expenditures for public elementary and secondary schools are projected to be $654 billion for the 2018–19 school year. The current expenditure per student is projected to be $12,910 for the 2018–19 school year (source).

Attainment

About 3.6 million students are expected to graduate from high school in 2018–19, including 3.3 million students from public high schools and 0.4 million students from private high schools (source).

College and University Education

Enrollment

The number of students projected to attend American colleges and universities in fall 2018 is 19.9 million, which is higher than the enrollment of 15.3 million students in fall 2000, but lower than the enrollment peak of 21.0 million in fall 2010 (source). Total enrollment is expected to increase between fall 2018 and fall 2027 to 20.5 million.

Females are expected to account for the majority of college and university students in fall 2018: about 11.2 million females will attend in fall 2018, compared with 8.7 million males. Also, more students are expected to attend full time (an estimated 12.1 million students) than part time (7.8 million students) (source).

Some 6.7 million students will attend 2-year institutions and 13.3 million will attend 4-year institutions in fall 2018 (source). About 17.0 million students are expected to enroll in undergraduate programs, and 2.9 million are expected to enroll in postbaccalaureate programs (source).

In 2018, a projected 12.3 million college and university students will be under age 25 and 7.6 million students will be 25 years old and over. The number of college and university students under age 25 hit a peak of 12.2 million in 2011 and has remained steady since that time. The number of students 25 years old and over hit a similar peak in 2010 (of 8.9 million) but the overall enrollment for this age group declined from 2010 to 2018 (source).

Attainment

During the 2018–19 school year, colleges and universities are expected to award 1.0 million associate‘s degrees; 1.9 million bachelor's degrees; 780,000 master's degrees; and 182,000 doctor's degrees (source). In 2015–16, postsecondary institutions awarded 939,000 certificates below the associate‘s degree level, 1.0 million associate‘s degrees, 1.9 million bachelor‘s degrees, 786,000 master‘s degrees, and 178,000 doctor‘s degrees (source).

Background information from prior school years:

Some information on the 2018–19 school year is not available. This section presents selected highlights from prior school years to provide some context for the current school year.

Elementary and Secondary Schools and Districts

In 2015–16, there were about 13,600 public school districts (source) with close to 98,300 public schools, including about 6,900 charter schools (source). In fall 2015, there were about 34,600 private schools offering kindergarten or higher grades (source).

In 2016–17, about one-third (32 percent) of districts reported that all of their Career and Technical Education (CTE) programs were structured as career pathways that align with related postsecondary programs, and an additional one-third (33 percent) reported that most of their programs were structured this way (source).

High School Dropout

The percentage of high school dropouts among 16- to 24-year-olds declined from 10.9 percent in 2000 to 6.1 percent in 2016 (source). Reflecting the overall decline in the dropout rate between 2000 and 2016, the rates also declined for White, Black, and Hispanic students.

Immediate College Enrollment

The percentage of students enrolling in college in the fall immediately following high school completion was 69.8 percent in 2016 (source).

Postsecondary Demographics

Higher numbers and percentages of Black and Hispanic students are attending colleges and universities. The percentage of all students attending colleges and universities who were Black was higher in 2016 than in 2000 (13.7 vs. 11.7 percent), and the percentage who were Hispanic rose from 9.9 to 18.2 percent over the same time period (source). Also, the percentage of Hispanic 18- to 24-year-olds enrolled in colleges and universities increased from 21.7 percent in 2000 to 39.2 percent in 2016, and the percentage of Black 18- to 24-year-olds enrolled increased from 30.5 percent to 36.2 percent in that same period (source).

Postsecondary Finance

For the 2016–17 academic year, the average annual price for undergraduate tuition, fees, room, and board was $17,237 at public institutions, $44,551 at private nonprofit institutions, and $25,431 at private for-profit institutions. Charges for tuition and required fees averaged $6,817 at public institutions, $32,556 at private nonprofit institutions, and $14,419 at private for-profit institutions (source).

Labor Force Outcomes

In 2016, about 78.8 percent of 25- to 34-year-olds with a bachelor's or higher degree in the labor force had year-round, full-time jobs, compared with 72.3 percent of those with an associate's degree, 69.5 percent of those with some college education, 68.9 percent of those who completed high school, and 60.1 percent of those without a high school diploma or its equivalent (source). In 2017, the unemployment rate for 25- to 34-year-olds with a bachelor's or higher degree (2.5 percent) was lower than the rate for young adults with some college (4.4 percent), those who had completed high school (7.2 percent), and those who had not completed high school (13.2 percent) (source).

In 2016, for young adults ages 25–34 who worked full time, year round, higher educational attainment was associated with higher median earnings; this pattern was consistent from 2000 through 2016. For example, in 2016, the median earnings of young adults with a bachelor's degree ($50,000) were 57 percent higher than those of young adult high school completers ($31,800). The median earnings of young adult high school completers were 26 percent higher than those of young adults who did not complete high school ($25,400). In addition, in 2016, the median earnings of young adults with a master's or higher degree were $64,100, some 28 percent higher than those of young adults with a bachelor's degree ($50,000) (source).

For more information, please see the following:

- The Condition of Education: The annual report to Congress on important developments and trends in U.S. education.
- The Digest of Education Statistics: A compilation of statistical information covering the broad field of American education from prekindergarten through graduate school.
- State-level data resource page: Links to selected publications and websites that provide state-by-state information on achievement, attainment, demographics, enrollment, finances, and teachers at the elementary, secondary, and postsecondary levels.
- U.S. Department of Education program and budget information can be found here.
- U.S. Census Bureau Current Population Survey: The Current Population Survey (CPS) is a monthly survey of about 60,000 households conducted by the U.S. Census Bureau. The CPS is the primary source of information on labor force statistics and also contains information on enrollment and educational attainment.

Footnote 12 Document

EPA - National Primary Drinking Water Regulations

National Primary Drinking Water Regulations

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
Beta photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	**zero**
Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort; anemia	Water additive used to control microbes	**MRDLG=4[1]**
Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	**zero**
Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	**MRDLG=4[1]**
Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Water additive used to control microbes	**MRDLG=0.8[1]**
Chlorite	1.0	Anemia; infants, young children, and fetuses of pregnant women: nervous system effects	Byproduct of drinking water disinfection	**0.8**
Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	**0.1**
Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	**0.1**
Copper	TT[5]; Action Level=1.3	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	**1.3**
Cryptosporidium	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	**0.2**
2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	**0.07**
Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	**0.2**
1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	**zero**
o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	**0.6**
p-Dichlorobenzene	0.075	Anemia; liver, kidney, or spleen damage; changes in blood	Discharge from industrial chemical factories	**0.075**
1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	**0.007**
cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	**0.07**
trans-1,2, Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	**0.1**
Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from industrial chemical factories	**zero**
1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	**zero**
Di(2-ethylhexyl) adipate	0.4	Weight loss, liver problems, or possible reproductive difficulties	Discharge from chemical factories	**0.4**
Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	**zero**
Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	**0.007**
Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	**zero**
Diquat	0.02	Cataracts	Runoff from herbicide use	**0.02**
Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	**0.1**
Endrin	0.002	Liver problems	Residue of banned insecticide	**0.002**
Epichlorohydrin	TT[4]	Increased cancer risk; stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	**zero**
Ethylbenzene	0.7	Liver or kidney problems	Discharge from petroleum refineries	**0.7**
Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	**zero**
Fecal coliform and *E. coli*	MCL[6]	Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes may cause short term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.	Human and animal fecal waste	**zero[6]**

LEGEND

DISINFECTANT
DISINFECTION BYPRODUCT
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Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	**4.0**
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	**0.7**
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	**zero**
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	**zero**
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	**n/a**
Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	**zero**
Hexachloro-cyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	**0.05**
Lead	TT[5]; Action Level=0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	**zero**
Legionella	TT[7]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	**zero**
Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, and gardens	**0.0002**
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	**0.002**
Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, and livestock	**0.04**
Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**10**

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	**1**
Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	**0.2**
Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood-preserving factories	**zero**
Picloram	0.5	Liver problems	Herbicide runoff	**0.5**
Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	**zero**
Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	**zero**
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines	**0.05**
Simazine	0.004	Problems with blood	Herbicide runoff	**0.004**
Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	**0.1**
Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	**zero**
Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	**0.0005**
Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	**1**
Total Coliforms	5.0 percent[8]	Coliforms are bacteria that indicate that other, potentially harmful bacteria may be present. See fecal coliforms and *E. coli*	Naturally present in the environment	**zero**
Total Trihalomethanes (TTHMs)	0.080	Liver, kidney, or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	**n/a[9]**
Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	**zero**
2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	**0.05**
1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	**0.07**

LEGEND

DISINFECTANT | DISINFECTION BYPRODUCT | INORGANIC CHEMICAL | MICROORGANISM | ORGANIC CHEMICAL | RADIONUCLIDES

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	**0.2**
1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	**0.003**
Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	**zero**
Turbidity	TT[7]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause short term symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	**n/a**
Uranium	30μg/L	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	**zero**
Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	**zero**
Viruses (enteric)	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	**zero**
Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	**10**

LEGEND

DISINFECTANT — DISINFECTION BYPRODUCT — INORGANIC CHEMICAL — MICROORGANISM — ORGANIC CHEMICAL — RADIONUCLIDES

NOTES

1 Definitions
- **Maximum Contaminant Level Goal (MCLG):** The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- **Maximum Contaminant Level (MCL):** The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- **Maximum Residual Disinfectant Level Goal (MRDLG):** The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- **Maximum Residual Disinfectant Level (MRDL):** The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- **Treatment Technique (TT):** A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 Health effects are from long-term exposure unless specified as short-term exposure.

4 Each water system must certify annually, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05 percent dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01 percent dosed at 20 mg/L (or equivalent).

5 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

6 A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples--if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples--if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.

7 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:
- ***Cryptosporidium***: 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.
- **Giardia lamblia:** 99.9 percent removal/inactivation
- **Viruses:** 99.9 percent removal/inactivation
- ***Legionella***: No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.
- **Turbidity:** For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.
- **HPC:** No more than 500 bacterial colonies per milliliter
- **Long Term 1 Enhanced Surface Water Treatment:** Surface water systems or ground water systems under the direct influence of surface water serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- **Long Term 2 Enhanced Surface Water Treatment:** This rule applies to all surface water systems or ground water systems under the direct influence of surface water. The rule targets additional *Cryptosporidium* treatment requirements for higher risk systems and includes provisions to reduce risks from uncovered finished water storages facilities and to ensure that the systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts. (Monitoring start dates are staggered by system size. The largest systems (serving at least 100,000 people) will begin monitoring in October 2006 and the smallest systems (serving fewer than 10,000 people) will not begin monitoring until October 2008. After completing monitoring and determining their treatment bin, systems generally have three years to comply with any additional treatment requirements.)
- **Filter Backwash Recycling:** The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

8 No more than 5.0 percent samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli. If two consecutive TC-positive samples, and one is also positive for E. coli or fecal coliforms, system has an acute MCL violation.

9 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:
- **Haloacetic acids:** dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- **Trihalomethanes:** bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

NATIONAL SECONDARY DRINKING WATER REGULATION

National Secondary Drinking Water Regulations are non-enforceable guidelines regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, some states may choose to adopt them as enforceable standards.

Contaminant	Secondary Maximum Contaminant Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	Noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

FOR MORE INFORMATION ON EPA'S SAFE DRINKING WATER:

visit: **epa.gov/safewater**

call: **(800) 426-4791**

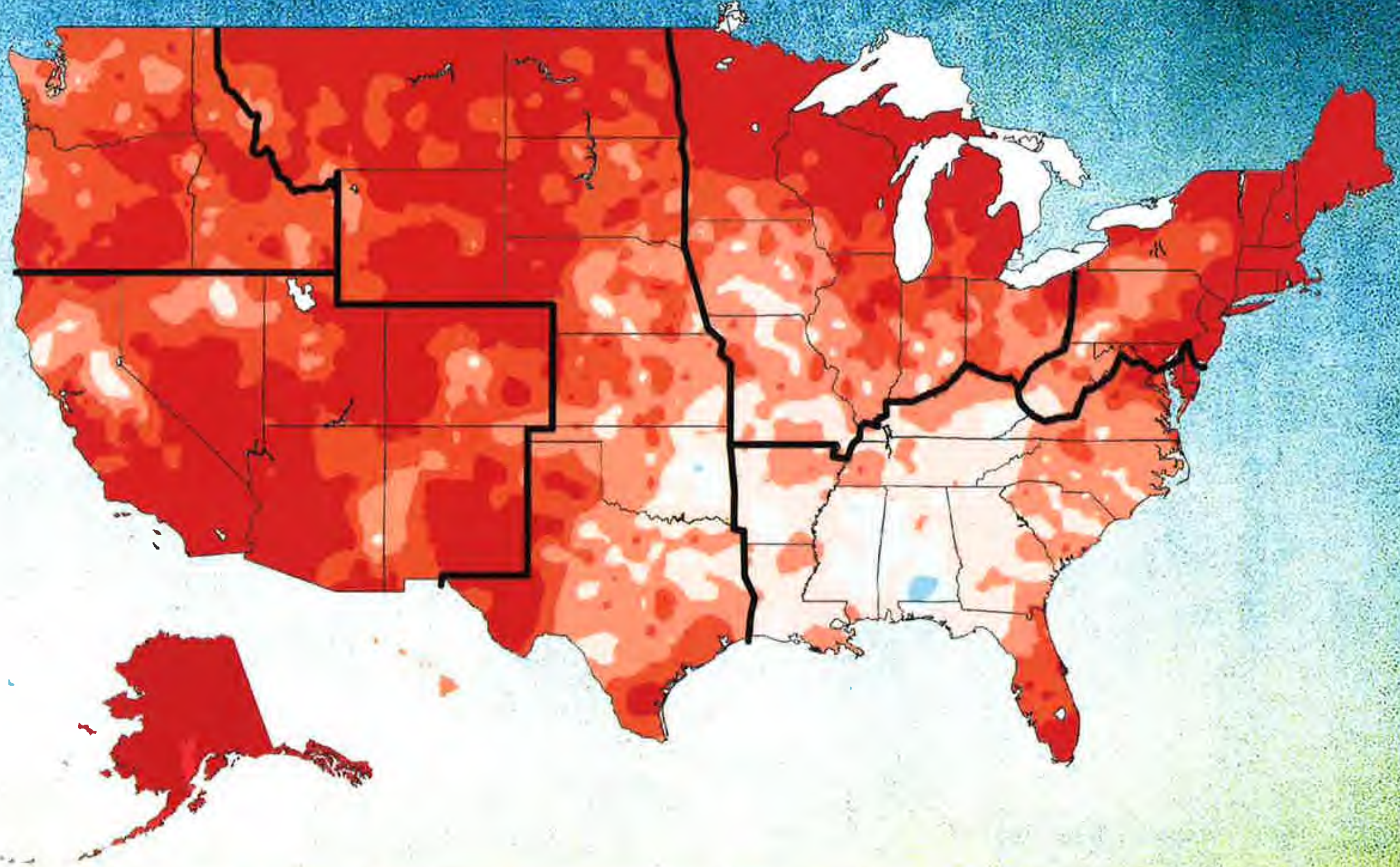
ADDITIONAL INFORMATION:

To order additional posters or other ground water and drinking water publications, please contact the National Service Center for Environmental Publications at: **(800) 490-9198**, or email: **nscep@bps-lmit.com**.

Footnote 14

Climate Change Impacts in the United States, ch. 17 – Southeast and the Caribbean
(Partial Document that includes Cover Page, Executive Summary and Chapter 17)

Climate Change Impacts in the United States



U.S. National Climate Assessment

U.S. Global Change Research Program

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CLIMATE CHANGE AND THE AMERICAN PEOPLE

Climate change, once considered an issue for a distant future, has moved firmly into the present. Corn producers in Iowa, oyster growers in Washington State, and maple syrup producers in Vermont are all observing climate-related changes that are outside of recent experience. So, too, are coastal planners in Florida, water managers in the arid Southwest, city dwellers from Phoenix to New York, and Native Peoples on tribal lands from Louisiana to Alaska. This National Climate Assessment concludes that the evidence of human-induced climate change continues to strengthen and that impacts are increasing across the country.

Americans are noticing changes all around them. Summers are longer and hotter, and extended periods of unusual heat last longer than any living American has ever experienced. Winters are generally shorter and warmer. Rain comes in heavier downpours. People are seeing changes in the length and severity of seasonal allergies, the plant varieties that thrive in their gardens, and the kinds of birds they see in any particular month in their neighborhoods.

Other changes are even more dramatic. Residents of some coastal cities see their streets flood more regularly during storms and high tides. Inland cities near large rivers also experience more flooding, especially in the Midwest and Northeast. Insurance rates are rising in some vulnerable locations, and insurance is no longer available in others. Hotter and drier weather and earlier snowmelt mean that wildfires in the West start earlier in the spring, last later into the fall, and burn more acreage. In Arctic Alaska, the summer sea ice that once protected the coasts has receded, and autumn storms now cause more erosion, threatening many communities with relocation.

Scientists who study climate change confirm that these observations are consistent with significant changes in Earth's climatic trends. Long-term, independent records from weather stations, satellites, ocean buoys, tide gauges, and many other data sources all confirm that our nation, like the rest of the world, is warming. Precipitation patterns are changing, sea level is rising, the oceans are becoming more acidic, and the frequency and intensity of some extreme weather events are increasing. Many lines of independent evidence demonstrate that the rapid warming of the past half-century is due primarily to human activities.

The observed warming and other climatic changes are triggering wide-ranging impacts in every region of our country and throughout our economy. Some of these changes can be beneficial over the short run, such as a longer growing season in some regions and a longer shipping season on the Great Lakes. But many more are detrimental, largely because our society and its infrastructure were designed for the climate that we have had, not the rapidly changing climate we now have and can expect in the future. In addition, climate change does not occur in isolation. Rather, it is superimposed on other stresses, which combine to create new challenges.

This National Climate Assessment collects, integrates, and assesses observations and research from around the country, helping us to see what is actually happening and understand what it means for our lives, our livelihoods, and our future. This report includes analyses of impacts on seven sectors – human health, water, energy, transportation, agriculture, forests, and ecosystems – and the interactions among sectors at the national level. This report also assesses key impacts on all U.S. regions: Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, Hawai'i and the Pacific Islands, as well as the country's coastal areas, oceans, and marine resources.

Over recent decades, climate science has advanced significantly. Increased scrutiny has led to increased certainty that we are now seeing impacts associated with human-induced climate change. With each passing year, the accumulating evidence further expands our understanding and extends the record of observed trends in temperature, precipitation, sea level, ice mass, and many other variables recorded by a variety of measuring systems and analyzed by independent research groups from around the world. It is notable that as these data records have grown longer and climate models have become more comprehensive, earlier predictions have largely been confirmed. The only real surprises have been that some changes, such as sea level rise and Arctic sea ice decline, have outpaced earlier projections.

What is new over the last decade is that we know with increasing certainty that climate change is happening now. While scientists continue to refine projections of the future, observations unequivocally show that climate is changing and that the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases. These emissions come mainly from burning coal, oil, and gas, with additional contributions from forest clearing and some agricultural practices.

Global climate is projected to continue to change over this century and beyond, but there is still time to act to limit the amount of change and the extent of damaging impacts.

This report documents the changes already observed and those projected for the future. It is important that these findings and response options be shared broadly to inform citizens and communities across our nation. Climate change presents a major challenge for society. This report advances our understanding of that challenge and the need for the American people to prepare for and respond to its far-reaching implications.

ABOUT THIS REPORT

This report assesses the science of climate change and its impacts across the United States, now and throughout this century. It integrates findings of the U.S. Global Change Research Program (USGCRP)[a] with the results of research and observations from across the U.S. and around the world, including reports from the U.S. National Research Council. This report documents climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels.

REPORT REQUIREMENTS, PRODUCTION, AND APPROVAL

The Global Change Research Act[1] requires that, every four years, the USGCRP prepare and submit to the President and Congress an assessment of the effects of global change in the United States. As part of this assessment, more than 70 workshops were held involving a wide range of stakeholders who identified issues and information for inclusion (see Appendix 1: Process). A team of more than 300 experts was involved in writing this report. Authors were appointed by the National Climate Assessment and Development Advisory Committee (NCADAC),[b] the federal advisory committee assembled for the purpose of conducting this assessment. The report was extensively reviewed and revised based on comments from the public and experts, including a panel of the National Academy of Sciences. The report was reviewed and approved by the USGCRP agencies and the federal Committee on Environment, Natural Resources, and Sustainability (CENRS). This report meets all federal requirements associated with the Information Quality Act (see Appendix 2: IQA), including those pertaining to public comment and transparency.

REPORT SOURCES

The report draws from a large body of scientific, peer-reviewed research, as well as a number of other publicly available sources. Author teams carefully reviewed these sources to ensure a reliable assessment of the state of scientific understanding. Each source of information was determined to meet the four parts of the IQA Guidance provided to authors: 1) utility, 2) transparency and traceability, 3) objectivity, and 4) integrity and security (see Appendix 2: IQA). Report authors made use of technical input reports produced by federal agencies and other interested parties in response to a request for information by the NCADAC;[2] other peer-reviewed scientific assessments (including those of the Intergovernmental Panel on Climate Change); the U.S. National Climate Assessment's 2009 report titled Global Climate Change Impacts in the United States;[3] the National Academy of Science's America's Climate Choices reports;[4] a variety of regional climate impact assessments, conference proceedings, and government statistics (such as population census and energy usage); and observational data. Case studies were also provided as illustrations of climate impacts and adaptation programs.

[a] The USGCRP is made up of 13 Federal departments and agencies that carry out research and support the nation's response to global change The USGCRP is overseen by the Subcommittee on Global Change Research (SGCR) of the National Science and Technology Council's Committee on Environment, Natural Resources and Sustainability (CENRS), which in turn is overseen by the White House Office of Science and Technology Policy (OSTP). The agencies within USGCRP are: the Department of Agriculture, the Department of Commerce (NOAA), the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of the Interior, the Department of State, the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Smithsonian Institution, and the U.S. Agency for International Development.

[b] The NCADAC is a federal advisory committee sponsored by the National Oceanic and Atmospheric Administration under the requirements of the Federal Advisory Committee Act.

A GUIDE TO THE REPORT

The report has eight major sections, outlined below:

- **Overview and Report Findings:** gives a high-level perspective on the full National Climate Assessment and sets out the report's 12 key findings. The Overview synthesizes and summarizes the ideas that the authors consider to be of greatest importance to the American people.
- **Our Changing Climate:** presents recent advances in climate change science, which includes discussions of extreme weather events, observed and projected changes in temperature and precipitation, and the uncertainties associated with these projections. Substantial additional material related to this chapter can be found in the Appendices.
- **Sectors:** focuses on climate change impacts for seven societal and environmental sectors: human health, water, energy, transportation, agriculture, forests, and ecosystems and biodiversity; six additional chapters consider the interactions among sectors (such as energy, water, and land use) in the context of a changing climate.
- **Regions:** assesses key impacts on U.S. regions – Northeast, Southeast and Caribbean, Midwest, Great Plains, Southwest, Northwest, Alaska, and Hawai'i and the U.S. affiliated Pacific Islands – as well as coastal areas, oceans, and marine resources.
- **Responses:** assesses the current state of responses to climate change, including adaptation, mitigation, and decision support activities.
- **Research Needs:** highlights major gaps in science and research to improve future assessments. New research is called for in climate science in support of assessments, climate impacts in regions and sectors, and adaptation, mitigation, and decision support.
- **Sustained Assessment Process:** describes an initial vision for and components of an ongoing, long-term assessment process.
- **Appendices:** Appendix 1 describes key aspects of the report process, with a focus on engagement; Appendix 2 describes the guidelines used in meeting the terms of the Federal Information Quality Act; Appendix 3 supplements the chapter on Our Changing Climate with an extended treatment of selected science issues; Appendix 4 provides answers to Frequently Asked Questions about climate change; Appendix 5 describes scenarios and models used in this assessment; and Appendix 6 describes possible topics for consideration in future assessments.

OVERARCHING PERSPECTIVES

Four overarching perspectives, derived from decades of observations, analysis, and experience, have helped to shape this report: 1) climate change is happening in the context of other ongoing changes across the U.S. and the globe; 2) climate change impacts can either be amplified or reduced by societal decisions; 3) climate change related impacts, vulnerabilities, and opportunities in the U.S. are linked to impacts and changes outside the United States, and vice versa; and 4) climate change can lead to dramatic tipping points in natural and social systems. These overarching perspectives are briefly discussed below.

Global Change Context

Climate change is one of a number of global changes affecting society, the environment, and the economy; others include population growth, land-use change, air and water pollution, and rising consumption of resources by a growing and wealthier global population. This perspective has implications for assessments of climate change impacts and the design of research questions at the national, regional, and local scales. This assessment explores some of the consequences of interacting factors by focusing on sets of crosscutting issues in a series of six chapters: Energy, Water, and Land Use; Biogeochemical Cycles; Indigenous Peoples, Lands, and Resources; Urban Systems, Infrastructure, and Vulnerability; Land Use and Land Cover Change; and Rural Communities. The assessment also includes discussions of how climate change impacts cascade through different sectors such as water and energy, and affect and are affected by land-use decisions. These and other interconnections greatly stress society's capacity to respond to climate-related crises that occur simultaneously or in rapid sequence.

Societal Choices

Because environmental, cultural, and socioeconomic systems are tightly coupled, climate change impacts can either be amplified or reduced by cultural and socioeconomic decisions. In many arenas, it is clear that societal decisions have substantial influence on the vulnerability of valued resources to climate change. For example, rapid population growth and development in coastal areas tends to amplify climate change related impacts. Recognition of these couplings, together with recognition of multiple sources of vulnerability, helps identify what information decision-makers need as they manage risks.

International Context

Climate change is a global phenomenon; the causes and the impacts involve energy-use, economic, and risk-management decisions across the globe. Impacts, vulnerabilities, and opportunities in the U.S. are related in complex and interactive ways with changes outside the United States, and vice versa. In order for U.S. concerns related to climate change to be addressed comprehensively, the international context must be considered. Foreign assistance, health, environmental quality objectives, and economic interests are all affected by climate changes experienced in other parts of the world. Although there is significantly more work to be done in this area, this report identifies some initial implications of global and international trends that can be more fully investigated in future assessments.

Thresholds, Tipping Points, and Surprises

While some climate changes will occur slowly and relatively gradually, others could be rapid and dramatic, leading to unexpected breaking points in natural and social systems. Although they have potentially large impacts, these breaking points or tipping points are difficult to predict, as there are many uncertainties about future conditions. These uncertainties and potential surprises come from a number of sources, including insufficient data associated with low probability/high consequence events, models that are not yet able to represent all the interactions of multiple stresses, incomplete understanding of physical climate mechanisms related to tipping points, and a multitude of issues associated with human behavior, risk management, and decision-making. Improving our ability to anticipate thresholds and tipping points can be helpful in developing effective climate change mitigation and adaptation strategies (Ch. 2: Our Changing Climate; Ch. 29: Research Needs; and Appendices 3 and 4).

RISK MANAGEMENT FRAMEWORK

Authors were asked to consider the science and information needs of decision-makers facing climate change risks to infrastructure, natural ecosystems, resources, communities, and other things of societal value. They were also asked to consider opportunities that climate change might present. For each region and sector, they were asked to assess a small number of key climate-related vulnerabilities of concern based on the risk (considering likelihood and consequence) of impacts. They were also asked to address the most important information needs of stakeholders, and to consider the decisions stakeholders are facing. The criteria provided for identifying key vulnerabilities in each sector or region included magnitude, timing, persistence/reversibility, scale, and distribution of impacts, likelihood whenever possible, importance of impacts (based on the perceptions of relevant parties), and the potential for adaptation. Authors were encouraged to think about these topics from both a quantitative and qualitative perspective and to consider the influence of multiple stresses whenever possible.

RESPONDING TO CLIMATE CHANGE

While the primary focus of this report is on the impacts of climate change in the United States, it also documents some of the actions society is taking or can take to respond. Responses to climate change fall into two broad categories. The first involves "mitigation" measures to reduce future climate change by reducing emissions of heat-trapping gases and particles, or increasing removal of carbon dioxide from the atmosphere. The second involves "adaptation" measures to improve society's ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. At this point, both of these response activities are necessary to limit the magnitude and impacts of global climate change on the United States.

More effective mitigation measures can reduce the amount of climate change, and therefore reduce the need for future adaptation. This report underscores the effects of mitigation measures by comparing impacts resulting from higher versus lower emissions scenarios. This shows that choices made about emissions in the next few decades will have far-reaching consequences for climate change impacts throughout this century. Lower emissions will reduce the rate and lessen the magnitude of climate change and its impacts. Higher emissions will do the opposite.

While the report demonstrates the importance of mitigation as an essential part of the nation's climate change strategy, it does not evaluate mitigation technologies or policies or undertake an analysis of the effectiveness of various approaches. The range of mitigation responses being studied includes, but is not limited to, policies and technologies that lead to more efficient production and use of energy, increased use of non-carbon-emitting energy sources such as wind and solar power, and carbon capture and storage.

Adaptation actions are complementary to mitigation actions. They are focused on moderating harmful impacts of current and future climate variability and change and taking advantage of possible opportunities. While this report assesses the current state of adaptation actions and planning across the country in a general way, the implementation of adaptive actions is still nascent. A comprehensive assessment of actions taken, and of their effectiveness, is not yet possible. This report documents some of the actions currently being pursued to address impacts such as increased urban heat extremes and air pollution, and describes the challenges decision-makers face in planning for and implementing adaptation responses.

TRACEABLE ACCOUNTS: PROCESS AND CONFIDENCE

The "traceable accounts" that accompany each chapter: 1) document the process the authors used to reach the conclusions in their key messages; 2) provide additional information to reviewers and other readers about the quality of the information used; 3) allow traceability to resources; and 4) provide the level of confidence the authors have in the main findings of the chapters. The authors have assessed a wide range of information in the scientific literature and various technical reports. In assessing confidence, they have considered the strength and consistency of the observed evidence, the skill, range, and consistency of model projections, and insights from peer-reviewed sources.

When it is considered scientifically justified to report the likelihood of particular impacts within the range of possible outcomes, this report takes a plain-language approach to expressing the expert judgment of the author team based on the best available evidence. For example, an outcome termed "likely" has at least a two-thirds chance of occurring; an outcome termed "very likely" has more than a 90% chance. Key sources of information used to develop these characterizations are referenced.

1 OVERVIEW AND REPORT FINDINGS

Climate change is already affecting the American people in far-reaching ways. Certain types of extreme weather events with links to climate change have become more frequent and/or intense, including prolonged periods of heat, heavy downpours, and, in some regions, floods and droughts. In addition, warming is causing sea level to rise and glaciers and Arctic sea ice to melt, and oceans are becoming more acidic as they absorb carbon dioxide. These and other aspects of climate change are disrupting people's lives and damaging some sectors of our economy.

Coal-fired power plants emit heat-trapping carbon dioxide to the atmosphere.

Climate Change: Present and Future

Evidence for climate change abounds, from the top of the atmosphere to the depths of the oceans. Scientists and engineers from around the world have meticulously collected this evidence, using satellites and networks of weather balloons, thermometers, buoys, and other observing systems. Evidence of climate change is also visible in the observed and measured changes in location and behavior of species and functioning of ecosystems. Taken together, this evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity.

Multiple lines of independent evidence confirm that human activities are the primary cause of the global warming of the past 50 years. The burning of coal, oil, and gas, and clearing of forests have increased the concentration of carbon dioxide in the atmosphere by more than 40% since the Industrial Revolution, and it has been known for almost two centuries that this carbon dioxide traps heat. Methane and nitrous oxide emissions from agriculture and other human activities add to the atmospheric burden of heat-trapping gases. Data show that natural factors like the sun and volcanoes cannot have caused the warming observed over the past 50 years. Sensors on satellites have measured the sun's output with great accuracy and found no overall increase during the past half century. Large volcanic eruptions during this period, such as Mount Pinatubo in 1991, have exerted a short-term *cooling* influence. In fact, if not for human activities, global climate would actually have cooled slightly over the past 50 years. The pattern of temperature change through the layers of the atmosphere, with warming near the surface and cooling higher up in the stratosphere, further confirms that it is the buildup of heat-trapping gases (also known as "greenhouse gases") that has caused most of the Earth's warming over the past half century.

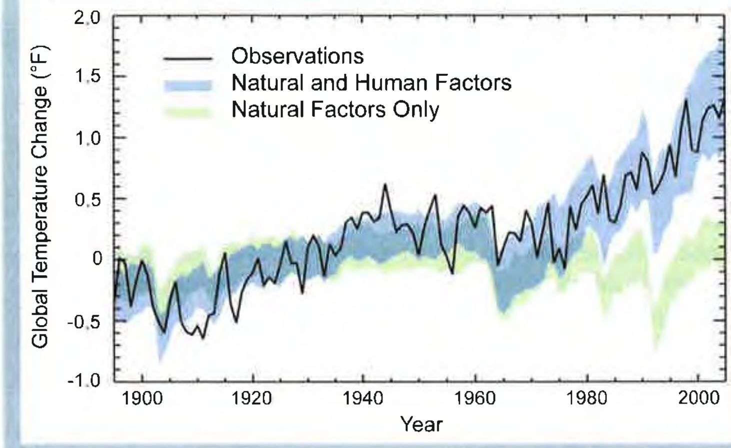
Ten Indicators of a Warming World

These are just some of the indicators measured globally over many decades that show that the Earth's climate is warming. White arrows indicate increasing trends; black arrows indicate decreasing trends. All the indicators expected to increase in a warming world are increasing, and all those expected to decrease in a warming world are decreasing. (Figure source: NOAA NCDC, based on data updated from Kennedy et al. 2010").

Because human-induced warming is superimposed on a background of natural variations in climate, warming is not uniform over time. Short-term fluctuations in the long-term upward trend are thus natural and expected. For example, a recent slowing in the rate of surface air temperature rise appears to be related to cyclic changes in the oceans and in the sun's energy output, as well as a series of small volcanic eruptions and other factors. Nonetheless, global temperatures are still on the rise and are expected to rise further.

U.S. average temperature has increased by 1.3°F to 1.9°F since 1895, and most of this increase has occurred since 1970. The most recent decade was the nation's and the world's hottest on record, and 2012 was the hottest year on record in the continental United States. All U.S. regions have experienced warming in recent decades, but the extent of warming has not been uniform. In general, temperatures are rising more quickly in the north. Alaskans have experienced some of the largest increases in temperature between 1970 and the present. People living in the Southeast have experienced some of the smallest temperature increases over this period.

Separating Human and Natural Influences on Climate

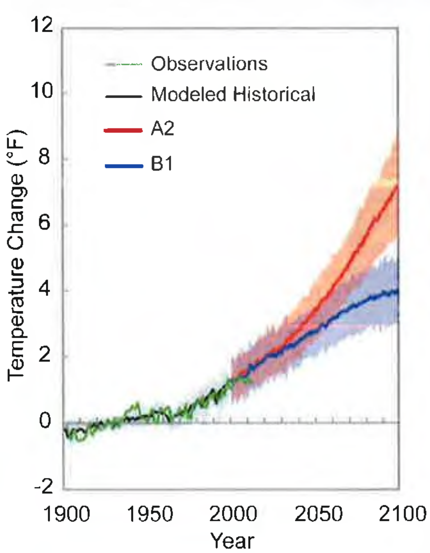


The green band shows how global average temperature would have changed over the last century due to natural forces alone, as simulated by climate models. The blue band shows model simulations of the effects of human and natural forces (including solar and volcanic activity) combined. The black line shows the actual observed global average temperatures. Only with the inclusion of human influences can models reproduce the observed temperature changes. (Figure source: adapted from Huber and Knutti 2012[8]).

Temperatures are projected to rise another 2°F to 4°F in most areas of the United States over the next few decades. Reductions in some short-lived human-induced emissions that contribute to warming, such as black carbon (soot) and methane, could reduce some of the projected warming over the next couple of decades, because, unlike carbon dioxide, these gases and particles have relatively short atmospheric lifetimes.

The amount of warming projected beyond the next few decades is directly linked to the cumulative global emissions of heat-trapping gases and particles. By the end of this century, a roughly 3°F to 5°F rise is projected under a lower emissions scenario, which would require substantial reductions in emissions (referred to as the "B1 scenario"), and a 5°F to 10°F rise for a higher emissions scenario assuming continued increases in emissions, predominantly from fossil fuel combustion (referred to as the "A2 scenario"). These projections are based on results from 16 climate models that used the two emissions scenarios in a formal intermodel comparison study. The range of model projections for each emissions scenario is the result of the differences in the ways the models represent key factors such as water vapor, ice and snow reflectivity, and clouds, which can either dampen or amplify the initial effect of human influences on temperature. The net effect of these feedbacks is expected to amplify warming. More information about the models and scenarios used in this report can be found in Appendix 5 of the full report.[1]

Projected Global Temperature Change



Different amounts of heat-trapping gases released into the atmosphere by human activities produce different projected increases in Earth's temperature. The lines on the graph represent a central estimate of global average temperature rise (relative to the 1901-1960 average) for the two main scenarios used in this report. A2 assumes continued increases in emissions throughout this century, and B1 assumes significant emissions reductions, though not due explicitly to climate change policies. Shading indicates the range (5th to 95th percentile) of results from a suite of climate models. In both cases, temperatures are expected to rise, although the difference between lower and higher emissions pathways is substantial. (Figure source: NOAA NCDC / CICS-NC).

Prolonged periods of high temperatures and the persistence of high nighttime temperatures have increased in many locations (especially in urban areas) over the past half century. High nighttime temperatures have widespread impacts because people, livestock, and wildlife get no respite from the heat. In some regions, prolonged periods of high temperatures associated with droughts contribute to conditions that lead to larger wildfires and longer fire seasons. As expected in a warming climate, recent trends show that extreme heat is becoming more common, while extreme cold is becoming less common. Evidence indicates that the human influence on climate has already roughly doubled the probability of extreme heat events such as the record-breaking summer heat experienced in 2011 in Texas and Oklahoma. The incidence of record-breaking high temperatures is projected to rise.[2]

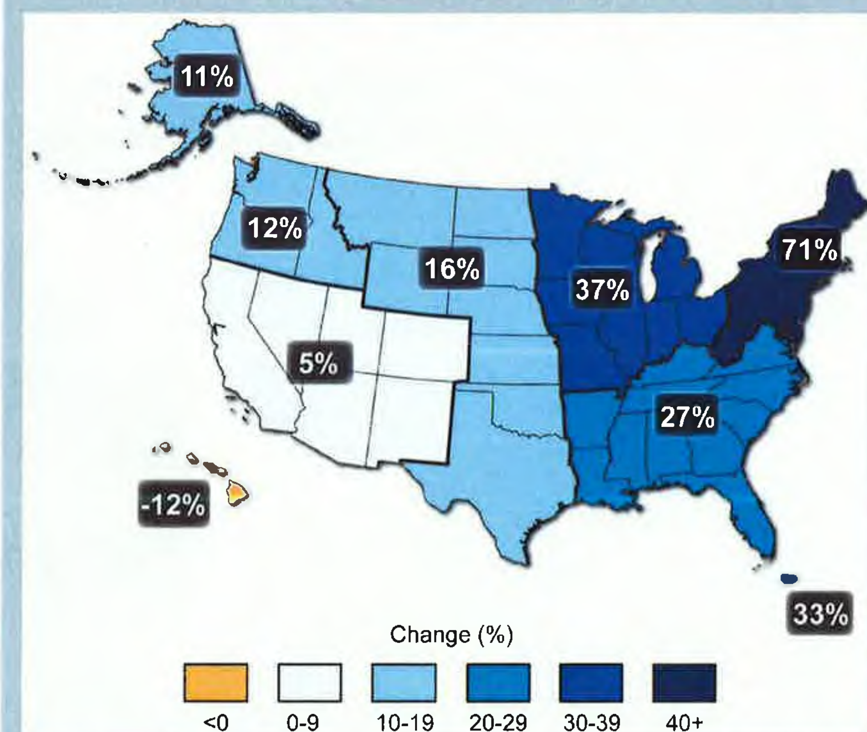
Human-induced climate change means much more than just hotter weather. Increases in ocean and freshwater temperatures, frost-free days, and heavy downpours have all been documented. Global sea level has risen, and there have been large reductions in snow-cover extent, glaciers, and sea ice. These changes and other climatic changes have affected and will continue to affect human health, water supply, agriculture, transportation, energy, coastal areas, and many other sectors of society, with increasingly adverse impacts on the American economy and quality of life.[3]

Some of the changes discussed in this report are common to many regions. For example, large increases in heavy precipitation have occurred in the Northeast, Midwest, and Great Plains, where heavy downpours have frequently led to runoff that exceeded the capacity of storm drains and levees, and caused flooding events and accelerated erosion. Other impacts, such as those associated with the rapid thawing of permafrost in Alaska, are unique to a particular U.S. region. Permafrost thawing is causing extensive damage to infrastructure in our nation's largest state.[4]

Some impacts that occur in one region ripple beyond that region. For example, the dramatic decline of summer sea ice in the Arctic – a loss of ice cover roughly equal to half the area of the continental United States – exacerbates global warming by reducing the reflectivity of Earth's surface and increasing the amount of heat absorbed. Similarly, smoke from wildfires in one location can contribute to poor air quality in faraway regions, and evidence suggests that particulate matter can affect atmospheric properties and therefore weather patterns. Major storms and the higher storm surges exacerbated by sea level rise that hit the Gulf Coast affect the entire country through their cascading effects on oil and gas production and distribution.[5]

Water expands as it warms, causing global sea levels to rise; melting of land-based ice also raises sea level by adding water to the oceans. Over the past century, global average sea level has risen by about 8 inches. Since 1992, the rate of global sea level rise measured by satellites has been roughly twice the rate observed over the last century, providing evidence of acceleration. Sea level rise, combined with coastal storms, has increased the risk of erosion, storm surge damage, and flooding for coastal communities, especially along the Gulf Coast, the Atlantic seaboard, and in Alaska. Coastal infrastructure, including roads, rail lines, energy infrastructure, airports, port facilities, and military bases, are increasingly at risk from sea level rise and damaging storm surges. Sea level is projected to rise by another 1 to 4 feet in this century, although the rise in sea level in specific regions is expected to vary from this global average for a number of reasons. A wider range of scenarios,

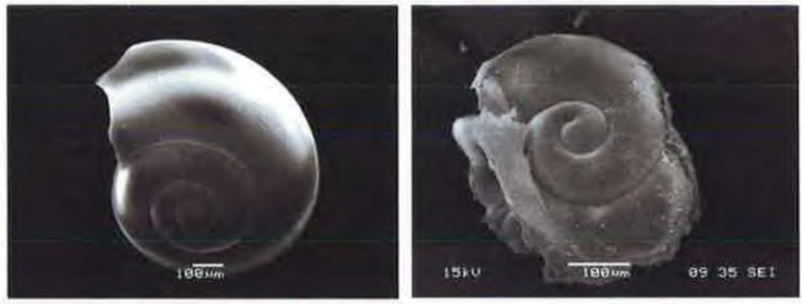
Observed Change in Very Heavy Precipitation



Percent changes in the amount of precipitation falling in very heavy events (the heaviest 1%) from 1958 to 2012 for each region. There is a clear national trend toward a greater amount of precipitation being concentrated in very heavy events, particularly in the Northeast and Midwest. (Figure source: updated from Karl et al. 2009[7]).

from 8 inches to more than 6 feet by 2100, has been used in risk-based analyses in this report. In general, higher emissions scenarios that lead to more warming would be expected to lead to higher amounts of sea level rise. The stakes are high, as nearly five million Americans and hundreds of billions of dollars of property are located in areas that are less than four feet above the local high-tide level.[6]

Shells Dissolve in Acidified Ocean Water



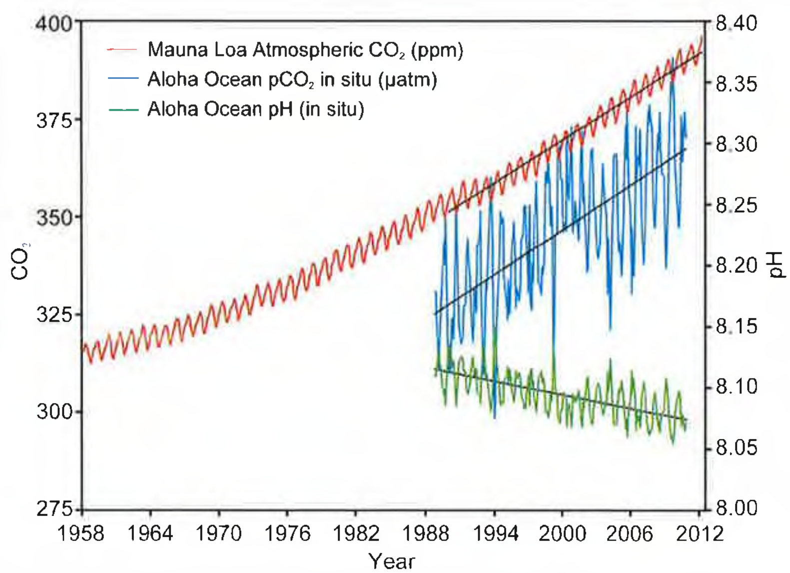
Pteropods, or "sea butterflies," are eaten by a variety of marine species ranging from tiny krill to salmon to whales. The photos show what happens to a pteropod's shell in seawater that is too acidic. On the left is a shell from a live pteropod from a region in the Southern Ocean where acidity is not too high. The shell on the right is from a pteropod in a region where the water is more acidic. (Figure source: (left) Bednaršek et al. 2012[8] (right) Nina Bednaršek).

In addition to causing changes in climate, increasing levels of carbon dioxide from the burning of fossil fuels and other human activities have a direct effect on the world's oceans. Carbon dioxide interacts with ocean water to form carbonic acid, increasing the ocean's acidity. Ocean surface waters have become 30% more acidic over the last 250 years as they have absorbed large amounts of carbon dioxide from the atmosphere. This ocean acidification makes water more corrosive, reducing the capacity of marine organisms with shells or skeletons made of calcium carbonate (such as corals, krill, oysters, clams, and crabs) to survive, grow, and reproduce, which in turn will affect the marine food chain.[7]

Widespread Impacts

Impacts related to climate change are already evident in many regions and sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond. Climate changes interact with other environmental and societal factors in ways that can either moderate or intensify these impacts.

As Oceans Absorb CO_2 They Become More Acidic



The correlation between rising levels of carbon dioxide in the atmosphere (red) with rising carbon dioxide levels (blue) and falling pH in the ocean (green). As carbon dioxide accumulates in the ocean, the water becomes more acidic (the pH declines). (Figure source: modified from Feely et al. 2009[d]).

Observed and projected climate change impacts vary across the regions of the United States. Selected impacts emphasized in the regional chapters are shown below, and many more are explored in detail in this report.

Region	Impacts
Northeast	Communities are affected by heat waves, more extreme precipitation events, and coastal flooding due to sea level rise and storm surge.
Southeast and Caribbean	Decreased water availability, exacerbated by population growth and land-use change, causes increased competition for water. There are increased risks associated with extreme events such as hurricanes.
Midwest	Longer growing seasons and rising carbon dioxide levels increase yields of some crops, although these benefits have already been offset in some instances by occurrence of extreme events such as heat waves, droughts, and floods.
Great Plains	Rising temperatures lead to increased demand for water and energy and impacts on agricultural practices.
Southwest	Drought and increased warming foster wildfires and increased competition for scarce water resources for people and ecosystems.
Northwest	Changes in the timing of streamflow related to earlier snowmelt reduce the supply of water in summer, causing far-reaching ecological and socioeconomic consequences.
Alaska	Rapidly receding summer sea ice, shrinking glaciers, and thawing permafrost cause damage to infrastructure and major changes to ecosystems. Impacts to Alaska Native communities increase.
Hawai'i and Pacific Islands	Increasingly constrained freshwater supplies, coupled with increased temperatures, stress both people and ecosystems and decrease food and water security.
Coasts	Coastal lifelines, such as water supply infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, and other climate-related changes.
Oceans	The oceans are currently absorbing about a quarter of human-caused carbon dioxide emissions to the atmosphere and over 90% of the heat associated with global warming, leading to ocean acidification and the alteration of marine ecosystems.

Some climate changes currently have beneficial effects for specific sectors or regions. For example, current benefits of warming include longer growing seasons for agriculture and longer ice-free periods for shipping on the Great Lakes. At the same time, however, longer growing seasons, along with higher temperatures and carbon dioxide levels, can increase pollen production, intensifying and lengthening the allergy season. Longer ice-free periods on the Great Lakes can result in more lake-effect snowfalls.

Sectors affected by climate changes include agriculture, water, human health, energy, transportation, forests, and ecosystems. Climate change poses a major challenge to U.S. agriculture because of the critical dependence of agricultural systems on climate. Climate change has the potential to both positively and negatively affect the location, timing, and productivity of crop, livestock, and fishery systems at local, national, and global scales. The United States produces nearly $330 billion per year in agricultural commodities. This productivity is vulnerable to direct impacts on crops and livestock from changing climate conditions and extreme weather events and indirect impacts through increasing pressures from pests and pathogens. Climate change will also alter the stability of food supplies and create new food security challenges for the United States as the world seeks to feed nine billion people by 2050. While the agriculture sector has proven to be adaptable to a range of stresses, as evidenced by continued growth in production and efficiency across the United States, climate change poses a new set of challenges.[8]

Climate change can exacerbate respiratory and asthma-related conditions through increases in pollen, ground-level ozone, and wildfire smoke.

Water quality and quantity are being affected by climate change. Changes in precipitation and runoff, combined with changes in consumption and withdrawal, have reduced surface and groundwater supplies in many areas. These trends are expected to continue, increasing the likelihood of water shortages for many uses. Water quality is also diminishing in many areas, particularly due to sediment and contaminant concentrations after heavy downpours. Sea level rise, storms and storm surges, and changes in surface and groundwater use patterns are expected to compromise the sustainability of coastal freshwater aquifers and wetlands. In most U.S. regions, water resources managers and planners will encounter new risks, vulnerabilities, and opportunities that may not be properly managed with existing practices.[9]

Certain groups of people are more vulnerable to the range of climate change related health impacts, including the elderly, children, the poor, and the sick.

Increasing air and water temperatures, more intense precipitation and runoff, and intensifying droughts can decrease water quality in many ways. Here, middle school students in Colorado test water quality.

Climate change affects human health in many ways. For example, increasingly frequent and intense heat events lead to more heat-related illnesses and deaths and, over time, worsen drought and wildfire risks, and intensify air pollution. Increasingly frequent extreme precipitation and associated flooding can lead to injuries and increases in waterborne disease. Rising sea surface temperatures have been linked with increasing levels and ranges of diseases. Rising sea levels intensify coastal flooding and storm surge, and thus exacerbate threats to public safety during storms. Certain groups of people are more vulnerable to the range of climate change related health impacts, including the elderly, children, the poor, and the sick. Others are vulnerable because of where they live, including those in floodplains, coastal zones, and some urban areas. Improving and properly supporting the public health infrastructure will be critical to managing the potential health impacts of climate change.[10]

Climate change also affects the living world, including people, through changes in ecosystems and biodiversity. Ecosystems provide a rich array of benefits and services to humanity, including habitat for fish and wildlife, drinking water storage and filtration, fertile soils for growing crops, buffering against a range of stressors including climate change impacts, and aesthetic and cultural values. These benefits are not always easy to quantify, but they support jobs, economic growth, health, and human well-being. Climate change driven disruptions to ecosystems have direct and indirect human impacts, including reduced water supply and quality, the loss of iconic species and landscapes, effects on food chains and the timing and success of species migrations, and the potential for extreme weather and climate events to destroy or degrade the ability of ecosystems to provide societal benefits.[11]

> The amount of future climate change will still largely be determined by choices society makes about emissions.

Human modifications of ecosystems and landscapes often increase their vulnerability to damage from extreme weather events, while simultaneously reducing their natural capacity to moderate the impacts of such events. For example, salt marshes, reefs, mangrove forests, and barrier islands defend coastal ecosystems and infrastructure, such as roads and buildings, against storm surges. The loss of these natural buffers due to coastal development, erosion, and sea level rise increases the risk of catastrophic damage during or after extreme weather events. Although floodplain wetlands are greatly reduced from their historical extent, those that remain still absorb floodwaters and reduce the effects of high flows on river-margin lands. Extreme weather events that produce sudden increases in water flow, often carrying debris and pollutants, can decrease the natural capacity of ecosystems to cleanse contaminants.[12]

The climate change impacts being felt in the regions and sectors of the United States are affected by global trends and economic decisions. In an increasingly interconnected world, U.S. vulnerability is linked to impacts in other nations. It is thus difficult to fully evaluate the impacts of climate change on the United States without considering consequences of climate change elsewhere.

Response Options

As the impacts of climate change are becoming more prevalent, Americans face choices. Especially because of past emissions of long-lived heat-trapping gases, some additional climate change and related impacts are now unavoidable. This is due to the long-lived nature of many of these gases, as well as the amount of heat absorbed and retained by the oceans and other responses within the climate system. The amount of future climate change, however, will still largely be determined by choices society makes about emissions. Lower emissions of heat-trapping gases and particles mean less future warming and less-severe impacts; higher emissions mean more warming and more severe impacts. Efforts to limit emissions or increase carbon uptake fall into a category of response options known as "mitigation," which refers to reducing the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.[13]

The other major category of response options is known as "adaptation," and refers to actions to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities. Mitigation and adaptation actions are linked in multiple ways, including that effective mitigation reduces the need for adaptation in the future. Both are essential parts of a comprehensive climate change response strategy. The threat of irreversible impacts makes the timing of mitigation efforts particularly critical. This report includes chapters on Mitigation, Adaptation, and Decision Support that offer an overview of the options and activities being planned or implemented around the country as local, state, federal, and tribal governments, as well as businesses, organizations, and individuals begin to respond to climate change. These chapters conclude that while response actions are under development, current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.[14]

Large reductions in global emissions of heat-trapping gases, similar to the lower emissions scenario (B1) analyzed in this assessment, would reduce the risks of some of the worst impacts of climate change. Some targets called for in international climate negotiations to date would require even larger reductions than those outlined in the B1 scenario. Meanwhile, global emissions are still rising and are on a path to be even higher than the high emissions scenario (A2) analyzed in this report. The recent U.S. contribution to annual global emissions is about 18%, but the U.S. contribution to cumulative global emissions over the last century is much higher. Carbon dioxide lasts for a long time in the atmosphere, and it is the cumulative carbon emissions that determine the amount of global climate change. After decades of increases, U.S. CO_2 emissions from energy use (which account for 97% of total U.S. emissions) declined by around 9% between 2008 and 2012, largely due to a shift from coal to less CO_2-intensive natural gas for electricity production. Governmental actions in city, state, regional, and federal programs to promote energy efficiency have also contributed to reducing U.S. carbon emissions. Many, if not most of these programs are motivated by other policy objectives, but some are directed specifically at greenhouse gas emissions.

These U.S. actions and others that might be undertaken in the future are described in the Mitigation chapter of this report. Over the remainder of this century, aggressive and sustained greenhouse gas emission reductions by the United States and by other nations would be needed to reduce global emissions to a level consistent with the lower scenario (B1) analyzed in this assessment.[15]

With regard to adaptation, the pace and magnitude of observed and projected changes emphasize the need to be prepared for a wide variety and intensity of impacts. Because of the growing influence of human activities, the climate of the past is not a good basis for future planning. For example, building codes and landscaping ordinances could be updated to improve energy efficiency, conserve water supplies, protect against insects that spread disease (such as dengue fever), reduce susceptibility to heat stress, and improve protection against extreme events. The fact that climate change impacts are increasing points to the urgent need to develop and refine approaches that enable decision-making and increase flexibility and resilience in the face of ongoing and future impacts. Reducing non-climate-related stresses that contribute to existing vulnerabilities can also be an effective approach to climate change adaptation.[16]

Adaptation can involve considering local, state, regional, national, and international jurisdictional objectives. For example, in managing water supplies to adapt to a changing climate, the implications of international treaties should be considered in the context of managing the Great Lakes, the Columbia River, and the Colorado River to deal with increased drought risk. Both "bottom up" community planning and "top down" national strategies may help regions deal with impacts such as increases in electrical brownouts, heat stress, floods, and wildfires.[17]

Proactively preparing for climate change can reduce impacts while also facilitating a more rapid and efficient response to changes as they happen. Such efforts are beginning at the federal, regional, state, tribal, and local levels, and in the corporate and non-governmental sectors, to build adaptive capacity and resilience to climate change impacts. Using scientific information to prepare for climate changes in advance can provide economic opportunities, and proactively managing the risks can reduce impacts and costs over time.[18]

There are a number of areas where improved scientific information or understanding would enhance the capacity to estimate future climate change impacts. For example, knowledge of the mechanisms controlling the rate of ice loss in Greenland and Antarctica is limited, making it difficult for scientists to narrow the range of expected future sea level rise. Improved understanding of ecological and social responses to climate change is needed, as is understanding of how ecological and social responses will interact.[19]

A sustained climate assessment process could more efficiently collect and synthesize the rapidly evolving science and help supply timely and relevant information to decision-makers. Results from all of these efforts could continue to deepen our understanding of the interactions of human and natural systems in the context of a changing climate, enabling society to effectively respond and prepare for our future.[20]

The cumulative weight of the scientific evidence contained in this report confirms that climate change is affecting the American people now, and that choices we make will affect our future and that of future generations.



Cities providing transportation options including bike lanes, buildings designed with energy saving features such as green roofs, and houses elevated to allow storm surges to pass underneath are among the many response options being pursued around the country.

Report Findings

These findings distill important results that arise from this National Climate Assessment. They do not represent a full summary of all of the chapters' findings, but rather a synthesis of particularly noteworthy conclusions.

1. Global climate is changing and this is apparent across the United States in a wide range of observations. The global warming of the past 50 years is primarily due to human activities, predominantly the burning of fossil fuels.

Many independent lines of evidence confirm that human activities are affecting climate in unprecedented ways. U.S. average temperature has increased by 1.3°F to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the warmest on record. Because human-induced warming is superimposed on a naturally varying climate, rising temperatures are not evenly distributed across the country or over time.[21]

2. Some extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities.

Changes in extreme weather events are the primary way that most people experience climate change. Human-induced climate change has already increased the number and strength of some of these extreme events. Over the last 50 years, much of the United States has seen an increase in prolonged periods of excessively high temperatures, more heavy downpours, and in some regions, more severe droughts.[22]

3. Human-induced climate change is projected to continue, and it will accelerate significantly if global emissions of heat-trapping gases continue to increase.

Heat-trapping gases already in the atmosphere have committed us to a hotter future with more climate-related impacts over the next few decades. The magnitude of climate change beyond the next few decades depends primarily on the amount of heat-trapping gases that human activities emit globally, now and in the future.[23]

4. Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond.

Climate change is already affecting societies and the natural world. Climate change interacts with other environmental and societal factors in ways that can either moderate or intensify these impacts. The types and magnitudes of impacts vary across the nation and through time. Children, the elderly, the sick, and the poor are especially vulnerable. There is mounting evidence that harm to the nation will increase substantially in the future unless global emissions of heat-trapping gases are greatly reduced.[24]

5. Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water.

Climate change is increasing the risks of heat stress, respiratory stress from poor air quality, and the spread of waterborne diseases. Extreme weather events often lead to fatalities and a variety of health impacts on vulnerable populations, including impacts on mental health, such as anxiety and post-traumatic stress disorder. Large-scale changes in the environment due to climate change and extreme weather events are increasing the risk of the emergence or reemergence of health threats that are currently uncommon in the United States, such as dengue fever.[25]

6. Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change.

Sea level rise, storm surge, and heavy downpours, in combination with the pattern of continued development in coastal areas, are increasing damage to U.S. infrastructure including roads, buildings, and industrial facilities, and are also increasing risks to ports and coastal military installations. Flooding along rivers, lakes, and in cities following heavy downpours, prolonged rains, and rapid melting of snowpack is exceeding the limits of flood protection infrastructure designed for historical conditions. Extreme heat is damaging transportation infrastructure such as roads, rail lines, and airport runways.[26]

7. Water quality and water supply reliability are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods.

Surface and groundwater supplies in some regions are already stressed by increasing demand for water as well as declining runoff and groundwater recharge. In some regions, particularly the southern part of the country and the Caribbean and Pacific Islands, climate change is increasing the likelihood of water shortages and competition for water among its many uses. Water quality is diminishing in many areas, particularly due to increasing sediment and contaminant concentrations after heavy downpours.[27]

8. Climate disruptions to agriculture have been increasing and are projected to become more severe over this century.

Some areas are already experiencing climate-related disruptions, particularly due to extreme weather events. While some U.S. regions and some types of agricultural production will be relatively resilient to climate change over the next 25 years or so, others will increasingly suffer from stresses due to extreme heat, drought, disease, and heavy downpours. From mid-century on, climate change is projected to have more negative impacts on crops and livestock across the country – a trend that could diminish the security of our food supply.[28]

9. Climate change poses particular threats to Indigenous Peoples' health, well-being, and ways of life.

Chronic stresses such as extreme poverty are being exacerbated by climate change impacts such as reduced access to traditional foods, decreased water quality, and increasing exposure to health and safety hazards. In parts of Alaska, Louisiana, the Pacific Islands, and other coastal locations, climate change impacts (through erosion and inundation) are so severe that some communities are already relocating from historical homelands to which their traditions and cultural identities are tied. Particularly in Alaska, the rapid pace of temperature rise, ice and snow melt, and permafrost thaw are significantly affecting critical infrastructure and traditional livelihoods.[29]

10. Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed.

Climate change impacts on biodiversity are already being observed in alteration of the timing of critical biological events such as spring bud burst and substantial range shifts of many species. In the longer term, there is an increased risk of species extinction. These changes have social, cultural, and economic effects. Events such as droughts, floods, wildfires, and pest outbreaks associated with climate change (for example, bark beetles in the West) are already disrupting ecosystems. These changes limit the capacity of ecosystems, such as forests, barrier beaches, and wetlands, to continue to play important roles in reducing the impacts of these extreme events on infrastructure, human communities, and other valued resources.[30]

11. Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulation, chemistry, ecosystems, and marine life.

More acidic waters inhibit the formation of shells, skeletons, and coral reefs. Warmer waters harm coral reefs and alter the distribution, abundance, and productivity of many marine species. The rising temperature and changing chemistry of ocean water combine with other stresses, such as overfishing and coastal and marine pollution, to alter marine-based food production and harm fishing communities.[31]

12. Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread, but current implementation efforts are insufficient to avoid increasingly negative social, environmental, and economic consequences.

Actions to reduce emissions, increase carbon uptake, adapt to a changing climate, and increase resilience to impacts that are unavoidable can improve public health, economic development, ecosystem protection, and quality of life.[32]

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Numbered references for the Overview indicate the chapters that provide supporting evidence for the reported conclusions.

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2. Ch. 2, 3, 6, 9, 20.
3. Ch. 2, 3, 4, 5, 6, 9, 10, 12, 16, 20, 24, 25.
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18. Ch. 28.
19. Ch. 29, Appendix 6.
20. Ch. 30.
21. Ch. 2, Appendices 3 and 4.
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Climate Change Impacts in the United States

CHAPTER 17
SOUTHEAST AND THE CARIBBEAN

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INFORMATION DRAWN FROM THIS CHAPTER IS INCLUDED IN THE HIGHLIGHTS REPORT AND IS IDENTIFIED BY THIS ICON

17 SOUTHEAST AND THE CARIBBEAN

Key Messages

1. **Sea level rise poses widespread and continuing threats to both natural and built environments and to the regional economy.**
2. **Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and built environments, energy, agriculture, and forestry.**
3. **Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and unique ecosystems.**

The Southeast and Caribbean are exceptionally vulnerable to sea level rise, extreme heat events, hurricanes, and decreased water availability. The geographic distribution of these impacts and vulnerabilities is uneven, since the region encompasses a wide range of natural system types, from the Appalachian Mountains to the coastal plains. It is also home to more than 80 million people[1] and draws millions of visitors every year. In 2009, Puerto Rico hosted 3.5 million tourists who spent $3.5 billion.[2] In 2012, Louisiana and Florida alone hosted more than 115 million visitors.[3]

The region has two of the most populous metropolitan areas in the country (Miami and Atlanta) and four of the ten fastest-growing metropolitan areas.[1] Three of these (Palm Coast, FL, Cape Coral-Fort Myers, FL, and Myrtle Beach area, SC) are along the coast and are vulnerable to sea level rise and storm surge. Puerto Rico has one of the highest population densities in the world, with 56% of the population living in coastal municipalities.[4]

The Gulf and Atlantic coasts are major producers of seafood and home to seven major ports[5] that are also vulnerable. The Southeast is a major energy producer of coal, crude oil, and natural gas, and is the highest energy user of any of the National Climate Assessment regions.[5]

The Southeast's climate is influenced by many factors, including latitude, topography, and proximity to the Atlantic Ocean

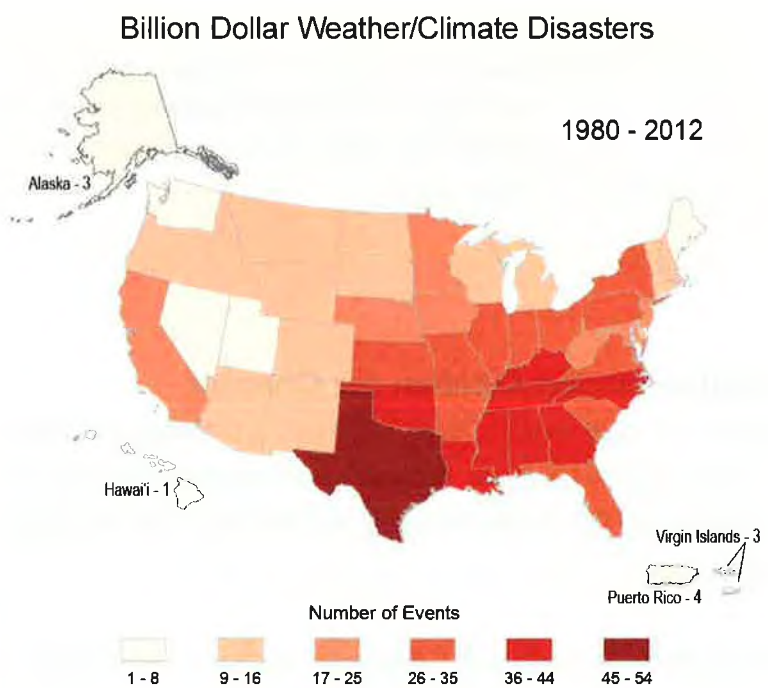

Figure 17.1. This map summarizes the number of times each state has been affected by weather and climate events over the past 30 years that have resulted in more than a billion dollars in damages. The Southeast has been affected by more billion-dollar disasters than any other region. The primary disaster type for coastal states such as Florida is hurricanes, while interior and northern states in the region also experience sizeable numbers of tornadoes and winter storms. For a list of events and the affected states, see: http://www.ncdc.noaa.gov/billions/events.[6] (Figure source: NOAA NCDC).

Stories of change: coastal Louisiana tribal communities

Climate change impacts, especially sea level rise and related increases in storm surges pulsing farther inland, will continue to exacerbate ongoing land loss already affecting Louisiana tribes. Four Native communities in Southeast Louisiana (Grand Bayou Village, Grand Caillou/Dulac, Isle de Jean Charles, and Pointe-au-Chien) have already experienced significant land loss. Management of river flow has deprived the coastal wetlands of the freshwater and sediment that they need to replenish and persist. Dredging of canals through marshes for oil and gas exploration and pipelines has led to erosion and intense saltwater intrusion, resulting in additional land loss. Due to these and other natural and man-made problems, Louisiana has lost 1,880 square miles of land in the last 80 years.[8] This combination of changes has resulted in a cascade of losses of sacred places, healing plants, habitat for important wildlife, food security,[9] and in some cases connectivity with the mainland. Additional impacts include increased inundation of native lands, further travel to reach traditional fishing grounds, reduced connections among family members as their lands have become more flood-prone and some have had to move, and declining community cohesiveness as heat requires more indoor time.[10] (For more specifics, see Ch. 12: Indigenous Peoples). Numerous other impacts from increases in temperature, sea level rise, land loss, erosion, subsidence, and saltwater intrusion amplify these existing problems.

Shrinking Lands for Tribal Communities

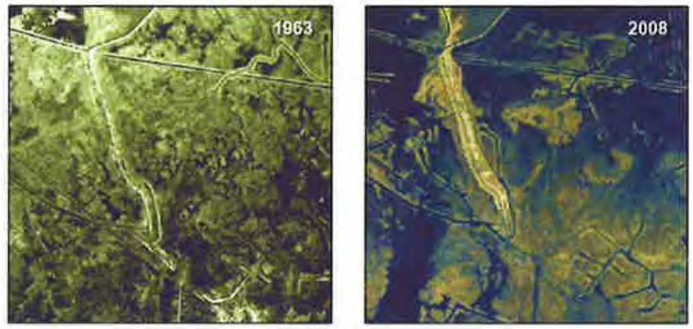

Figure 17.2. Aerial photos of Isle de Jean Charles in Louisiana taken 45 years apart shows evidence of the effects of rising seas, sinking land, and human development. The wetlands adjacent to the Isle de Jean Charles community (about 60 miles south of New Orleans) have been disappearing rapidly since the photo on the left was taken in 1963. By 2008, after four major hurricanes, significant erosion, and alteration of the surrounding marsh for oil and gas extraction, open water surrounds the greatly reduced dry land. See Ch. 25: Coasts for more information. (Photo credit: USGS).

and the Gulf of Mexico. Temperatures generally decrease northward and into mountain areas, while precipitation decreases with distance from the Gulf and Atlantic coasts. The region's climate also varies considerably over seasons, years, and decades, largely due to natural cycles such as the El Niño-Southern Oscillation (ENSO – periodic changes in ocean surface temperatures in the Tropical Pacific Ocean), the semi-permanent high pressure system over Bermuda, differences in atmospheric pressure over key areas of the globe, and land-falling tropical weather systems.[7] These cycles alter the occurrences of hurricanes, tornadoes, droughts, flooding, freezing winters, and ice storms, contributing to climate and weather disasters in the region that have exceeded the total number of billion dollar disasters experienced in all other regions of the country combined (see Figure 17.1).

Observed and Projected Climate Change

Average annual temperature during the last century across the Southeast cycled between warm and cool periods (see Figure 17.3, black line). A warm peak occurred during the 1930s and 1940s followed by a cool period in the 1960s and 1970s. Temperatures increased again from 1970 to the present by an average of 2°F, with higher average temperatures during summer months. There have been increasing numbers of days above 95°F and nights above 75°F, and decreasing numbers of extremely cold days since 1970.[11] The Caribbean also exhibits a trend since the 1950s, with increasing numbers of very warm days and nights, and with daytime maximum temperatures above 90°F and nights above 75°F.[4] Daily and five-day rainfall intensities have also increased.[5] Also, summers have been either increasingly dry or extremely wet.[11] For the Caribbean, precipitation trends are unclear, with some regions experiencing smaller annual amounts of rainfall and some increasing amounts.[4] Although the number of major tornadoes has increased over the last 50 years, there is no statistically significant trend (Ch 2: Our Changing Climate, Key Message 9).[11,12] This increase may be attributable to better reporting of tornadoes. The number of Category 4 and 5 hurricanes in the Atlantic basin has increased substantially since the early 1980s compared to the historical record that dates back to the mid-1880s (Ch. 2: Our Changing Climate, Key Message 8). This can be attributed to both natural variability and climate change.

Temperatures across the Southeast and Caribbean are expected to increase during this century, with shorter-term (year-to-year and decade-to-decade) fluctuations over time due to natural climate variability (Ch. 2: Our Changing Climate, Key Message 3).[4] Major consequences of warming include significant increases in the number of hot days (95°F or above) and decreases in freezing events. Although projected increases for some parts of the region by the year 2100 are generally smaller than for other regions of the United States, projected increases for interior states of the region are larger than coastal regions by 1°F to 2°F. Regional average increases are in the range of 4°F to 8°F (combined 25th to 75th percentile range for A2 and B1 emissions scenarios) and 2°F to 5°F for Puerto Rico.[11]

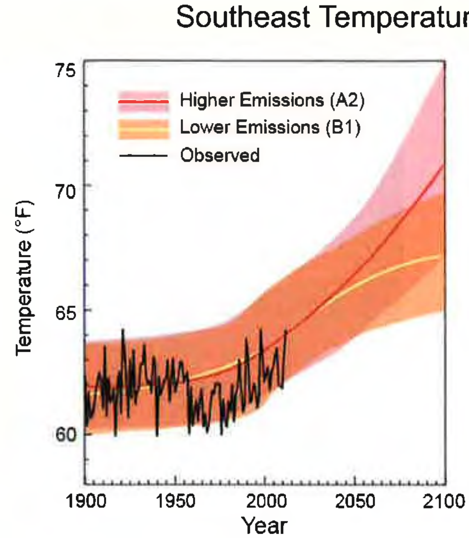

Figure 17.3. Observed annual average temperature for the Southeast and projected temperatures assuming substantial emissions reductions (lower emissions, B1) and assuming continued growth in emissions (higher emissions, A2).[11] For each emissions scenario, shading shows the range of projections and the line shows a central estimate. The projections were referenced to observed temperatures for the period 1901-1960. The region warmed during the early part of last century, cooled for a few decades, and is now warming again. The lack of an overall upward trend over the entire period of 1900-2012 is unusual compared to the rest of the U.S. and the globe. This feature has been dubbed the "warming hole" and has been the subject of considerable research, although a conclusive cause has not been identified. (Figure source: adapted from Kunkel et al. 2013[11]).

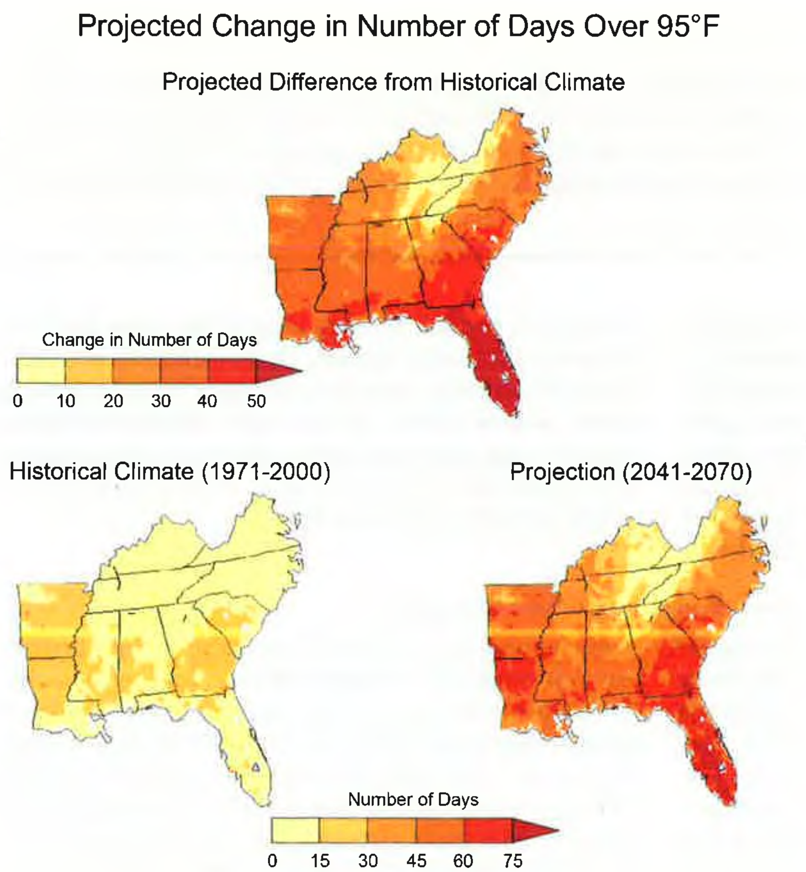

Figure 17.4. Projected average number of days per year with maximum temperatures above 95°F for 2041-2070 compared to 1971-2000, assuming emissions continue to grow (A2 scenario). Patterns are similar, but less pronounced, assuming a reduced emissions scenario (B1). (Figure source: NOAA NCDC / CICS-NC).

Projections of future precipitation patterns are less certain than projections for temperature increases.[11] Because the Southeast is located in the transition zone between projected wetter conditions to the north and drier conditions to the southwest, many of the model projections show only small changes relative to natural variations. However, many models do project drier conditions in the far southwest of the region and wetter conditions in the far northeast of the region, consistent with the larger continental-scale pattern of wetness and dryness (Ch. 2: Our Changing Climate, Key Message 5).[11] For the Caribbean, it is equally difficult to project the magnitude of precipitation changes, although the majority of models show future decreases in precipitation are likely, with a few areas showing increases. In general, annual average decreases are likely to be spread across the entire region.[4] Projections further suggest that warming will cause tropical storms to be fewer in number globally, but stronger in force, with more Category 4 and 5 storms (Ch. 2: Our Changing Climate, Key Message 8).[13] On top of the large increases in extreme precipitation observed during last century and early this century (Ch. 2: Our Changing Climate, Figures 2.16, 2.17, and 2.18), substantial further increases are projected as this century progresses (Ch. 2: Our Changing Climate, Figure 2.19).

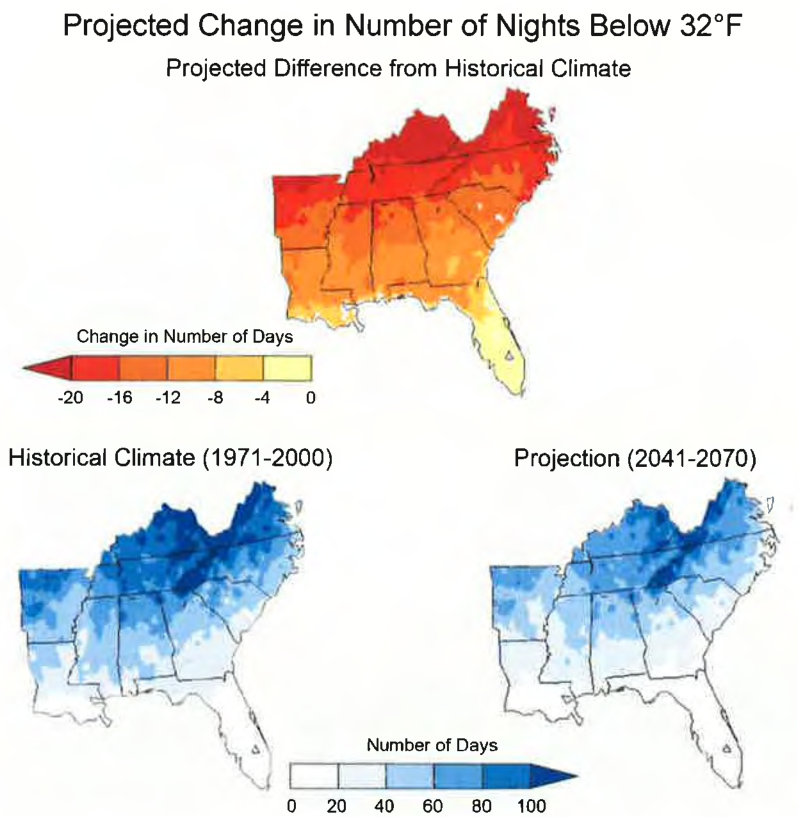

Figure 17.5. Projected average number of days per year with temperatures less than 32°F for 2041-2070 compared to 1971-2000, assuming emissions continue to grow (A2 scenario). Patterns are similar, but less pronounced, assuming a reduced emissions scenario (B1). (Figure source: NOAA NCDC / CICS-NC).

Key Message 1: Sea Level Rise Threats

Sea level rise poses widespread and continuing threats to both natural and built environments and to the regional economy.

Global sea level rise over the past century averaged approximately eight inches (Ch. 2: Our Changing Climate, Key Message 10),[14,15] and that rate is expected to accelerate through the end of this century.[16] Portions of the Southeast and Caribbean are highly vulnerable to sea level rise.[4,5] How much sea level rise is experienced in any particular place depends on whether and how much the local land is sinking (also called subsidence) or rising, and changes in offshore currents.[16,17]

Large numbers of cities, roads, railways, ports, airports, oil and gas facilities, and water supplies are at low elevations and potentially vulnerable to the impacts of sea level rise. New Orleans (with roughly half of its population living below sea level[19]), Miami, Tampa, Charleston, and Virginia Beach are among those most at risk.[20] As a result of current sea level rise, the coastline of Puerto Rico around Rincón is being eroded at a rate of 3.3 feet per year.[4]

According to a recent study co-sponsored by a regional utility, coastal counties and parishes in Alabama, Mississippi, Louisiana, and Texas, with a population of approximately 12 million, assets of about $2 trillion, and producers of $634 billion in annual gross domestic product, already face significant losses that annually average $14 billion from hurricane winds, land subsidence, and sea level rise. Future losses for the 2030 timeframe could reach $18 billion (with no sea level rise or change in hurricane wind speed) to $23 billion (with a nearly 3% increase in hurricane wind speed and just under 6 inches of sea level rise). Approximately 50% of the increase in the estimated losses is related to climate change. The study identified $7 billion in cost-effective adaptation investments that could reduce estimated annual losses by about 30% in the 2030 timeframe.[21]

The North Carolina Department of Transportation is raising the roadbed of U.S. Highway 64 across the Albemarle-Pamlico Peninsula by four feet, which includes 18 inches to allow for high-

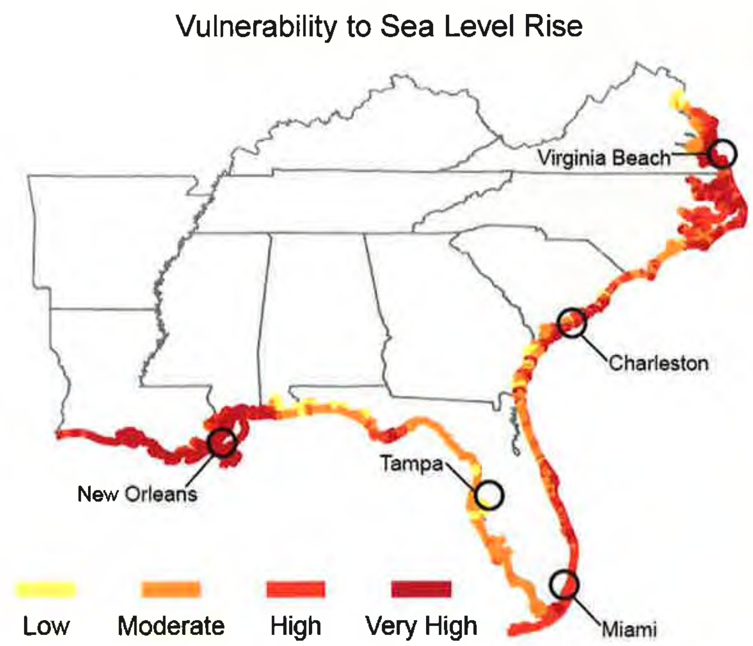

Figure 17.6. The map shows the relative risk that physical changes will occur as sea level rises. The Coastal Vulnerability Index used here is calculated based on tidal range, wave height, coastal slope, shoreline change, landform and processes, and historical rate of relative sea level rise. The approach combines a coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, and yields a relative measure of the system's natural vulnerability to the effects of sea level rise. (Data from Hammar-Klose and Thieler 2001[18]).

er future sea levels.[22] Louisiana State Highway 1, heavily used for delivering critical oil and gas resources from Port Fourchon, is literally sinking, resulting in more frequent and more severe flooding during high tides and storms.[8] The Department of Homeland Security estimated that a 90-day shutdown of this road would cost the nation $7.8 billion.[23]

Sea level rise increases pressure on utilities – such as water and energy – by contaminating potential freshwater supplies with saltwater. Such problems are amplified during extreme dry periods with little runoff. Uncertainties in the scale, timing, and location of climate change impacts can make decision-making difficult, but response strategies, especially those that try to anticipate possible unintended consequences, can be more effective with early planning. Some utilities in the region are already taking sea level rise into account in the construction of new facilities and are seeking to diversify their water sources.[24]

There is an imminent threat of increased inland flooding during heavy rain events in low-lying coastal areas such as southeast Florida, where just inches of sea level rise will impair the capacity of stormwater drainage systems to empty into the ocean.[24] Drainage problems are already being experienced in many locations during seasonal high tides, heavy rains, and storm surge events. Adaptation options that are being assessed in this region include the redesign and improvement of storm drainage canals, flood control structures, and stormwater pumps.

As temperatures and sea levels increase, changes in marine and coastal systems are expected to affect the potential for energy resource development in coastal zones and the outer continental shelf. Oil and gas production infrastructure in bays and coves that are protected by barrier islands, for example, are likely to become increasingly vulnerable to storm surge as sea level rises and barrier islands deteriorate along the central Gulf Coast. The capacity for expanding and maintaining onshore and offshore support facilities and transportation networks is also apt to be affected.[25]

Sea level rise and storm surge can have impacts far beyond the area directly affected. Homes and infrastructure in low areas are increasingly prone to flooding during tropical storms. As a result, insurance costs may increase or coverage may become unavailable[26] and people may move from vulnerable areas, stressing the social and infrastructural capacity of surrounding areas. This migration also happens in response to extreme events such as Hurricane Katrina, when more than 200,000 migrants were temporarily housed in Houston and 42% indicated they would try to remain there (Ch. 9: Human Health, Figure 9.10).[27]

Homes and infrastructure in low-lying areas are increasingly vulnerable to flooding due to storm surge as sea level rises.

Highway 1 to Port Fourchon: Vulnerability of a Critical Link for U.S. Oil

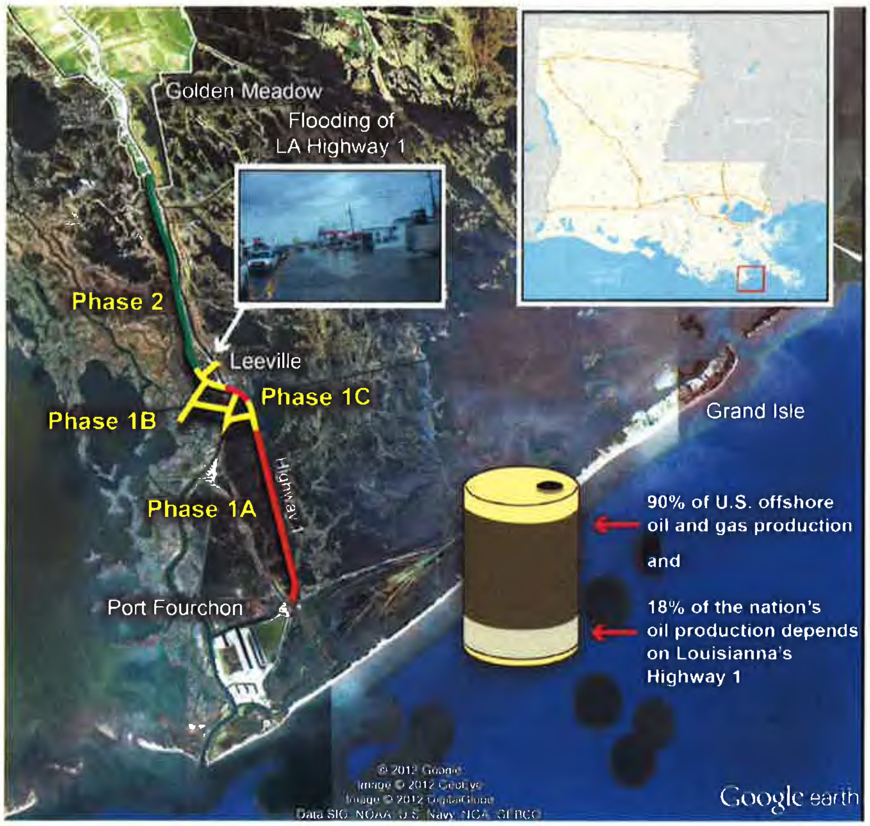

Figure 17.7. Highway 1 in southern Louisiana is the only road to Port Fourchon, whose infrastructure supports 18% of the nation's oil and 90% of the nation's offshore oil and gas production. Flooding is becoming more common on Highway 1 in Leeville (inset photo from flooding in 2004), on the way to Port Fourchon. See also Ch. 25: Coasts, Figure 25.5. (Figure and photo sources: Louisiana Department of Transportation and Development; State of Louisiana 2012[8]).

Reduction of wetlands also increases the potential for losses of important fishery habitat. Additionally, ocean warming could support shifts in local species composition, invasive or new locally viable species, changes in species growth rates, shifts in migratory patterns or dates, and alterations to spawning seasons.[4,31] Any of these could affect the local or regional seafood output and thus the local economy.

In some southeastern coastal areas, changes in salinity and water levels due to a number of complex interactions (including subsidence, availability of sediment, precipitation, and sea level rise) can happen so fast that local vegetation cannot adapt quickly enough and those areas become open water.[32] Fire, hurricanes, and other disturbances have similar effects, causing ecosystems to cross thresholds at which dramatic changes occur over short time frames.[33]

The impacts of sea level rise on agriculture derive from decreased freshwater availability, land loss, and saltwater intrusion. Saltwater intrusion is projected to reduce the availability of fresh surface and groundwater for irrigation, thereby limiting crop production in some areas.[34] Agricultural areas around Miami-Dade County and southern Louisiana with shallow groundwater tables are at risk of increased inundation and future loss of cropland with a projected loss of 37,500 acres in Florida with a 27-inch sea level rise,[35] which is well within the 1- to 4-foot range of sea level rise projected by 2100 (Ch. 2: Our Changing Climate, Key Message 10).

Furthermore, because income is a key indicator of climate vulnerability, people that have limited economic resources are more likely to be adversely affected by climate change impacts such as sea level rise. In the Gulf region, nearly 100% of the "most socially vulnerable people live in areas unlikely to be protected from inundation," bringing equity issues and environmental justice into coastal planning efforts.[28]

Ecosystems of the Southeast and Caribbean are exposed to and at risk from sea level rise, especially tidal marshes and swamps. Some tidal freshwater forests are already retreating, while mangrove forests (adapted to coastal conditions) are expanding landward.[29] The pace of sea level rise will increasingly lead to inundation of coastal wetlands in the region. Such a crisis in land loss has occurred in coastal Louisiana for several decades, with 1,880 square miles having been lost since the 1930s as a result of natural and man-made factors.[8,30] With tidal wetland loss, protection of coastal lands and people against storm surge will be compromised.

There are basically three types of adaptation options to rising sea levels: protect (such as building levees or other "hard" methods), accommodate (such as raising structures or using "soft" or natural protection measures such as wetlands restoration), and retreat.[15,32] Individuals and communities are using all of these strategies. However, regional cooperation among local, state, and federal governments can greatly improve the success of adapting to impacts of climate change and sea level rise. An excellent example is the Southeast Florida Regional Compact. Through collaboration of county, state, and federal agencies, a comprehensive action plan was developed that includes hundreds of actions and special Adaptation Action Areas.[37]

South Florida: Uniquely Vulnerable to Sea Level Rise

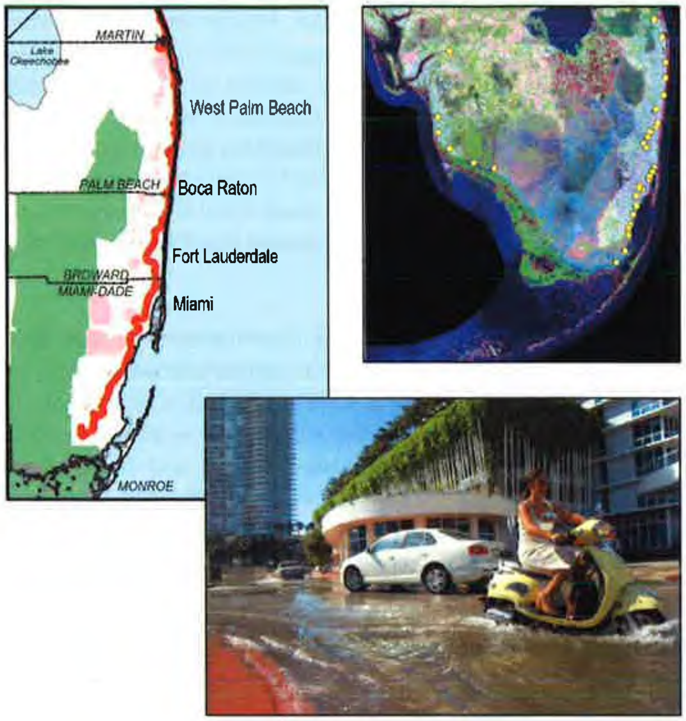

Figure 17.8. Sea level rise presents major challenges to South Florida's existing coastal water management system due to a combination of increasingly urbanized areas, aging flood control facilities, flat topography, and porous limestone aquifers. For instance, South Florida's freshwater well field protection areas (left map: pink areas) lie close to the current interface between saltwater and freshwater (red line), which will shift inland with rising sea level, affecting water managers' ability to draw drinking water from current resources. Coastal water control structures (right map: yellow circles) that were originally built about 60 years ago at the ends of drainage canals to keep saltwater out and to provide flood protection to urbanized areas along the coast are now threatened by sea level rise. Even today, residents in some areas such as Miami Beach are experiencing seawater flooding their streets (lower photo). (Maps from The South Florida Water Management District.[36] Photo credit: Luis Espinoza, Miami-Dade County Department of Regulatory and Economic Resources).

Key Message 2: Increasing Temperatures

Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and built environments, energy, agriculture, and forestry.

The negative effects of heat on human cardiovascular, cerebral, and respiratory systems are well established (Ch. 9: Human Health)(for example: Kovats and Hajat 2008; O'Neill and Ebi 2009[38]). Atlanta, Miami, New Orleans, and Tampa have already had increases in the number of days with temperatures exceeding 95°F, during which the number of deaths is above average.[39] Higher temperatures also contribute to the formation of harmful air pollutants and allergens.[40] Ground-level ozone is projected to increase in the 19 largest urban areas of the Southeast, leading to an increase in deaths.[41] A rise in hospital admissions due to respiratory illnesses, emergency room visits for asthma, and lost school days is expected.[42]

The climate in many parts of the Southeast and Caribbean is suitable for mosquitoes carrying malaria and yellow and dengue fevers. The small island states in the Caribbean already have a high health burden from climate-sensitive disease, including vector-borne and zoonotic (animal to human) diseases.[43] It is still uncertain how regional climate changes will affect vector-borne and zoonotic disease transmissions. While higher temperatures are likely to shorten both development and incubation time,[44] vectors (like disease-carrying insects) also need

Local Planning

Figure 17.9. Miami-Dade County staff leading workshop on incorporating climate change considerations in local planning. (Photo credit: Armando Rodriguez, Miami-Dade County).

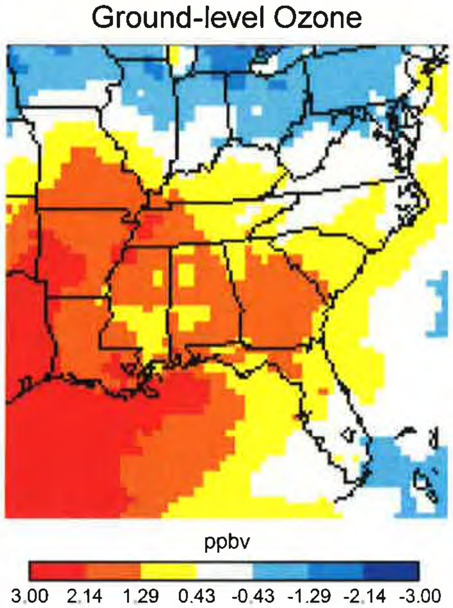

Figure 17.10. Ground-level ozone is an air pollutant that is harmful to human health and which generally increases with rising temperatures. The map shows projected changes in average annual ground level ozone pollution concentration in 2050 as compared to 2001, using a mid-range emissions scenario (A1B, which assumes gradual reductions from current emissions trends beginning around mid-century). (Figure source: adapted from Tagaris et al. 2009[42]).

the right conditions for breeding (water), for dispersal (vegetation and humidity), and access to susceptible vertebrate hosts to complete the disease transmission cycle.[5] While these transmission cycles are complex, increasing temperatures have the potential to result in an expanded region with more favorable conditions for transmission of these diseases.[45,46]

Climate change is expected to increase harmful algal blooms and several disease-causing agents in inland and coastal waters, which were not previously problems in the region.[47,48,49] For instance, higher sea surface temperatures are associated with higher rates of ciguatera fish poisoning,[48,50] one of the most common hazards from algal blooms in the region.[51] The algae that causes this food-borne illness is moving northward, following increasing sea surface temperatures.[52] Certain species of bacteria (*Vibrio,* for example) that grow in warm coastal waters and are present in Gulf Coast shellfish can cause infections in humans. Infections are now frequently reported both earlier and later by one month than traditionally observed.[53]

Coral reefs in the Southeast and Caribbean, as well as worldwide, are susceptible to climate change, especially warming waters and ocean acidification, whose impacts are exacerbated when coupled with other stressors, including disease, runoff, over-exploitation, and invasive species.[4,5]

An expanding population and regional land-use changes have reduced land available for agriculture and forests faster in the Southeast than in any other region in the contiguous United States.[54] Climate change is also expected to change the unwanted spread and locations of some non-native plants, which will result in new management challenges.[55]

Heat stress adversely affects dairy and livestock production.[56] Optimal temperatures for milk production are between 40ºF and 75ºF, and additional heat stress could shift dairy production northward.[57] A 10% decline in livestock yield is projected across the Southeast with a 9ºF increase in temperatures (applied as an incremental uniform increase in temperature between 1990 and 2060), related mainly to warmer summers.[58]

Summer heat stress is projected to reduce crop productivity, especially when coupled with increased drought (Ch. 6: Agriculture). The 2007 drought cost the Georgia agriculture industry $339 million in crop losses,[59] and the 2002 drought cost the agricultural industry in North Carolina $398 million.[5] A 2.2ºF increase in temperature would likely reduce overall productivity for corn, soybeans, rice, cotton, and peanuts across the South – though rising CO_2 levels could partially offset these decreases based on a crop yield simulation model.[60] In Georgia, climate projections indicate corn yields could decline by 15% and wheat yields by 20% through 2020.[61] In addition, many fruit crops from long-lived trees and bushes require chilling periods and may need to be replaced in a warming climate.[60]

Adaptation for agriculture involves decisions at many scales, from infrastructure investments (like reservoirs) to management decisions (like cropping patterns).[62] Dominant adaptation strategies include altering local planting choices to better match new climate conditions[62] and developing heat-tolerant crop varieties and breeds of livestock.[5,57] Most critical for effective adaptation is the delivery of climate risk information to decision-makers at appropriate temporal and spatial scales[57,62] and a focus on cropping systems that increase water-use efficiency, shifts toward irrigation, and more precise control of irrigation delivery (see also Ch. 28: Adaptation, Table 28.6).[5,57]

The southeastern U.S. (data include Texas and Oklahoma, not Puerto Rico) leads the nation in number of wildfires, averaging 45,000 fires per year,[63] and this number continues to increase.[64,65] Increasing temperatures contribute to increased fire frequency, intensity, and size,[63] though at some level of fire frequency, increased fire frequency would lead to decreased fire intensity. Lightning is a frequent initiator of wildfires,[66] and the Southeast currently has the greatest frequency of lightning strikes of any region of the country.[67] Increasing temperatures and changing atmospheric patterns may affect the number of lightning strikes in the Southeast, which could influence air quality, direct injury, and wildfires. Drought often correlates with large wildfire events, as seen with the Okeefenokee (2007) and Florida fires (1998). The 1998 Florida fires led to losses of more than $600 million.[68] Wildfires also affect human health through reduced air quality and direct injuries.[68,69,70] Expanding population and associated land-use fragmentation will limit the application of prescribed burning, a useful adaptive strategy.[65] Growth management could enhance the ability to pursue future adaptive management of forest fuels.

Forest disturbances caused by insects and pathogens are altered by climate changes due to factors such as increased tree stress, shifting phenology, and altered insect and pathogen lifecycles.[71] Current knowledge provides limited insights into specific impacts on epidemics, associated tree growth and mortality, and economic loss in the Southeast, though the overall extent and virulence of some insects and pathogens have been on the rise (for example, Hemlock Woolly Adelgid in the Southern Appalachians), while recent declines in southern pine beetle (*Dendroctonus frontalis* Zimmerman) epidemics in Louisiana and East Texas have been attributed to rising temperatures.[72] Due to southern forests' vast size and the high cost of management options, adaptation strategies are limited, except through post-epidemic management responses – for example, sanitation cuts and species replacement.

The Southeast has the existing power plant capacity to produce 32% of the nation's electricity.[73] Energy use is approximately 27% of the U.S. total, more than any other region.[5] Net energy demand is projected to increase, largely due to higher temperatures and increased use of air conditioning. This will potentially stress electricity generating capacity, distribution infrastructure, and energy costs. Energy costs are of particular concern for lower income households, the elderly, and other vulnerable communities, such as native tribes.[5,10] Long periods of extreme heat could also damage roadways by softening asphalt and cause deformities of railroad tracks, bridge joints, and other transportation infrastructure.[74]

Increasing temperatures will affect many facets of life in the Southeast and Caribbean region. For each impact there could be many possible responses. Many adaptation responses are described in other chapters in this document. For examples, please see the sector chapter of interest and Ch. 28: Adaptation.

Key Message 3: Water Availability

Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and unique ecosystems.

Water resources in the Southeast are abundant and support heavily populated urban areas, rural communities, unique ecosystems, and economies based on agriculture, energy, and tourism. The region also experiences extensive droughts, such as the 2007 drought in Atlanta, Georgia, that created water conflicts among three states.[11,75] In northwestern Puerto Rico, water was rationed for more than 200,000 people during the winter and spring of 1997-1998 because of low reservoir levels.[76] Droughts are one of the most frequent climate hazards in the Caribbean, resulting in economic losses.[77] Water supply and demand in the Southeast and Caribbean are influenced by many changing factors, including climate (for example, temperature increases that contribute to increased transpiration from plants and evaporation from soils and water bodies), population, and land use.[4,5] While change in projected precipitation for this region has high uncertainty (Ch. 2: Our Changing Climate), there is still a reasonable expectation that there will be reduced water availability due to the increased evaporative losses resulting from rising temperatures alone.

With projected increases in population, the conversion of rural areas, forestlands, and wetlands into residential, commercial, industrial, and agricultural zones is expected to intensify.[54] The continued development of urbanized areas will increase water demand, exacerbate saltwater intrusion into freshwater aquifers, and threaten environmentally sensitive wetlands bordering urban areas.[24]

Additionally, higher sea levels will accelerate saltwater intrusion into freshwater supplies from rivers, streams, and groundwater sources near the coast. The region's aquaculture industry also may be compromised by climate-related stresses on groundwater quality and quantity.[78] Porous aquifers in some areas make them particularly vulnerable to saltwater intrusion.[36,79] For example, officials in the city of Hallandale Beach, Florida, have already abandoned six of their eight drinking water wells.[80]

With increasing demand for food and rising food prices, irrigated agriculture will expand in some states. Also, population expansion in the region is expected to increase domestic water demand. Such increases in water demand by the energy, agricultural, and urban sectors will increase the competition for water, particularly in situations where environmental water needs conflict with other uses.[5]

As seen from Figure 17.11, the net water supply availability in the Southeast is expected to decline over the next several decades, particularly in the western part of the region.[82] Analysis of current and future water resources in the Caribbean shows

Trends in Water Availability

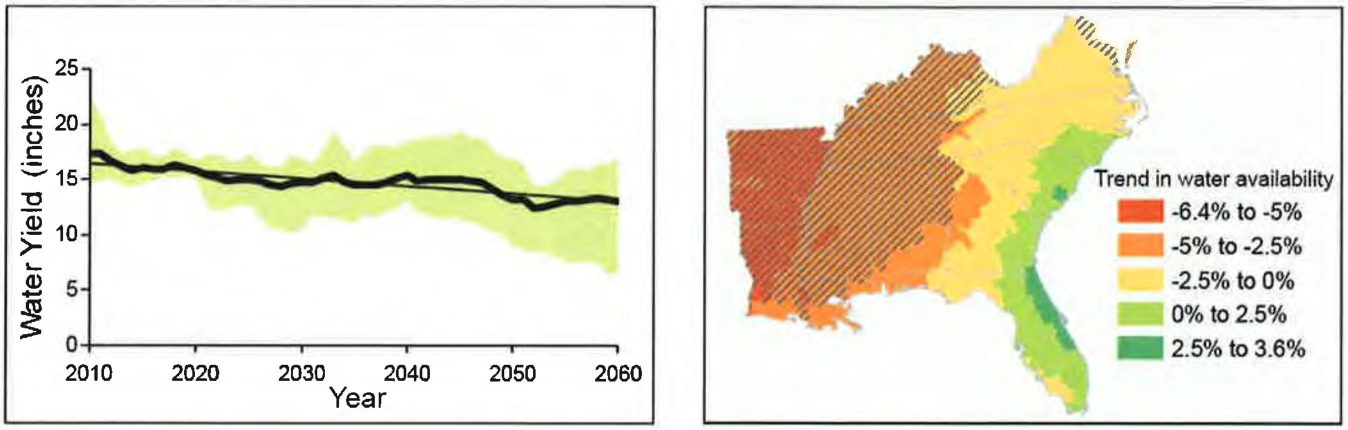

Figure 17.11. Left: Projected trend in Southeast-wide annual water yield (equivalent to water availability) due to climate change. The green area represents the range in predicted water yield from four climate model projections based on the A1B and B2 emissions scenarios. Right: Spatial pattern of change in water yield for 2010-2060 (decadal trend relative to 2010). The hatched areas are those where the predicted negative trend in water availability associated with the range of climate scenarios is statistically significant (with 95% confidence). As shown on the map, the western part of the Southeast region is expected to see the largest reductions in water availability. (Figure source: adapted from Sun et al. 2013[82]).

many of the small islands would be exposed to severe water stress under all climate change scenarios.[83]

New freshwater well fields may have to be established inland to replenish water supply lost from existing wells closer to the ocean once they are compromised by saltwater intrusion. Programs to increase water-use efficiency, reuse of wastewater, and water storage capacity are options that can help alleviate water supply stress.

The Southeast and Caribbean, which has a disproportionate number of the fastest-growing metropolitan areas in the country and important economic sectors located in low-lying coastal areas, is particularly vulnerable to some of the expected impacts of climate change. The most severe and widespread impacts are likely to be associated with sea level rise and changes in temperature and precipitation, which ultimately affect water availability. Changes in land use and land cover, more rapid in the Southeast and Caribbean than most other areas of the country, often interact with and serve to amplify the effects of climate change on regional ecosystems.

A Southeast River Basin Under Stress

Figure 17.12. The Apalachicola-Chattahoochee-Flint River Basin in Georgia exemplifies a place where many water uses are in conflict, and future climate change is expected to exacerbate this conflict.[84] The basin drains 19,600 square miles in three states and supplies water for multiple, often competing, uses, including irrigation, drinking water and other municipal uses, power plant cooling, navigation, hydropower, recreation, and ecosystems. Under future climate change, this basin is likely to experience more severe water supply shortages, more frequent emptying of reservoirs, violation of environmental flow requirements (with possible impacts to fisheries at the mouth of the Apalachicola), less energy generation, and more competition for remaining water. Adaptation options include changes in reservoir storage and release procedures and possible phased expansion of reservoir capacity.[84,85] Additional adaptation options could include water conservation and demand management. (Figure source: Georgakakos et al. 2010[84]).

Water recycling

Because of Clayton County, Georgia's, innovative water recycling project during the 2007-2008 drought, they were able to maintain reservoirs at near capacity and an abundant supply of water while neighboring Lake Lanier, the water supply for Atlanta, was at record lows. Clayton County developed a series of constructed wetlands used to filter treated water that recharges groundwater and supplies surface reservoirs. They have also implemented efficiency and leak detection programs[81] (for additional specific information see the Clayton County Water Authority website at: http://www.ccwa.us/).

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SUPPLEMENTAL MATERIAL
TRACEABLE ACCOUNTS

Process for Developing Key Messages
A central component of the process was the Southeast Regional Climate Assessment Workshop that was held on September 26-27, 2011, in Atlanta, with approximately 75 attendees. This workshop began the process leading to a foundational Technical Input Report (TIR). That 341-page foundational "Southeast Region Technical Report to the National Climate Assessment"[5] comprised 14 chapters from over 100 authors, including all levels of government, non-governmental organizations, and business.

The writing team held a 2-day meeting in April 2012 in Ft. Lauderdale, engaged in multiple teleconference and webinar technical discussions, which included careful review of the foundational TIR,[5] nearly 60 additional technical inputs provided by the public, and other published literature and professional judgment. Discussions were followed by expert deliberation of draft key messages by the authors, and targeted consultation with additional experts by the Southeast chapter writing team and lead author of each key message.

Key message #1 Traceable Account

Sea level rise poses widespread and continuing threats to both natural and built environments and to the regional economy.

Description of evidence base
The key message and supporting text summarize extensive evidence documented in the Southeast Technical Input Report.[5] A total of 57 technical inputs on a wide range of southeast-relevant topics (including sea level rise) were also received and reviewed as part of the Federal Register Notice solicitation for public input.

Evidence that the rate of sea level rise has increased is based on satellite altimetry data and direct measurements such as tide gauges (Ch. 2: Our Changing Climate, Key Message 10). Numerous peer-reviewed publications describe increasing hazards associated with sea level rise and storm surge, heat waves, and intense precipitation for the Southeast.[5] For sea level rise, the authors relied on the NCA Sea Level Change Scenario[16] and detailed discussion in the foundational TIR.[5]

Evidence that sea level rise is a threat to natural and human environments is documented in detail within the foundational TIR[5] and other technical inputs, as well as considerable peer-reviewed literature (for example, Campanella 2010).[19] Field studies document examples of areas that are being flooded more regularly, saltwater intrusion into fresh water wells,[80] and changes from fresh to saltwater in coastal ecosystems (for example, freshwater marshes) causing them to die,[32] and increases in vulnerability of many communities to coastal erosion. Economic impacts are seen in the cost to avoid flooded roads, buildings, and ports;[23] the need to drill new fresh water wells;[80] and the loss of coastal ecosystems and their storm surge protection.

New information and remaining uncertainties
Tremendous improvement has been made since the last Intergovernmental Panel on Climate Change evaluation of sea level rise in 2007,[86] with strong evidence of mass loss of Greenland icecap and glaciers worldwide (Ch. 2: Our Changing Climate). Improved analyses of tide gauges, coastal elevations, and circulation changes in offshore waters have also provided new information on accelerating rates of rise (Ch. 2: Our Changing Climate, Figure 2.26). These have been documented in the NCA Sea Level Change Scenario publication.[16]

Uncertainties in the rate of sea level rise through this century stems from a combination of large differences in projections among different climate models, natural climate variability, uncertainties in the melting of land-based glaciers and the Antarctic and Greenland ice sheets especially, and uncertainties about future rates of fossil fuel emissions. A further key uncertainty is the rate of vertical land movement at specific locations. The two factors – sea level rise and subsidence – when combined, increase the impact of global sea level rise in any specific area. A third area of uncertainty is where and what adaptive plans and actions are being undertaken to avoid flooding and associated impacts on people, communities, facilities, infrastructure, and ecosystems.

Assessment of confidence based on evidence
Sea level is expected to continue to rise for several centuries, even if greenhouse gas emissions are stabilized, due to the time it takes for the ocean to absorb heat energy from the atmosphere. Because sea levels determine the locations of human activities and

ecosystems along the coasts, increases in sea level and in the rate of rise will nearly certainly have substantial impacts on natural and human systems along the coastal area. What specific locations will be impacted under what specific levels of sea level rise needs to be determined location-by-location. However, given that many locations are already being affected by rising seas, more and more locations will be impacted as sea levels continue to rise. Confidence in this key message is therefore judged to be very high.

Confidence Level
Very High
Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus
High
Moderate evidence (several sources, some consistency, methods vary and/or documentation limited, etc.), medium consensus
Medium
Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought
Low
Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts

Key message #2 Traceable Account

Increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events will affect public health, natural and built environments, energy, agriculture, and forestry.

Description of evidence base

The key message and supporting text summarize extensive evidence documented in the Southeast Technical Input Report.[5] Technical inputs (57) on a wide range of topics were also received and reviewed as part of the Federal Register Notice solicitation for public input.

Numerous peer-reviewed publications describe increasing hazards associated with heat events and rising temperatures for the Southeast. The authors of a report on the Southeast climate[11] worked closely with the region's state climatologists on both the climatology and projections for temperature and associated heat events. Evidence of rising temperatures and current impacts[38,39] is based on an extensive set of field measurements.

There is considerable evidence of the effects of high air temperatures across a wide range of natural and managed systems in the Southeast. Increased temperatures affect human health and hospital admissions.[38,40,42]

Rising water temperatures also increase risks of bacterial infection from eating Gulf Coast shellfish[53] and increase algal blooms that have negative human health effects.[47,48] There is also evidence that there will be an increase in favorable conditions for mosquitoes that carry diseases.[46] Higher temperatures are detrimental to natural and urban environments, through increased wildfires in natural areas and managed forests[63,64,65,70] and increased invasiveness of some non-native plants.[55] High temperatures also contribute to more roadway damage and deformities of transportation infrastructure such as railroad tracks and bridges (Ch. 5: Transportation).[74] In addition, high temperatures increase net energy demand and costs, placing more stress on electricity generating plants and distribution infrastructure.

Increasing temperatures in the Southeast cause more stresses on crop and livestock agricultural systems. Heat stress reduces dairy and livestock production[56] and also reduces yields of various crops grown in this region (corn, soybean, peanuts, rice, and cotton).[60,61]

New information and remaining uncertainties

Since 2007, studies on impacts of higher temperatures have increased in many areas. Most of the publications cited above concluded that increasing temperatures in the Southeast will result in negative impacts on human health, the natural and built environments, energy, agriculture, and forestry.

A key issue (uncertainty) is the detailed mechanistic responses, including adaptive capacities and/or resilience, of natural and built environments, the public health system, energy systems, agriculture, and forests to increasing temperatures and extreme heat events.

Another uncertainty is how combinations of stresses, for example lack of water in addition to extreme heat, will affect outcomes. There is a need for more monitoring to document the extent and location of vulnerable areas (natural and human), and then research to assess how those impacts will affect productivity of key food and forest resources and human well-being. There is also a need for research that develops or identifies more resilient, adapted systems.

Assessment of confidence based on evidence

Increasing Temperatures: There is **high** confidence in documentation that projects increases in air temperatures (but not in the precise amount) and associated increases in the frequency, intensity, and duration of extreme heat events. Projections for increases in temperature are more certain in the Southeast than projections of changes in precipitation.

Impacts of increasing temperatures: Rising temperatures and the substantial increase in duration of high temperatures (for either the low [B1] or high [A2] emissions scenarios) above critical thresholds will have significant impacts on the population, agricultural industries, and ecosystems in the region. There is **high** confidence in documentation that increases in temperature in the Southeast will result in higher risks of negative impacts on human health, agricultural, and forest production; on natural systems; on the built environment; and on energy demand. There is **lower** confidence in the magnitude of these impacts, partly due to lack of information on how these systems will adapt (without human intervention) or be adapted (by people) to higher temperatures, and partly due to the limited knowledge base on the wide diversity that exists across this region in climates and human and natural systems.

Key message #3 Traceable Account

Decreased water availability, exacerbated by population growth and land-use change, will continue to increase competition for water and affect the region's economy and unique ecosystems.

Description of evidence base

The key message and supporting text summarize extensive evidence documented in the Southeast Technical Input Report (TIR).[5] Technical inputs (57) on a wide range of topics were also received and reviewed as part of the Federal Register Notice solicitation for public input.

Chapter 2, Our Changing Climate, describes evidence for drought and precipitation in its key messages. Numerous salient studies support the key message of decreased water availability, as summarized for the Southeast in the TIR.[5]

Evidence for the impacts on the region's economy and unique ecosystems is also detailed in the TIR[5] and the broader literature surveyed by the authors.[77]

New information and remaining uncertainties

Many studies have been published since 2007 documenting increasing demands for water in the Southeast due to increases in populations and irrigated agriculture, in addition to water shortages due to extensive droughts.[5,11] There is also new evidence of losses in fresh water wells near coastlines due to saltwater intrusion[79,80] and of continuing conflicts among states for water use, particularly during drought periods.[5,84]

It is a virtual certainty that population growth in the Southeast will continue in the future and will be accompanied by a significant change in patterns of land use, which is projected to include a larger fraction of urbanized areas, reduced agricultural areas, and reduced forest cover.[54] With increasing population and human demand, competition for water among the agriculture, urban, and environment sectors is projected to continue to increase. However, the projected population increases for the lower (B1) versus higher (A2) emissions scenarios differ significantly (33% versus 151%).[11] Consequently, the effect of climate change on urban water demand for the lower emissions scenario is projected to be much lower than for that of the higher emissions scenario. Land-use change will also alter the regional hydrology significantly. Unless measures are adopted to increase water storage, availability of freshwater during dry periods will decrease, partly due to drainage and other human activities.

Projected increase in temperature will increase evaporation, and in areas (the western part of the region[87]) where precipitation is projected to decrease in response to climate change, the net amount of water supply for human and environmental uses may decrease significantly.

Along the coastline of the Southeast, accelerated intrusion of saltwater due to sea level rise will impact both freshwater well fields and potentially freshwater intakes in rivers and streams connected to the ocean. Although sea level rise (SLR) corresponding to the higher emissions scenario is much higher (twice as much), even the SLR for the lower emissions scenario will increasingly impact water supply availability in low-lying areas of the region, as these areas are already being impacted by SLR and land subsidence.

Projections of specific spatial and temporal changes in precipitation in the Southeast remain highly uncertain and it is important to know with a reasonable confidence the sign and the magnitude of this change in various parts of the large Southeast region.

For the Southeast, there are no reliable projections of evapotranspiration, another major factor that determines water yield. This adds to uncertainty about water availability.

There are inadequate regional studies at basin scales to determine the future competition for water supply among sectors (urban, agriculture, and environment).

There is a need for more accurate information on future changes in drought magnitude and frequency.

Assessment of confidence based on evidence

There is **high** confidence in each aspect of the key message: it is virtually certain that the water demand for human consumption in the Southeast will increase as a result of population growth. The past evidence of impacts during droughts and the projected changes in drivers (land-use change, population growth, and climate change) suggest that there is a **high** confidence of the above assessment of future water availability. However, without additional studies, the resilience and the adaptive capacity of the socioeconomic and environmental systems are not known.

Water supply is critical for sustainability of the region, particularly in view of increasing population and land-use changes. Climate models' precipitation projections are uncertain. Nonetheless, the combined effects of possible decreases in precipitation, increasing evaporation losses due to warming, and increasing demands for water due to higher populations (under either lower [B1] or higher [A2] emissions scenarios) will have a significant impact on water availability for all sectors.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

57. Provide a copy of the KAWC report cited by Mr. O'Neill in footnote 4 of his Direct Testimony. Provide the original 2015 study and all subsequent updates.

Response:

Please find attached:

Kentucky American: Aging Infrastructure, A Review of the Water Distribution System – 2015

Kentucky American: Aging Infrastructure, A Review of the Water Distribution System – 2017

Kentucky American: Replacement Program Report – 2018.

AGING INFRASTRUCTURE

A REVIEW OF THE WATER DISTRIBUTION SYSTEM

2015

Kentucky-American Water Company

Contents

Introduction

Similar to other water utilities, the water distribution system of Kentucky American Water is beginning to reach its expected life expectancy. Even though the company has made investments in the replacement of the aging infrastructure, the rate at which existing infrastructure is reaching its useful life continues to increase at a quicker pace than the work to replace the outdated mains occurs.

One of the major challenges that water utilities face is that the distribution systems were installed to support the growth of communities that varied over time. The mains installed during the high growth periods reach their life expectancy at the same time, resulting in sections of communities that need all of the mains replaced in a short time period.

In addition, during the periods of system expansions, different pipe materials were used as they were introduced as an alternative to the existing main materials. With each pipe material, the life expectancy of the main is different. Unfortunately, that results in periods where pipes that were installed at different times in the past reach their useful life at the same time as other types of pipe material, increasing the amount of mains that need to be replaced throughout the system in a compressed timeframe.

As the American Water Works Association indicated in their May 2001 publication, “Reinvesting in Drinking Water Infrastructure,” a new era was emerging regarding the operation of our water infrastructure—the replacement era—where water providers would need to replace the water infrastructure that was built for us by earlier generations.

Although Kentucky American has made investments in the replacement of over the past decades, the amount of main replaced cannot keep up with the expected amount of main requiring replacement that will occur in the coming decades.

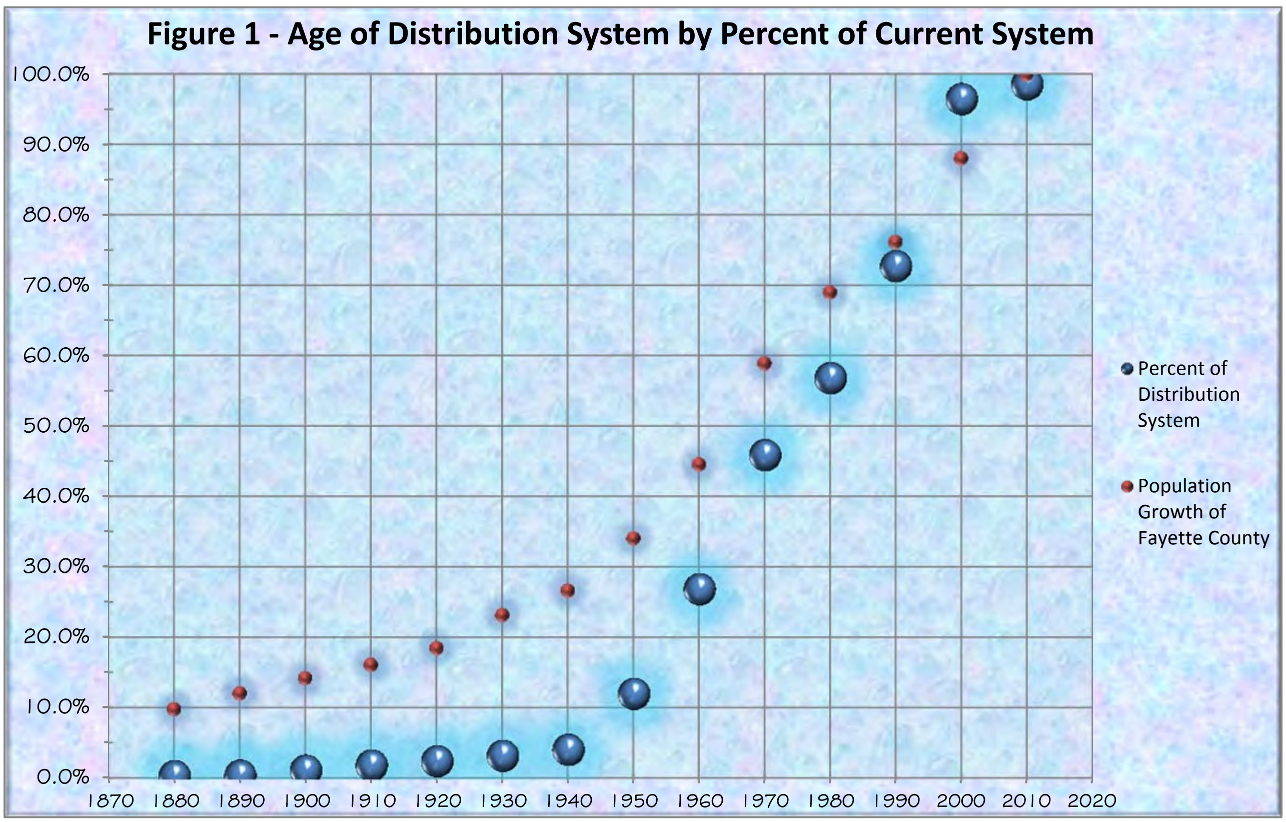
System Background

Kentucky American Water first began operation as the Lexington Hydraulic and Manufacturing Company providing water to Lexington in 1885. The company was started by three local businessmen who saw a need for a water system to help fight fires and prevent disease. During the early 1970s the name changed from the Lexington Water Company to the current Kentucky American Water Company.

Since 1885 the system has grown from serving approximately 200 customers to about 124,000 customers within 11 counties, including Fayette County. With that growth the distribution system has expanded to include approximately 1,975 miles of water mains of a variety of sizes and material types.

History of the Growth of the Distribution System

Kentucky American's water distribution system growth mirrors the growth of the City of Lexington and Fayette County. Figure 1 shows the percent of the water distribution system that was installed within each of the decades from 1880 to present.



From the start of the system in 1885 through the 1940's the area was predominately an agricultural based economy and growth was steady. Main installed during that period was unlined cast iron main and represents approximately 4% of the current distribution system (75 miles of main). This amount used to be a greater amount of the distribution system, however during the 1980s and 1990s the Company undertook a concerted effort to replace this era of cast iron main.

Following World War II, Lexington experienced an increased growth rate due to the move away from agriculture and the baby boom. During the 1950's and 60's, the distribution system also grew substantially to keep up with the expansion of Lexington. Main installed during that period was cast iron, both cement lined and unlined. During this period asbestos cement pipe was introduced for the first time into the distribution system. The main installed during this period represents 23% of the current distribution system (425 miles of main).

The Lexington system experienced its greatest growth during the 1970s through the housing boom of the first part of 2000. During this period Lexington experienced a growth due to industry and service companies locating and growing in Fayette County. In addition, Kentucky American acquired several outlying systems by growing into the counties surrounding Fayette County. Also during this period, the main extension from Kentucky River Station Two to the Lexington distribution system was placed into service during September 2010, which was during the end of this time frame. Main installed during this period represents 66% of the current distribution system (1,293 miles of main). Asbestos Cement pipe was the predominate material installed during the start of this period with Ductile Iron pipe and PVC becoming the predominate material during the 1980's.

From 2010 to present, the distribution system has seen a much slower growth rate and represents a little more than 2% of the current distribution system (39 miles). Currently, the predominate material installed is Ductile Iron with some PVC pipe.

Pipe Materials in Distribution System

The Kentucky American distribution system contains mostly five major material types. Those types are Ductile Iron, PVC, Asbestos Cement, Cast Iron Lined and Cast Iron Unlined. The period that the system was growing determines the areas and the amount of each material type in the system. Table 2 provides a listing of the major material types in the distribution system along with the amount of each material in miles and percentage of that material within the system:

Table 2 – Distribution System Material Types		
	Miles of Material	Percentage of System
Ductile Iron	808.5	43.3
PVC	418.0	22.4
Asbestos Cement	342.7	18.4
Cast Iron Unlined	170.7	9.1
Cast Iron Lined	65.9	4.1
Galvanized	6.0	0.2
Prestressed Concrete	15.8	1.0

Distribution of Pipe Material by Decade

When the material type is compared to the timeline of growth of the distribution system, certain periods of time were dominated by particular pipe materials. During the first part of the system development from 1885 to 1950, cast iron unlined and lined was the predominant material. During 1950 to 1980, asbestos cement pipe was used along with cast iron pipe and the introduction of ductile iron into the system. After 1980, ductile iron pipe dominated the material type being used to meet system growth. PVC pipe use in new water main was not prevalent in the distribution system except for small diameter pipe. During the 1980s, 90s and 2000s with the acquisition of systems, PVC was introduced into the Kentucky American distribution system. Table 3 provides a breakdown by decade of the material types used in the expansion of the distribution system.

Table 3 – Miles of Existing Material Types Installed by Decade

Decade	Material Types						
	Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized[2]	Other[1]
1881 - 1890	5.5						
1891 - 1900	1.6						
1901 - 1910	15.3	0.2					
1911 - 1920	11.7	0.7				0.1	
1921 - 1930	8.6	2.2					
1931 - 1940	7.6	6.7	0.1				
1941 - 1950	3.3	5.7	12.2				
1951 - 1960	21.2	55.1	71.8	0.5	0.2	1.2	8.5
1961 - 1970	49.5	5.1	96.5	65.0	50.5	1.2	12.8
1971 - 1980	46.4		122.8	138.4	15.4	0.1	22.2
1981 - 1990			13.8	35.9	163.9		
1991 - 2000			0.3	27.0	282.7	0.1	
2001 - 2010				145.6	265.5		
2011 -					30.4		

1 – Other represents Lead Pipe, Reinforced Concrete Pipe and PEP Pipe
2- In most cases the Galvanized Pipe indicated on this table occurred during acquisitions during these periods

Expected Life of Pipe Material

Based on information developed by American Water Works Association for the "Buried No Longer" report released in February 2012, Table 4 provides an estimated expected service life for pipes of varying material. The expected life was determined based on operating experiences of water utilities and insight from research with typical pipe conditions based on pipe material and varying conditions of age and size.

Table 4 – Average Expected Life of Pipe Material						
Material Types						
Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
110 yrs	100 yrs	90 yrs	55 yrs	80 yrs	70 yrs	105 yrs

This table is a simplification of reality since the life of the pipe is also impacted by the pipe material, soil properties, installation practices and climate conditions. Kentucky American has experienced that pipe life depends on many variables, such as soil conditions and installation practices, rather than just the age of the pipe itself. The company has had many pipes last longer than the typical service life indicated, but has had other pipes fail sooner than expected. For the purpose of this report and due to the lack of specific data that allows the company to develop an understanding of each condition that affects each pipe segment in the system, the average life expectancy provides a reasonable approximation of the replacement rate.

Using the average expected life for Kentucky American's distribution system indicates that the pipe that has been installed over the past 130 years will need to be replaced over the next 85 years to ensure that the system is maintained within the expected life of the networks pipe material.

Importance of Replacing Mains

Access to clean reliable water is critical for the communities served and has become an intrinsic responsibility of those who manage the water infrastructure throughout the world. Safe drinking water is important to the health and economic welfare of a community. The ability to obtain clean water, free of contaminants, reduces sickness and related health costs. In addition, the ability to access a sufficient supply creates economic opportunities throughout the community.

As the water distribution system begins to reach its useful life, failures in the infrastructure begins to occur that impact the ability to provide safe and reliable service to the community. Neglecting this aging infrastructure will increase the frequency of water main breaks and leaks, leading to the corrosion of surrounding utility pipes, disrupting automobile, pedestrian and public transportation and stymieing local economic activity.

Although most of these breaks are minor, serious ruptures can and do occur. With these serious breaks the impact can be catastrophic due to flooding of streets and sidewalks, and in some instances flooding of local businesses and basements of local residents. In rare instances, the loss of water can undermine pavement or building foundations that can lead to the failure of pavements or the loss of a building that can result in significant property damage and serious injuries.

We have seen numerous examples of serious failures over the past few years that have affected major metropolitan areas. On June 18, 2015 Louisville Water Company experienced a break on a 60-inch water main that impacted 33,000 customers and caused the road to buckle, breaking apart huge pieces of pavement that floated and damaged vehicles in the area. The break also caused damage in adjacent parking lots and impacted the ability of the local residents to continue with their regular routine.

This break follows a 48-inch water main break during April 24, 2014 near the intersection of Eastern Parkway and Baxter Avenue that caused the intersection to be closed for at least 6 days. The break sent water cascading down Baxter Avenue, flooding Tyler Parks and nearby yards. In addition, the break flooded athletic fields on the University of Louisville campus and caused concerns for participates of athletic camps that were on the fields at the time of the break.

One of the most significant breaks of 2015 was a water main break near the University of California in Los Angeles on July 29 that caused massive street flooding and damage on the campus. The break caused the loss of more than 20 million gallons during the 3 and half hours that it required to turn off the main. The water flooded into the university and entered numerous buildings and structures causing significant damage. Firefighters saved up to five people that were stuck in underground parking structures and trapped more than 730 cars with half of the vehicles being entirely submerged.

Kentucky American Water has not seen these dramatic of main breaks over the past few years, but it has seen several main breaks that have not only caused impact to the adjacent area that is surrounding the break but has also caused traffic disruptions and inconveniences due to repair activities. Some of these breaks have resulted in business disruptions and economic impact to the community.

The American Society of Civil Engineers study “Failure to Act,” released in 2012 on the economic impact of under-investing in our water and wastewater infrastructure, the authors estimated that remaining on the current track will cost American businesses and households $216 billion in increased costs between now and 2020, and the cumulative loss to our gross domestic product (GDP) will be $400 billion, directly due to deteriorating water infrastructure. Without additional investment in the infrastructure, almost 700,000 jobs will be threatened due to unreliable water delivery and wastewater treatment services.

The impact of a water main break is mostly a localized impact, with the exception of large main breaks that impact a large portion of the community or the loss of the service to the entire community. The loss of water through leaking pipe as the infrastructure ages is an impact that affects the entire community, most of the time with no one knowing it is occurring. This loss of water typically manifests itself in an increase in “non-revenue water.” A high level of non-revenue water affects the financial viability of water utilities through lost revenues and increased operational costs. Although Kentucky American Water’s non-revenue water is at or below the industry standard, there is concern that over time the ability to manage non-revenue water would be impacted without a systematic approach for replacing aging infrastructure.

Other than the impact of pipe failure, the aging infrastructure also impacts the ability to provide adequate service to our customers and the system’s ability to meet fire flow requirements. A majority of this older infrastructure was installed during a period where the expectations or requirements for fire service and household appliances were not as great as we see it today. In some cases, deposits within the pipes have also reduced its ability to provide adequate water flow for customer uses and fire service.

By investing in the replacement of the infrastructure enhances the system’s ability to meet the service expectations of the customers. The ability to replace this aging infrastructure allows the company to provide improved service to the customer and usually improves fire protection. In addition, the areas of the system that are replaced are made more robust and are more resilient during periods of high demands and reduces the number service disruptions.

The investment in replacing the infrastructure allows for a more robust system that enhance the ability of the community to compete for new business and industries, which is an important economic benefit to the community. According to the U.S. Conference of Mayors, every dollar invested in water infrastructure adds $6.35 to the national economy.

Previous Review of Network

During 2009, Kentucky American Water commissioned Gannett Fleming to conduct an Analysis of Non-Revenue Water for the system as ordered by the Commission as part of Case No. 2007-00134. A part of that analysis was a determination if there was a correlation or trend in the occurrence of main breaks and leaks in the Central Division. The analysis was conducted on 1,927 main breaks reported from January 2000 to October 2008.

Review of the main break data indicated that a majority of breaks (82%) in the system during this period were reportedly caused on Ground Shift/Other. Age and Deterioration was reported to be the cause of approximately 10% of the breaks. Pressure Surge, Tree Roots, and Clamp Failure were reported to be collectively the cause of the remaining 8% of the breaks during the period of January 2000 to October 2008.

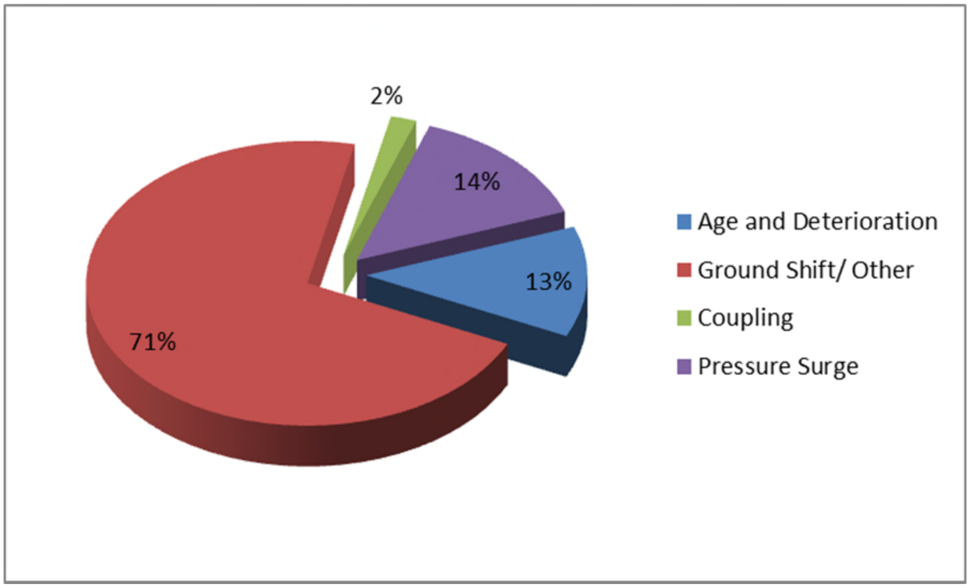
The main breaks that were reportedly caused by Age and Deterioration or Ground Shift/Other occurred on unlined cast iron main 53% of the time and, in particular, a significantly high percentage of reported breaks associated with age and deterioration occurred on unlined cast iron mains 37% of the time. The analysis indicated that the highest percentage of breaks caused by Ground Shift/Other occurred on unlined cast iron main and asbestos cement main (34% and 26%, respectively).

The analysis by Gannett Fleming found that replacing specific main sizes or types of material that exhibit a high concentration of breaks would not have a substantial impact on reducing non-revenue water. Gannett Fleming concluded that other factors should be considered with regard to replacement of problematic main rather than trying to control non-revenue water.

During the review of the main break history, Gannett Fleming found that the highest concentration of reported main breaks occurred on unlined cast iron. The concentration of reported main breaks on galvanized steel main was also significantly higher than the system average of 0.9 breaks per mile of main. Gannett Fleming suggested that a main replacement program targeting unlined cast iron main and galvanized steel main, specifically those less than 4 inches in diameter, should be considered to reduce the occurrence of main breaks.

Current Review of Network

Review of the main break history from January 2012 to August 2015 indicated that there has been 581 breaks during this period, averaging about 175 per year. Similar to the finding of the 2009 Gannett Fleming report, the current break history indicates that 71% of the main breaks are caused by ground shift. This percentage decreased from 82%, while the age and deterioration breaks increased to 14% compared to 10% during the past review. Although a small increase, it is an indication that the distribution system is aging and we would expect to see an increase in these types of breaks as the age of the mains increase.

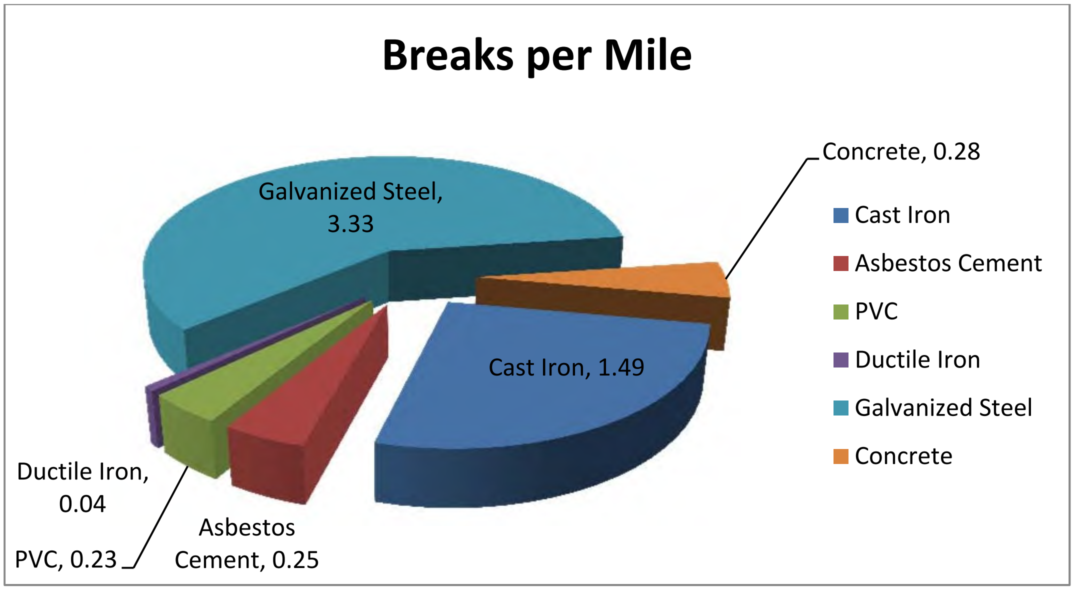


The average number of breaks per year has decreased from 222 per year for the period of January 2000 to October 2008 to 175 per year for January 2012 to August 2015. This reduction is indicative of the main replacement work conducted following 2008 that specifically targeted mains with high break incidents.

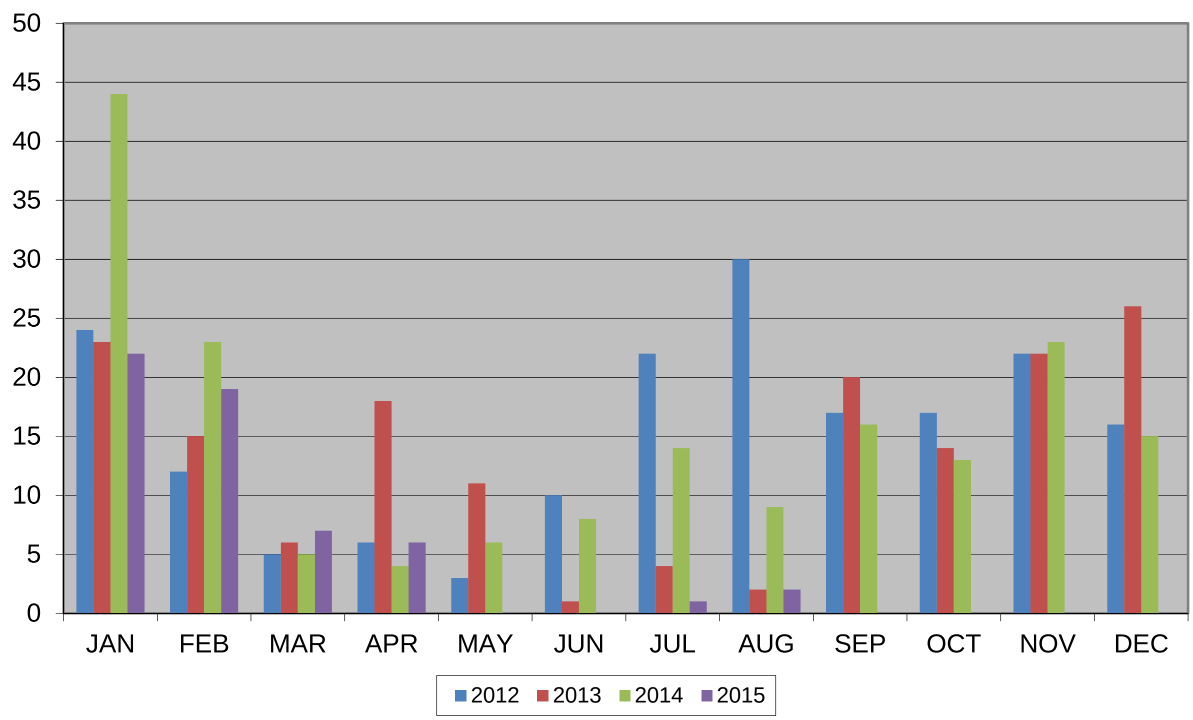
Review of the reported breaks from January 2012 to August 2015 indicated that main breaks on cast iron main represented 60% of all of the breaks. Since cast iron main lined and unlined material only represents 13% of the total inventory of mains in the ground, the break rate on this type of material is significantly higher than the other material in the system.

Table 5 – Breaks by Material					
Material Types					
Cast Iron	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
60.4%	14.9%	16.6%	5.3%	1.9%	0.9%

The break rate per mile of main shows that cast iron main had a break rate of 1.49 breaks per mile of main compared to ductile iron which saw a break rate of 0.04 breaks per mile of main from January 2012 to August 2015. The worst performing material was galvanized steel which had a break rate of 3.33 breaks per mile of main.



Another area reviewed in the main break data from January 2012 to August 2015 indicated that 52% of the breaks occur between November to February of each year with the lowest break period being during May and June. Analysis of the break reports would support that ground shift breaks cause the most failure of the pipe material and we would expect to see the ground shifts occur during the November to February time frame. It should be noted that the high break occurrence that is observed in July and August of 2012 is believed to be caused by ground shift breaks that occurred following high rain events during each of those months.



With ground shift breaks being 71% of the overall breaks that occurred during January 2012 to August 2015, this would correlate with pipe materials that are susceptible to ground movement or shifting being at greater risk than other materials. Cast iron and galvanized steel are not resilient to tension and bending forces that result in ground shifting and contributes to the higher break per mile numbers that the system has experiencing. In addition, both of these materials

Cast iron and galvanized steel are good at controlling internal forces and crushing forces that were generally used during the design stage when this material was placed into service. The industry gained the knowledge that cast iron and galvanized steel were susceptible to bending forces and encouraged the introduction of other materials. Materials such as ductile iron and PVC handle these types of forces and as such are more resilient to this type of ground movement. This resulted in the water utility industry standardizing on ductile iron and PVC and moving away from cast iron and galvanized steel.

Current Replacement Effort

Following the Gannett Fleming report in 2009, the replacement effort was predominantly driven by mains that exhibit high break frequency and requests by operations to replace mains to address multiple repair trips to the same main. During the period of 2009 to 2013 the average spend on main replacement projects was $1.06 million per year. The main replacement projects replaced all types of material that were experiencing high break frequencies, but the majority of the type of main replaced during this period was cast iron main. With this effort the amount of cast iron main replaced in the system was 10.5 miles with an average of 2.1 miles a year.

In 2014 there was a renewed effort to review the distribution infrastructure and start to address the aging infrastructure needs of the system. During 2014 and through August 2015 the average spend on main replacement projects was $4.2 million per year. Based on this current effort the amount of cast iron main replaced in the system from January 2014 through August 2015 was 7.8 miles with an average of 3.9 miles.

Since 2009 the main replacement work has replaced 18.3 miles of cast iron main from the system and replaced it primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.6 miles per year during the 7 year period including the accelerated rate of 3.9 miles per year over the past 2 years from 2014 and 2015. While this is making significant progress, it is still not enough to address the rapidity aging distribution system. At the current rate over the past few years it would take approximately 60.6 years to replace all of the cast iron main in the distribution system. At the end of the 60 year period the possible age of a cast iron main could be 200 years old or twice the life expectancy for this type of material.

Main Replacement Criteria Development

With the renewed effort to review the distribution system in 2014, Kentucky American Water analyzed the methodology for planning main replacement to ensure that the distribution system could meet the needs of its customers and strategize ways to reduce the failure rate of mains. The previous method of determining main replacement was based on break history and requests from the operations group on which mains to replace was determined to be too limited in determining the most critical mains to replace.

With the understanding that continued enhancement of the Kentucky American Water system would require a systematic replacement plan to ensure that the right mains were being replaced at the right time, the company established a goal in 2013 to research and develop tools to assist in developing the plan.

The first step was to develop the criteria that would be used to assess the existing mains and develop a list of mains that were in critical need of being replaced. It was determined that a main replacement assessment standard would require adoption of several criteria to determine which mains would need to be replaced. Development of the assessment standard considered the inclusion of eight criteria that played a major role in providing reliable service and were a good indicator of the condition of the main. These criteria are included in Table 6.

During developmental of the criteria it was determined that several of the criteria had interrelationships with each other and contributed to the performance of a section of water main. One of the interrelationships was main size and fire flow. In addition, it was determined that leaks can also be related to the age and material of the mains, and material types can be related to the water quality aspect of the main.

Due to the interrelationships of the eight criteria, the team established relative weights for each criterion to ensure that the targeted drivers for the main are given greater consideration. Age, material type, low pressure, number of breaks and water quality were the primary criteria that would be used to determine main replacement. These criteria allowed the main replacement program to ensure that mains that were not meeting the needs of the community and customers were addressed quickly.

Along with the criteria weighting, the assessment contains a rating standards for each of the eight criteria. A numeric rating of between 1 and 5 was used for each criterion – with 1 being the better rating and 5 being the worst rating.

TABLE 6 - MAIN REPLACEMENT CRITERIA						
Criteria (Max. Points)	***Weight***	***Rating***				
		1	***2***	***3***	***4***	***5***
Low Pressure (75)	15x	50 psi or greater	50 psi to 45 psi	45 psi to 40 psi	40 psi to 35 psi	< 35 psi
Number of Breaks/Leaks (75)	15x	0 breaks/5-year avg.	1-2 breaks/5-year avg.	3-4 breaks/5-year avg.	5-6 breaks/5-year avg.	< 6 breaks/5-year avg.
Fire Flow (50)	10x	Greater than 1,500 gpm (Blue)	1,500 to 1,000 gpm (Green)	999 gpm to 500 gpm (Yellow)	Less than 500 gpm (Red)	Known problems
Age (75)	15x	1995 or later	1980 to 1994	1970 to 1979	1960 to 1969	1959 and prior
Material Type (75)	15x	DI/RCP	PVC/HDPE	Transite/AC	CI/CLCI	Gal. / Steel
Size of Main (50)	10x	8 inch and above	6 inch	4 inch	2 inch to 3 inch	Main smaller than 2 inch
Water Quality (75)	15x	Flushing but not routine	Monthly Flushing	Bi weekly Flushing	Weekly (or more frequent) Flushing	Continuous Flushing (w/ discussion)
Customer Impact (25)	5x	less than 2 customers	2 to 10 customers	11 to 20 customers	greater than 20 customers	School/Hospital (Critical Customer)

An electronic database was developed to assist in the assessment and prioritization of the replacement mains and subsequent development of replacement schedules. The database is designed to perform the necessary queries and calculations to determine the main section overall rating and ranking. Initially 62 mains were entered into the database as a pilot to ensure that the assessment tool was capturing the critical needs of the system and identified the more critical sections to replace.

During most of 2013 through 2015 this initial list has provided a schedule for which mains are in need of replacement and provided a schedule that has been used to guide the main replacement program.

As with any tool, there are still external drivers that influence the main replacement program. These external items such as roadway paving schedules, weather or construction considerations are combined with the results of the assessment tool to make adjustments in the replacement program. This combination of tools and subjective considerations allows for a more reactive replacement program that is in concert with the community and allows for efficient use of available resources.

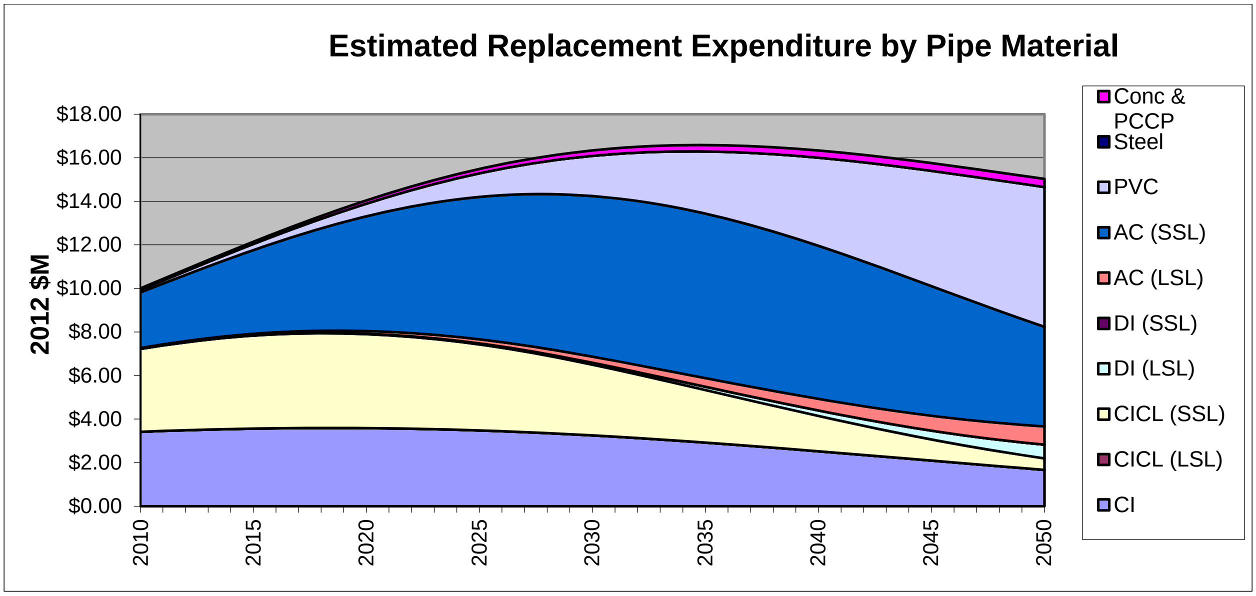
Nessie Model

While the assessment tool provides a numerical approach of determining the critical mains to replace, the company needed to determine the overall scope and financial impact over a longer planning horizon. The company looked for tools that could provide assistance in determining the capital needs for water main replacement in the coming years that considered the life expectancy of the infrastructure.

The American Water Works Association report "Dawn of the Replacement Era" developed a process that created a "Nessie Curve" for the 20 systems it reviewed in the report. The Nessie Curve, so called because the graph follows an outline this is likened to a silhouette of the Loch Ness Monster, provided a visual representation of the capital needs during a defined time frame to rebuild the underground infrastructure of the 20 systems. With the report "Buried No Longer," AWWA further developed the analysis of the underground infrastructure and developed the "Nessie Model."

The model uses pipe failure probability distributions based on past research with typical pipe conditions at different ages and sizes coupled with the indicative costs to replace each size and type of pipe, as well as the cost to repair the projected number of pipe breaks over time. The model projects the "typical" useful service life of the infrastructure based on pipe inventories of the system and estimates how much pipe of each type should be replaced in each of the coming 40 years. The model then combines the amount of infrastructure that should be replaced with the typical cost to replace the mains to create an estimate of the total investment cost for the 40 year planning horizon. The model represents this data through a series of Nessie Curves to depict the suggested amount of spending required to replace the main at the optimal life cycle for each material type.

Kentucky American Water utilized the Nessie Model to provide an insight on the amount of capital that is suggested to ensure that the distribution system is being replaced to account for the useful life of the distribution mains. The chart below provides the Nessie Curve developed by the model over a 40 year time frame of the estimated capital needed to replace the appropriate pipe material in the system based on the materials useful life.



The model identifies that cast iron main is the material that needs to be replaced initially followed by asbestos cement. During the 40 year period the model projects that during the first 20 years approximately $6 to $8 million each year is needed for cast iron main replacement declining to $3 million during the final 20 years. At the same time the model suggests that asbestos cement main be replaced at a rate of $3 to $7 million each year during the 40 year period. In the outer years of the planning horizon, replacement of PVC main and ductile main begin to be shown as a need in order to address the life expectancy of those material types.

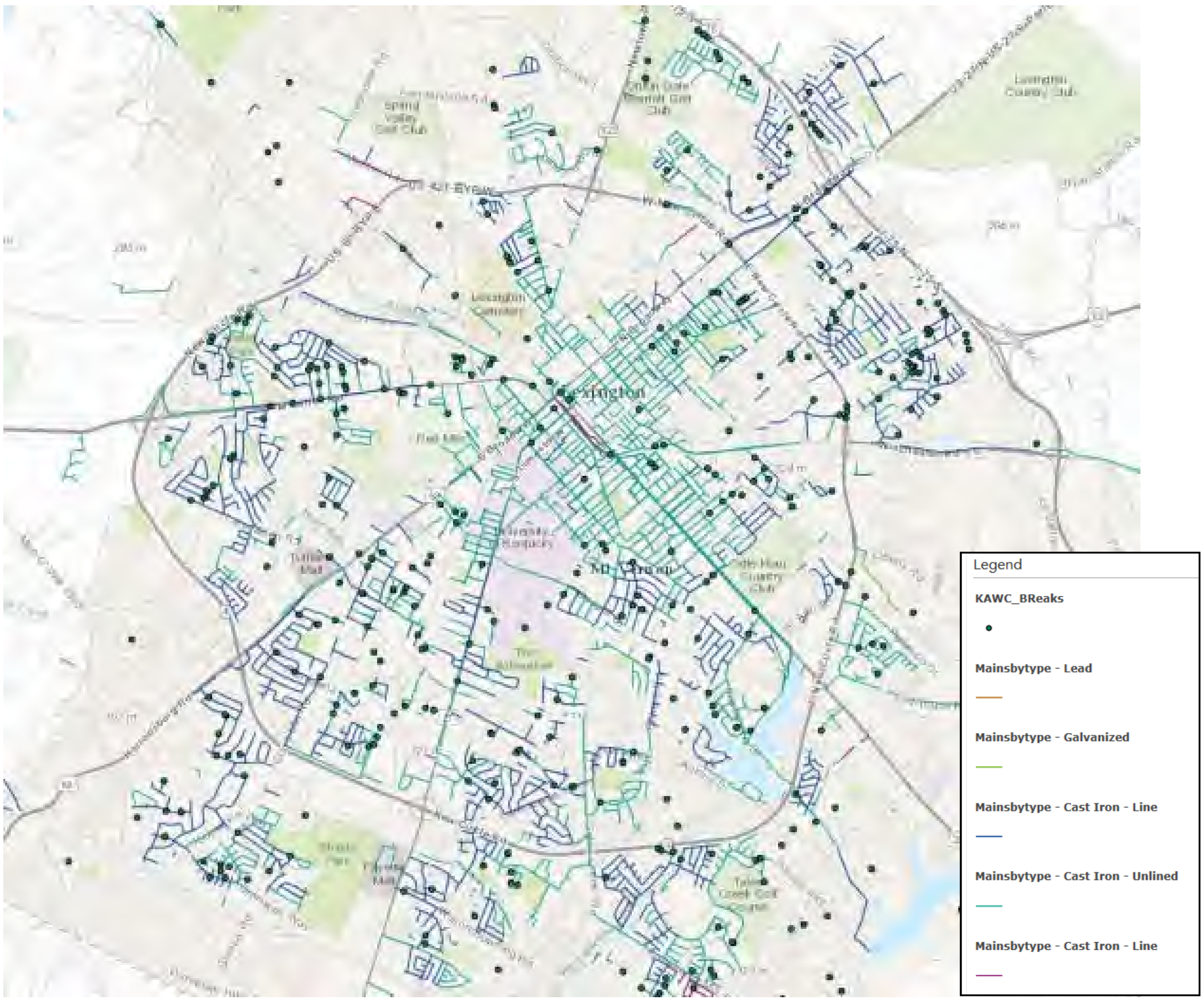
The curve reflects an “echo” of the original trends that shaped the development of the system starting in 1885. The identified capital needs is a reflection of the main installed nearly a century ago that have created a future obligation to replace the mains as they reach their useful life that is now coming due.

Proposed Accelerated Replacement Plan

Kentucky American recognizes that the past rate of replacement of aging mains the company has employed is not sufficient to address the increased replacement rate that will be required over the coming decades. The need to begin to rebuild the distribution infrastructure that was bequeathed to us by earlier generations is essential to maintain the needs of the community and customers.

Upon review of the distribution system and the material types used in the development of the system, Kentucky American believes that the first materials that need to be replaced in the system is cast iron main and galvanized steel. These two materials represent approximately 13% of the distribution system but account for approximately 62% of all main breaks in a given year.

The company utilized its Graphical Information System (GIS) to query the main breaks during the period of January 2012 to August 2015 against the main types in the system and found that empirical data from the database is depicted graphically. The following map shows the main breaks during the 2012 to 2015 period against cast iron and galvanized steel main.



The map identifies two items rather definitively. The first is that a majority of the cast iron main was installed during the first half of the development of Lexington. The map clearly shows that a majority of downtown Lexington remains cast iron and to the most extent unlined cast iron. In addition, with the development of the community away from downtown, the map shows those subdivisions during this period that cast was used as the predominate material to serve these areas. It is interesting to note that a majority of the development during the time was within the inner circle, with only small pockets of development along the outside of the circle.

The second item that the map shows is the correlation of the main breaks within the areas that are predominately cast iron and galvanized steel. The remaining main breaks shown on the map are scattered throughout the system and have no indication that there are significant trouble spots from the other distribution system material types at this time.

Based on the information reviewed by the company over the past few years and the data developed for this report, a majority of the mains that are susceptible to breaks are cast iron and galvanized steel. Kentucky American believes that the best course at this time is to target this type of pipe material over the next 25 years for replacement. The replacement of this type of material allows the company to address underperforming mains and reduce the impact of main breaks in the areas served by this type of material. A review of several replacement periods was reviewed and illustrated in Table 7, indicating that with a 15 year plan would cost $11 million annually and a 30 year period would cost $5.5 million per year.

TABLE 7 - POSSIBLE REPLACEMENT RATES FOR CAST IRON				
Period Length	15 year	20 year	25 year	30 year
Miles Replaced per year	16.0	12.0	9.6	8.0
Cost per year	$ 10,978,583	$ 8,233,938	$ 6,587,150	$ 5,489,292

Analysis of the four possible replacement rates lead the company to believe that a 25 year replacement period was more realistic. The 30 year replacement rate would result in a greater overlap of replacement activity between the completion of the cast iron main replacement and the start of the asbestos cement main replacement period.

With the 15 year and the 20 year replacement periods the removal of the cast iron main was removed from the system quicker and allows for the effort to replace asbestos cement to begin sooner. However, the amount of capital required per year was a concern with respect to support from the community. In addition, with the level of capital commitment per year for the 15 year and 20 year replacement rates could have a negative impact on Kentucky American to address other infrastructure replacement needs such as water treatment components at the water treatment plants that are also entering the end of their useful life.

Finally, the amount of mile of replacement main per year of 16 and 12 miles for the 15 year and 20 year replacement rates is a concern for the impact on available resource to complete the construction each year. The 15 year replacement rate is a fourfold increase in the amount of main replaced during the 2013 and 2014. This increase would be a significant strain on the available company and contractor resources and would require a substantial increase in labor and equipment that Kentucky American is concerned can be sustained over the period of the replacement program.

Through a 25 year replacement period, the 240 miles of cast iron main will be replaced at a rate of 9.6 miles per year at an expected cost of $6.59 million per year. At the conclusion of the 25 year replacement period for cast iron, the company will start to focus on the replacement of the 342 miles of asbestos cement pipe, which the earliest pipe installed during 1935, and at which point will be entering its 105th year of useful life.

Conclusion

Thanks to the work of past generations that developed and built the water distribution system to support the growth of our community, we have enjoyed the access to clean water and economic advantages that it has provided. Because these water mains last a long time we have never had to replace a significant amount of pipe on a large scale. We are on the edge of the period when these main are reaching their useful life and future generations will need to undertake large scale replacement efforts to ensure that we continue to benefit from our access to clean water.

It is important that instead of a entering this period in with a careless plan that only address the system as it fails, we undertake a prioritized renewal of the mains to ensure that our water infrastructure can reliably and cost-effectively support the public health, safety, and economic vitality of our community.

Kentucky American believes that with the replacement of cast iron and galvanized steel main through a 25 year replacement period is important to ensure the company can responsibly enter into the period of water infrastructure renewal. Through careful prioritization and looking at emerging technology the cost of replacing main just prior to failure will be of significant benefit to the community. Through the reduction of the number of failures the system experience we can reduce the negative of property damage, disruption of businesses and the community, and waste our water resources and ensure our future generations continue to benefit from access to reliable clean water that will support the economic growth of the community.

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APPENDIX –

Five Year Projected Projects for Main Replacement Program

PROJECTED YEAR ONE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	600 BLOCK SAYRE AVE	212	$31,800
2	900 BLOCK WHITNEY AVE	1,030	$154,500
3	200 BLOCK PERRY ST	466	$69,900
4	1000 BLOCK KASTLE RD	512	$76,800
5	1200 BLOCK EMBRY AVE	536	$80,400
6	200 BLOCK SPRUCE ST	624	$93,600
7	200 BLOCK HAMILTON PARK	978	$146,700
8	300 BLOCK GUNN ST	184	$27,600
9	100 BLOCK SHAWNEE PL	568	$85,200
10	200 BLOCK WARNOCK ST	492	$73,800
11	600 BLOCK ORCHARD AVE	380	$57,000
12	100 BLOCK AVON AVE 100 BLOCK BURNETT AVE	1,340	$201,000
13	1400 BLOCK CAMDEN AVE	1,082	$162,300
14	100 BLOCK WABASH DR 1800 BLOCK PENSACOLA DR 200 BLOCK LACKAWANNA RD 180 WABASH DR 140 WABASH DR	3,160	$474,000
16	200 AND 300 BLOCK LINCOLN AVE	3,928	$589,200
17	200 TO 400 BLOCKS OF PRESTON AVE	2,452	$367,800
18	300 BLOCK RICHMOND AVE 200 BLOCK WHITE AVE	814	$122,100
19	300 BLOCK PENNSYLVANIA CT	1,422	$213,300
20	300 BLOCK STRATHMORE RD	1,436	$215,400
21	100 BLOCK GARRETT AVE	968	$145,200
22	200 BLOCK GARRETT AVE	1,508	$226,200
23	300 BLOCK N PICADOME PARK	1,648	$247,200
24	600 BLOCK COOPER DR	218	$32,700
25	1300 BLOCK WILLOWLAWN AVE	438	$65,700
26	400 BLOCK UHLAN CT	768	$115,200
27	100 DELMONT DR	1,052	$157,800
28	200 BLOCK E VISTA ST	1,260	$189,000
29	200 BLOCK W VISTA ST	1,204	$180,600
30	100 BLOCK E VISTA ST	1,502	$225,300
31	400 BLOCK MORRISON AVE	608	$91,200
32	200 BLOCK LINWOOD DR	948	$142,200
33	500 BLOCK MCCUBBING DR	2,290	$343,500
34	1100 BLOCK SPARKS RD	2,358	$353,700
35	600 BLOCK LAGONDA AVE	1,980	$297,000
36	7OO BLOCK APPLETREE LN	980	$147,000
37	1600 BLOCK CLAYTON AVE	1,644	$246,600
ANTICIPATED YEAR TOTAL		42,990	$6,448,500

PROJECTED YEAR TWO PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	1600 BLOCK COURTNEY AVE	1,490	$223,500
2	EMERY CT	2,058	$308,700
	1600 BLOCK COURTNEY AVE		
3	600 BLOCK BLUE ASH DR	940	$141,000
4	200 BLOCK KOSTER DR	1,860	$279,000
5	200 BLOCK NORWAY ST	1,702	$255,300
6	100 BLCOK HALLS LANE	1,626	$243,900
7	LONE OAK DR	3,468	$520,200
8	2000 BLOCK RAINBOW RD	1,508	$226,200
	200 BLOCK DERBY DR		
	2000 BLOCK REBEL RD		
9	4800 BLOCK BOONE LN	3,762	$564,300
10	1100 BLOCK N CLEVELAND RD	5,356	$803,400
11	5400 BLOCK BRIAR HILL RD	4,280	$642,000
12	4400 BLCOK HALEY RD	50	$7,500
13	4600 BLOCK TODDS RD	3,496	$524,400
14	3500 BLOCK ROLLING HILLS CT	610	$91,500
15	5000 BLOCK SULPHUR LN	1,462	$219,300
16	5200 BLOCK WINCHESTER RD	5,423	$813,450
17	5400 BLOCK WINCHESTER RD	230	$34,500
18	1900 BLOCK BEACON HILL RD	1,576	$236,400
19	3100 BLOCK BRECKENWOOD DR	356	$53,400
20	LAMONT CT	226	$33,900
21	700 BLOCK LANDSDOWNE CIR	314	$47,100
22	3500 BLOCK MADDOX LN	2,732	$409,800
ANTICIPATED YEAR TOTAL		44,525	$6,678,750

PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	100 BLOCK NEW ZION RD	2,302	$345,300
2	SAMUEL LN	1,156	$173,400
3	TILLYBROOK CT	624	$93,600
4	3200 BLOCK RAVEN CIRCLE	360	$54,000
5	MALABU CT HUNTER CIRCLE HEATHER CT 300 BLOCK BELVOIR DR	1,556	$233,400
6	200 BLOCK BRADFORD CIR	352	$52,800
7	SHIRLEE CT	372	$55,800
8	OLD DOBBIN RD	482	$72,300
9	DELMONT CT	168	$25,200
10	1300 BLOCK HIALEIAH CT 1300 BLOCK HOT SPRINGS CT 1300 BLOCK KEENELAND CT	1,682	$252,300
11	CROSS KEYS CT	490	$73,500
12	200 BLOCK LEWIS ST	260	$39,000
13	THISTLETON CIRCLE	522	$78,300
14	EDINBURGH CT	258	$38,700
15	CROYDEN CT SHEFFIELD CT	942	$141,300
16	100 BLOCK GENTRY RD	176	$26,400
17	100 BLOCK N CLEVELAND RD	238	$35,700
18	7300 BLOCK OLD RICHMOND RD	646	$96,900
19	WILLIAMSBURG CT	368	$55,200
20	WOODSIDE CIRCLE	304	$45,600
21	600 BLOCK TATESWOOD DR	340	$51,000
22	RANGE CT	672	$100,800
23	GREENLAWN CT JADE CIRCLE KIMBERLITE CT GRANITE CIRCLE	1,438	$215,700
24	DURHAM CT	504	$75,600
25	100 BLOCK COLLEGE ST	1,098	$164,700
26	GAYLE CIRCLE	388	$58,200
27	SAYBROOK CT	282	$42,300
28	WAYCROSSE CIRCLE SHILOH CT	676	$101,400
29	KELSEY CT KELSEY PL YARMOUTH CT 1100 BLOCK KILRUSH DR	1,694	$254,100
30	CRICKLEWOOD CT	340	$51,000
31	1100 BLOCK APPIAN CROSSING WAY	978	$146,700
32	600 BLOCK CARDIGAN CT 3500 BLOCK BERWIN CT 3400 BL0CK IPSWICH CT	1,416	$212,400
33	3400 BLOCK FLINTRIDGE CIRCLE	426	$63,900
34	500 BLOCK FOLKSTONE DR	302	$45,300
35	1100 BLOCK GREENTREE CT GREENTREE PL GREENTREE CIRCLE	1,252	$187,800

PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
36	KING ARTHUR CT	1,272	$190,800
	3400 BLOCK KING ARTHUR DR		
37	PADDOCK CT	436	$65,400
38	TANNER CT	438	$65,700
39	PENWAY CT	438	$65,700
40	400 BLOCK PLAINVIEW RD	248	$37,200
41	100 BLOCK TORONTO DR	1,286	$192,900
	4000 BLOCK VICTORIA WAY		
	4000 BLOCK VICTORIA WAY		
	200 BLOCK TORONTO RD		
42	2600 BLOCKI WINBROOKE LN	408	$61,200
43	2800 BLOCK MIDDLESEX CT	778	$116,700
44	700 BLOCK HILL RISE CT	542	$81,300
45	1500 BLOCK HALSTED CT	2,420	$363,000
	KILDARE CT		
	KIRK CT		
46	800 BLOCK GENTRY LN	1,236	$185,400
47	200 BLOCK MULBERRY RD	1,148	$172,200
	OSAGE CT		
	2500 BLOCK BUTTERNUT HILL CT		
48	BLACKARROW CT	730	$109,500
49	BARBADOS LN	2,508	$376,200
	3100 BLOCK TABAGO CT		
	2700 BLOCK MARTINIQUE LN		
50	1800 BLOCK COLCHESTER DR	2,484	$372,600
	FELTNER CT		
	1800 BLOCK BOWEN CT		
	1800 BLOCK BARKSDALE DR		
	1800 BLOCK COLCHESTER DR		
51	HAVELOCK CIR	1,614	$242,100
	600 BLOCK SAGINAW CT		
	3400 BLOCK ALDERSHOT DR		
52	KILKENNY CT	932	$139,800
ANTICIPATED YEAR TOTAL		43,982	$6,597,300

PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	3100 BLOCK OLD CROW CT 3100 BLOCK CLAIR RD MONTAVESTA CT	1,916	$287,400
2	2000 BLOCK CUMMINS CT 2000 BLOCK DANIEL CT	758	$113,700
3	400 BLOCK CURRY AVE	468	$70,200
4	4000 BLOCK LILYDALE CT 4000 BLOCK WHITEMARK CT	1,634	$245,100
5	3500 BLOCK ORMOND CIR	636	$95,400
6	1900 BLOCK RITTENHOUSE CT	328	$49,200
7	2400 BLOCK PLUMTREE CT 2400 BLOCK THORNBERRY CT	1,236	$185,400
8	1200 BLOCK MAYWOOD PARK 1200 BLOCK OAKLAWN PARK 1200 BLOCK TANFORAN DR 1200 BLOCK NARRAGANSETT PARK LATONIA PARK 3200 BLOCK WATERFORD PARK	2,744	$411,600
9	200 BLOCK KELLY CT	1,352	$202,800
10	600 BLOCK FOGO CT 600 BLOCK CREWE CT 3400 BLOCK FRASERDALE CT 3400 BLOCK BIRKENHEAD CIR	2,020	$303,000
11	LOOKOUT CIR 2900 BLOCK MONTAVESTA RD	866	$129,900
12	WEM CT	562	$84,300
13	4100 BLOCK WINNIPE CT	630	$94,500
14	400 BLOCK WOODLAKE WAY	250	$37,500
15	3200 BLOCK WOOD VALLEY CT	256	$38,400
16	3500 BLOCK SUTHERLAND DR	1,020	$153,000
17	3500 BLOCK NIAGRA DR	688	$103,200
18	3300 BLOCK MOUNDVIEW CT	434	$65,100
19	LISA CIR MONA CT	912	$136,800
20	MARGO CT KAREN CT	1,846	$276,900
21	VERSIE CT JANNELLE CT	1,270	$190,500
22	200 BLOCK HEDGEWOOD CT	512	$76,800
23	TAMMY CT LAVERNE CT GREVEY CT HARRIS CT	2,726	$408,900
24	GRANT CT HOLLOW CREEK CT GRANT PL	1,034	$155,100
25	GRAIG CT	626	$93,900
26	LYNNWOOD CT WOODSTON CT CLEARWOOD CT	1,746	$261,900
27	3600 BLOCK CAYMAN LN JAMAICA CT	1,574	$236,100

PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
28	WATERS EDGE PL	1,580	$237,000
	2000 BLOCK HARMONY CT		
	2100 BLOCK BRIDGEPORT DR		
29	1600 BLOCK COSTIGAN DR	3,536	$530,400
	1900 BLOCK LEITNER CT		
	1900 BLOCK BEDINGER CT		
	1900 BLOCK COBYVILLE CT		
	900 BLOCK VALLEY FARM DR		
	1900 BLOCK CHRIS DR		
30	3400 BLOCK BELLMEADE RD	884	$132,600
	3400 BLOCK WARWICK CT		
31	1300 BLOCK OX HILL DR	758	$113,700
	BASS CT		
32	1200 BLOCK ASCOT PARK	1,594	$239,100
	1200 BLOCK BEULAH PARK		
	1300 BLOCK ATOKAD PARK		
	1300 BLOCK GOLDEN GATE PARK		
	1200 BLOCK AK-SAR-BEN PARK		
33	BRANDON CT	418	$62,700
34	SWOONALONG CT	2,350	$352,500
	PERSONALITY CT		
	1300 BLOCK CANONERO DR		
	GUNBOW CT		
	PERSONALITY CT		
35	3500 BLOCK GINGERTREE CIR	484	$72,600
36	KENIL CT	138	$20,700
37	2000 BLOCK VON LIST WAY	2,156	$323,400
ANTICIPATED YEAR TOTAL		43,942	$6,591,300

PROJECTED YEAR FIVE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	TREPASSEY CT	808	$121,200
2	100 BLOCK WESTGATE DR	2,022	$303,300
3	100 BLOCK MOORE DR	170	$25,500
4	3300 BLOCK PITTMAN CREEK CT	634	$95,100
5	4700 BLOCK HUFFMAN MILL PIKE	56	$8,400
6	300 BLOCK ROBERTSON ST 1100 BLOCK MARTIN AVE 300 BLOCK FERGUSON ST 300 BLOCK ANDERSON ST 300 BLOCK ROBERTSON ST	3,476	$521,400
7	3200 BLOCK BRACKTOWN RD	1,946	$291,900
8	400 BLOCK BRADLEY CT	1,602	$240,300
9	100 BLOCK CASTLEWOOD DR	1,152	$172,800
10	800 BLOCK CAMPBELL LN	1,184	$177,600
11	600 BLOCK CENTRAL AVE	362	$54,300
12	100 BLOCK CHELAN CT	700	$105,000
13	700 BLOCK E EUCLID AVE	378	$56,700
14	200 BLOCK E MAIN ST	478	$71,700
15	200 BLOCK SOUTHPORT DR	2,672	$400,800
16	TIMBERHILL CT ELDERBERRY CT	858	$128,700
17	HEATON CT 2400 BLOCK MIRAHILL DR 2400 BLOCK WINDWOOD CT	1,042	$156,300
18	1400 BLOCK ELIZABETH ST 100 BLOCK FOREST PARK RD	2,352	$352,800
19	200 BLOCK WESTWOOD CT	1,364	$204,600
20	100 BLOCK WESTWOOD DR	1,640	$246,000
21	1100 BLOCK FERN AVE	1,896	$284,400
22	1000 BLOCK FLOYD DR	232	$34,800
23	400 BLOCK GREENWOOD AVE	1,280	$192,000
24	800 BLOCK JOHNSDALE DR	552	$82,800
25	3200 BLOCK HALEY RD	1,616	$242,400
26	500 BLOCK LONGVIEW DR	94	$14,100
27	400 BLOCK MACADAM DR 600 BLOCK ROSEMILL DR	2,604	$390,600
28	3400 BLOCK MCFARLAND LN	3,650	$547,500
29	500 BLOCK MCKINLEY ST	308	$46,200
30	500 BLOCK MERINO ST	542	$81,300
31	300 BLOCK MEMORY LN	396	$59,400
32	600 BLOCK MONTGOMERY AVE	226	$33,900
33	700 BLOCK NATIONAL AVE 900 BLOCK NATIONAL AVE	1,242	$186,300
34	1100 BLOCK OAK HILL DR	470	$70,500
35	300 BLOCK OLD VINE ST	162	$24,300
36	2100 BLOCK PAIGE CT	358	$53,700
37	400 BLOCK PARK AVE	634	$95,100
38	500 BLOCK PINE ST	382	$57,300
39	200 BLOCK RIDGEWAY RD	556	$83,400
40	1400 BLOCK RUSSELL CAVE RD	210	$31,500
ANTICIPATED YEAR TOTAL		42,306	$6,345,900

KENTUCKY AMERICAN WATER

AGING INFRASTRUCTURE

A REVIEW OF THE WATER DISTRIBUTION SYSTEM

2017

Kentucky-American Water Company

Contents

Introduction

Similar to other water utilities, the water distribution system of Kentucky American Water is beginning to reach its expected life expectancy. Even though the company has made investments in the replacement of the aging infrastructure, the rate at which existing infrastructure is reaching its useful life continues to increase at a quicker pace than the work to replace the outdated mains occurs.

One of the major challenges that water utilities face is that the distribution systems were installed to support the growth of communities that varied over time. The mains installed during the high growth periods reach their life expectancy at the same time, resulting in sections of communities that need all of the mains replaced in a short time period.

In addition, during the periods of system expansions, different pipe materials were used as they were introduced as an alternative to the existing main materials. With each pipe material, the life expectancy of the main is different. Unfortunately, that results in periods where pipes that were installed at different times in the past reach their useful life at the same time as other types of pipe material, increasing the amount of mains that need to be replaced throughout the system in a compressed timeframe.

As the American Water Works Association indicated in their May 2001 publication, "Reinvesting in Drinking Water Infrastructure," a new era was emerging regarding the operation of our water infrastructure—the replacement era—where water providers would need to replace the water infrastructure that was built for us by earlier generations.

Although Kentucky American has made investments in the replacement of mains over the past decades, the amount of main replaced cannot keep up with the expected amount of main requiring replacement that will occur in the coming decades.

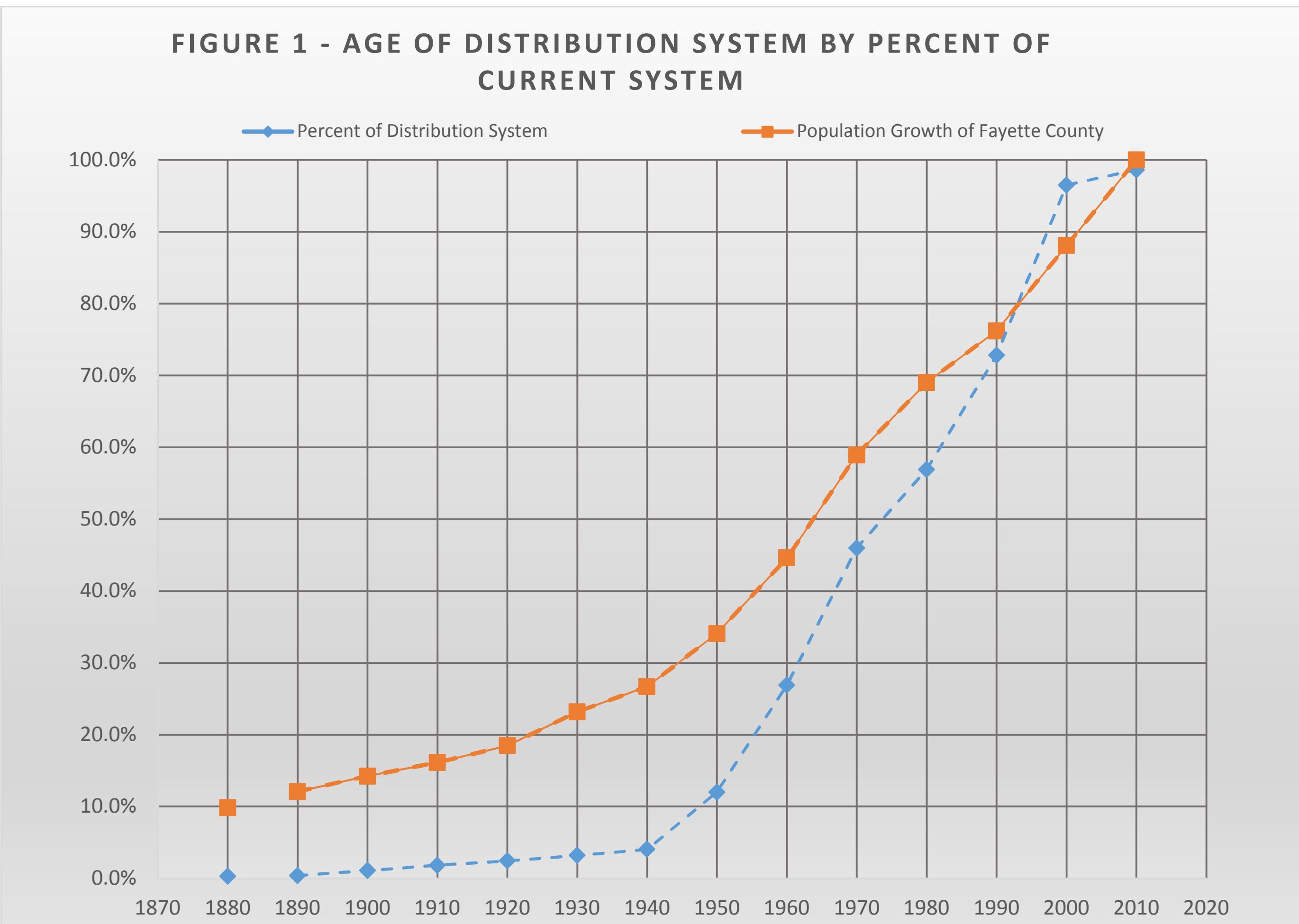
System Background

Kentucky American Water first began operation as the Lexington Hydraulic and Manufacturing Company providing water to Lexington in 1885. The company was started by three local businessmen who saw a need for a water system to help fight fires and prevent disease. During the early 1970s the name changed from the Lexington Water Company to the current Kentucky American Water Company.

Since 1885 the system has grown from serving approximately 200 customers to about 124,000 customers within 11 counties, including Fayette County. With that growth the distribution system has expanded to include approximately 2,017 miles of water mains of a variety of sizes and material types.

History of the Growth of the Distribution System

Kentucky American's water distribution system growth mirrors the growth of the City of Lexington and Fayette County. Figure 1 shows the percent of the water distribution system that was installed within each of the decades from 1880 to present.



From the start of the system in 1885 through the 1940's the area was predominately an agricultural based economy and growth was steady. Main installed during that period was cast iron main. Currently there remains approximately 63 miles of cast iron main that was installed during this period that still remains within the distribution system and represents approximately 3% of the current distribution system. This amount used to be a greater amount of the distribution system, however during the 1980s, 1990s and 2010s the Company undertook a concerted effort to replace this era of cast iron main.

Following World War II, Lexington experienced an increased growth rate due to the move away from agriculture and the baby boom. During the 1950's and 60's, the distribution system also grew substantially to keep up with the expansion of Lexington. Main installed during that period was cast iron, both cement lined and unlined. During this period asbestos cement pipe was introduced for the first time into the distribution system. The main installed during this period represents 25% of the current distribution system (514 miles of main).

The Lexington system experienced its greatest growth during the 1970s through the housing boom of the first part of 2000. During this period, Lexington experienced a growth due to industry and service companies locating and growing in Fayette County. In addition, Kentucky American acquired several outlying systems by growing into the counties surrounding Fayette County. Also during this period, the main extension from Kentucky River Station Two to the Lexington distribution system was placed into service during September 2010, which was during the end of this time frame. During this period of time approximately 1,290 miles of main were installed which represents 63% of the current distribution system. Asbestos Cement pipe was the predominate material installed during the start of this period with Ductile Iron pipe and PVC becoming the predominate material during the 1980's.

From 2010 to present, the distribution system has seen a much slower growth rate and represents a little more than 3% of the current distribution system (80 miles). Currently, the predominate material installed is Ductile Iron with some PVC pipe.

Pipe Materials in Distribution System

The Kentucky American distribution system contains mostly five major material types. Those types are Ductile Iron, PVC, Asbestos Cement, Cast Iron Lined and Cast Iron Unlined. The period that the system was growing determines the areas and the amount of each material type in the system. Table 2 provides a listing of the major material types in the distribution system along with the amount of each material in miles and percentage of that material within the system:

Table 2 – Distribution System Material Types		
	Miles of Material	Percentage of System
Ductile Iron	862.2	42.7
PVC	437.1	21.7
Asbestos Cement	339.3	16.8
Cast Iron Unlined	184.4	9.1
Cast Iron Lined	136.4	6.8
Prestressed Concrete	39.4	2.0
Galvanized	3.4	0.2
Other (Brass, Lead, Steel)	2.4	0.1
Unknown	12.3	0.6

Distribution of Pipe Material by Decade

When the material type is compared to the timeline of growth of the distribution system, certain periods of time were dominated by particular pipe materials. During the first part of the system development from 1885 to 1950, cast iron unlined and lined was the predominant material. During 1950 to 1980, asbestos cement pipe was used along with cast iron pipe and the introduction of ductile iron into the system. After 1980, ductile iron pipe dominated the material type being used to meet system growth. PVC pipe use in new water main was not prevalent in the distribution system except for small diameter pipe. During the 1980s, 90s and 2000s with the acquisition of systems, PVC was introduced into the Kentucky American distribution system. Table 3 provides a breakdown by decade of the material types used in the expansion of the distribution system.

Table 3 – Miles of Existing Material Types Installed by Decade							
Decade	Material Types						
	Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized[2]	Other[1]
1881 - 1890	5.5						
1891 - 1900	1.6						
1901 - 1910	15.9	0.2					
1911 - 1920	11.7	0.7				0.1	
1921 - 1930	11.3	2.2					
1931 - 1940	8.6	6.4	0.1				
1941 - 1950	3.3	5.2	13.3				
1951 - 1960	22.8	55.4	72.1	5.0	0.5	1.2	8.5
1961 - 1970	48.5	66.3	96.9	64.9	50.6	1.2	12.8
1971 - 1980			122.7	134.4	164.6	0.1	22.2
1981 - 1990			13.7	37.7	163.9		
1991 - 2000				27.9	286.0	0.1	
2001 - 2010				149.3	267.3		
2011 -				12.2	58.2		

1 – Other represents Lead Pipe, Reinforced Concrete Pipe and PEP Pipe
2- In most cases the Galvanized Pipe indicated on this table occurred during acquisitions during these periods

Expected Life of Pipe Material

Based on information developed by American Water Works Association for the "Buried No Longer" report released in February 2012, Table 4 provides an estimated expected service life for pipes of varying material. The expected life was determined based on operating experiences of water utilities and insight from research with typical pipe conditions based on pipe material and varying conditions of age and size.

Table 4 – Average Expected Life of Pipe Material						
Material Types						
Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
110 yrs	100 yrs	90 yrs	55 yrs	80 yrs	70 yrs	105 yrs

This table is a simplification of reality since the life of the pipe is also impacted by the pipe material, soil properties, installation practices and climate conditions. Kentucky American has experienced that pipe life depends on many variables, such as soil conditions and installation practices, rather than just the age of the pipe itself. The company has had many pipes last longer than the typical service life indicated, but has had other pipes fail sooner than expected. For the purpose of this report and due to the lack of specific data that allows the company to develop an understanding of each condition that affects each pipe segment in the system, the average life expectancy provides a reasonable approximation of the replacement rate.

Using the average expected life for Kentucky American's distribution system indicates that the pipe that has been installed over the past 130 years will need to be replaced over the next 85 years to ensure that the system is maintained within the expected life of the networks pipe material.

Importance of Replacing Mains

Access to clean reliable water is critical for the communities served and has become an intrinsic responsibility of those who manage the water infrastructure throughout the world. Safe drinking water is important to the health and economic welfare of a community. The ability to obtain clean water, free of contaminants, reduces sickness and related health costs. In addition, the ability to access a sufficient supply creates economic opportunities throughout the community.

As the water distribution system begins to reach its useful life, failures in the infrastructure begin to occur that impact the ability to provide safe and reliable service to the community. Neglecting this aging infrastructure will increase the frequency of water main breaks and leaks, leading to the corrosion of surrounding utility pipes, disrupting automobile, pedestrian and public transportation and stymieing local economic activity.

Although most of these breaks are minor, serious ruptures can and do occur. With these serious breaks the impact can be catastrophic due to flooding of streets and sidewalks, and in some instances flooding of local businesses and basements of local residents. In rare instances, the loss of water can undermine pavement or building foundations that can lead to the failure of pavements or the loss of a building that can result in significant property damage and serious injuries.

We have seen numerous examples of serious failures over the past few years that have affected major metropolitan areas. On June 18, 2015 Louisville Water Company experienced a break on a 60-inch water main that impacted 33,000 customers and caused the road to buckle, breaking apart huge pieces of pavement that floated and damaged vehicles in the area. The break also caused damage in adjacent parking lots and impacted the ability of the local residents to continue with their regular routine.

This break followed a 48-inch water main break during April 24, 2014 near the intersection of Eastern Parkway and Baxter Avenue that caused the intersection to be closed for at least 6 days. The break sent water cascading down Baxter Avenue, flooding Tyler Parks and nearby yards. In addition, the break flooded athletic fields on the University of Louisville campus and caused concerns for participants of athletic camps who were on the fields at the time of the break.

One of the most significant breaks of 2015 was a water main break near the University of California in Los Angeles on July 29 that caused massive street flooding and damage on the campus. The break caused the loss of more than 20 million gallons during the 3 and half hours that it required to turn off the main. The water flooded into the university and entered numerous buildings and structures causing significant damage. Firefighters saved up to five people that were stuck in underground parking structures and trapped more than 730 cars with half of the vehicles being entirely submerged.

Kentucky American Water has not seen these dramatic of main breaks over the past few years, but it has seen several main breaks that have not only caused impact to the adjacent area that is surrounding the break but has also caused traffic disruptions and inconveniences due to repair activities. Some of these breaks have resulted in business disruptions and economic impact to the community.

The American Society of Civil Engineers study “Failure to Act,” released in 2012 on the economic impact of under-investing in our water and wastewater infrastructure, the authors estimated that remaining on the current track will cost American businesses and households $216 billion in increased costs between now and 2020, and the cumulative loss to our gross domestic product (GDP) will be $400 billion, directly due to deteriorating water infrastructure. Without additional investment in the infrastructure, almost 700,000 jobs will be threatened due to unreliable water delivery and wastewater treatment services.

The impact of a water main break is mostly a localized impact, with the exception of large main breaks that impact a large portion of the community or the loss of the service to the entire community. The loss of water through leaking pipe as the infrastructure ages is an impact that affects the entire community, most of the time with no one knowing it is occurring. This loss of water typically manifests itself in an increase in “non-revenue water.” A high level of non-revenue water affects the financial viability of water utilities through lost revenues and increased operational costs. Although Kentucky American Water’s non-revenue water is at or below the industry standard, there is concern that over time the ability to manage non-revenue water would be impacted without a systematic approach for replacing aging infrastructure.

Other than the impact of pipe failure, the aging infrastructure also impacts the ability to provide adequate service to our customers and the system’s ability to meet fire flow requirements. A majority of this older infrastructure was installed during a period where the expectations or requirements for fire service and household appliances were not as great as we see it today. In some cases, deposits within the pipes have also reduced its ability to provide adequate water flow for customer uses and fire service.

Replacement of the infrastructure enhances the system’s ability to meet the service expectations of the customers. The ability to replace this aging infrastructure allows the company to provide improved service to the customer and usually improves fire protection. In addition, the areas of the system that are replaced are made more robust and are more resilient during periods of high demands and reduces the number service disruptions.

The investment in replacing the infrastructure allows for a more robust system that enhances the ability of the community to compete for new business and industries, which is an important economic benefit to the community. According to the U.S. Conference of Mayors, every dollar invested in water infrastructure adds $6.35 to the national economy.

Previous Review of Network

During 2009, Kentucky American Water commissioned Gannett Fleming to conduct an Analysis of Non-Revenue Water for the system as ordered by the Commission as part of Case No. 2007-00134. A part of that analysis was a determination if there was a correlation or trend in the occurrence of main breaks and leaks in the Central Division. The analysis was conducted on 1,927 main breaks reported from January 2000 to October 2008.

Review of the main break data indicated that a majority of breaks (82%) in the system during this period were reportedly caused on Ground Shift/Other. Age and Deterioration was reported to be the cause of approximately 10% of the breaks. Pressure Surge, Tree Roots, and Clamp Failure were reported to be collectively the cause of the remaining 8% of the breaks during the period of January 2000 to October 2008.

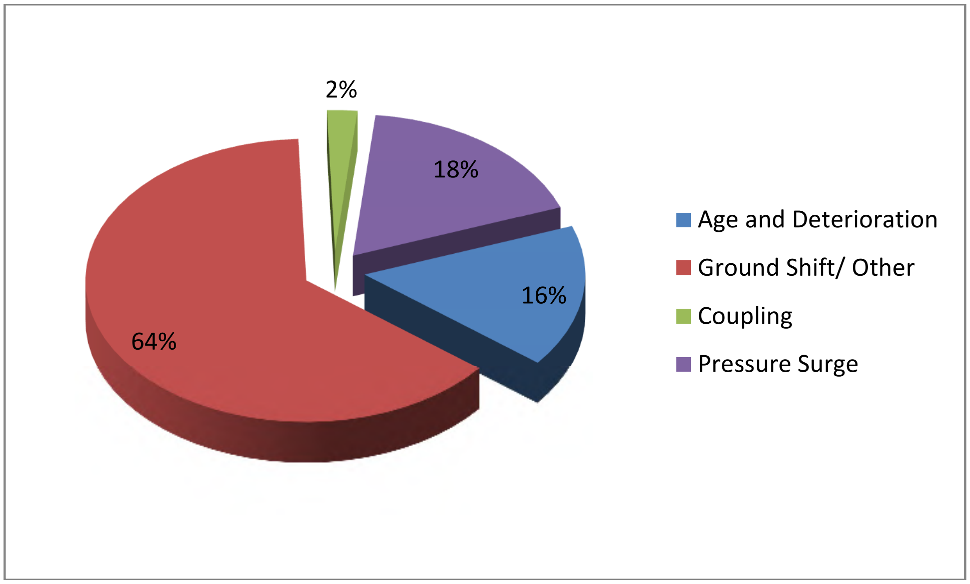
The main breaks that were reportedly caused by Age and Deterioration or Ground Shift/Other occurred on unlined cast iron main 53% of the time and, in particular, a significantly high percentage of reported breaks associated with age and deterioration occurred on unlined cast iron mains 37% of the time. The analysis indicated that the highest percentage of breaks caused by Ground Shift/Other occurred on unlined cast iron main and asbestos cement main (34% and 26%, respectively).

The analysis by Gannett Fleming found that replacing specific main sizes or types of material that exhibit a high concentration of breaks would not have a substantial impact on reducing non-revenue water. Gannett Fleming concluded that other factors should be considered with regard to replacement of problematic main rather than trying to control non-revenue water.

During the review of the main break history, Gannett Fleming found that the highest concentration of reported main breaks occurred on unlined cast iron. The concentration of reported main breaks on galvanized steel main was also significantly higher than the system average of 0.9 breaks per mile of main. Gannett Fleming suggested that a main replacement program targeting unlined cast iron main and galvanized steel main, specifically those less than 4 inches in diameter, should be considered to reduce the occurrence of main breaks.

Current Review of Network

Review of the main break history from January 2012 to December 2016 indicated that there have been 837 breaks during this period, averaging about 167 per year. Similar to the finding of the 2009 Gannett Fleming report, the current break history indicates that 64% of the main breaks are caused by ground shift. This percentage decreased from 82%, while the age and deterioration breaks increased to 16% compared to 10% during the past review. Although a small increase, it is an indication that the distribution system is aging and we would expect to see an increase in these types of breaks as the age of the mains increases.

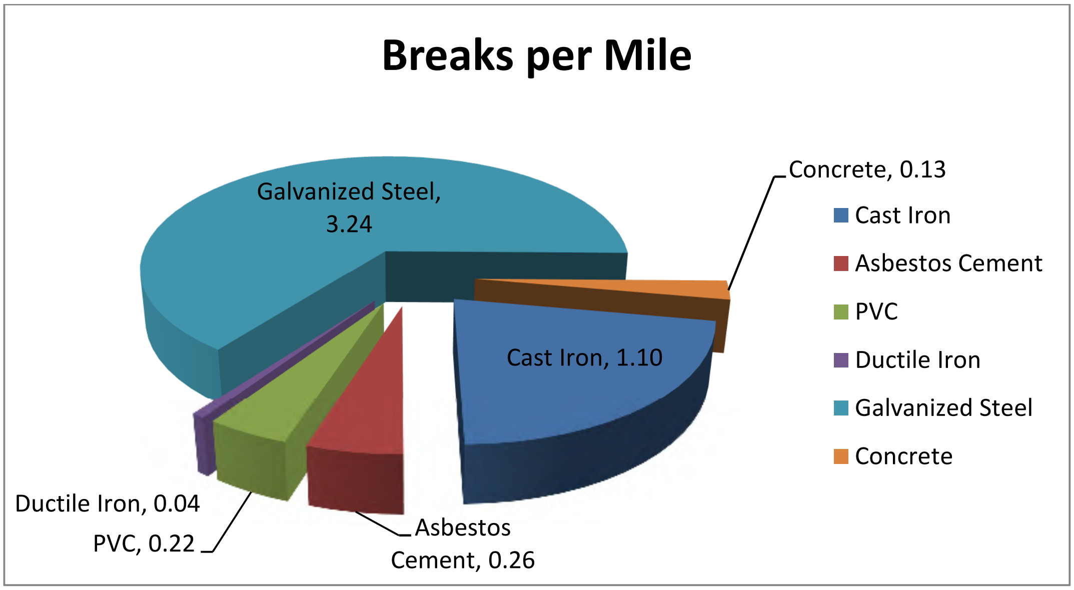


The average number of breaks per year has decreased from 222 per year for the period of January 2000 to October 2008 to 167 per year for January 2012 to December 2016. This reduction is indicative of the main replacement work conducted following 2008 that specifically targeted mains with high break incidents.

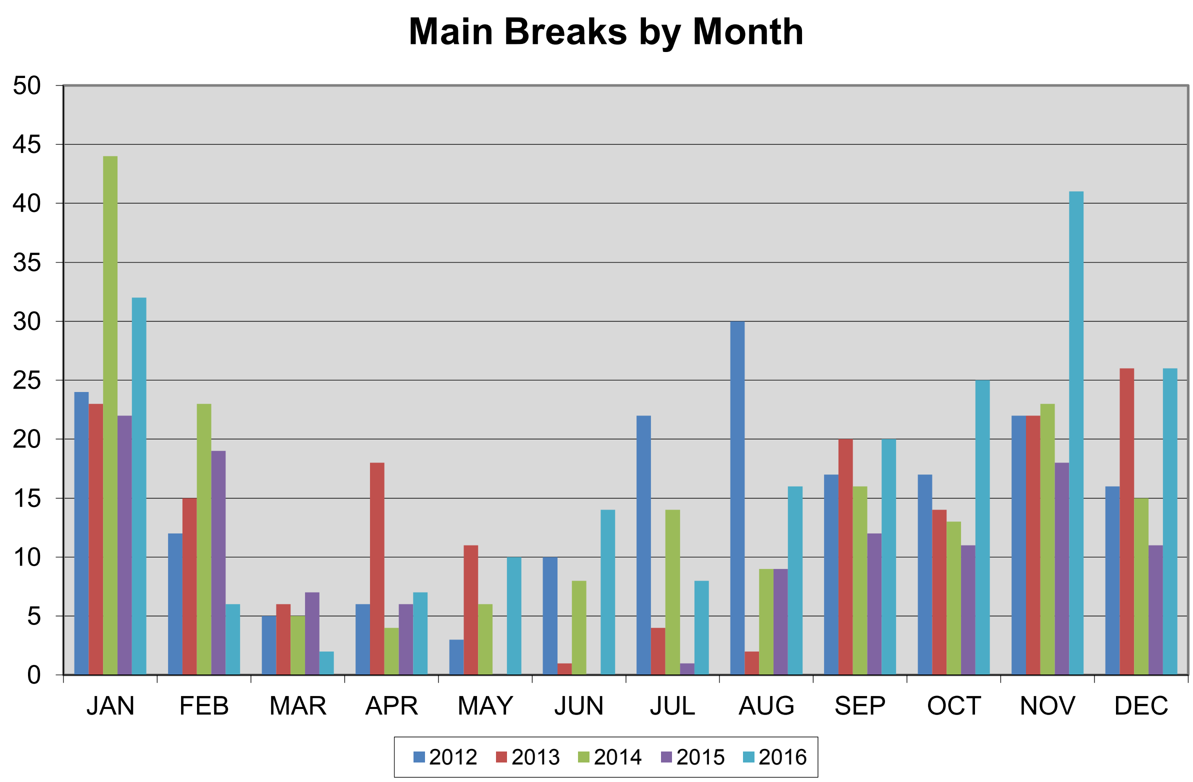
Review of the reported breaks from January 2012 to December 2016 indicates that main breaks on cast iron main represented 60% of all of the breaks. Since cast iron main lined and unlined material only represents 15.9% of the total inventory of mains in the ground, the break rate on this type of material is significantly higher than the other material in the system.

Table 5 – Breaks by Material					
Material Types					
Cast Iron	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
60.1%	15.5%	16.4%	6.2%	1.3%	0.5%

The break rate per mile of main shows that cast iron main had a break rate of 1.1 breaks per mile of main compared to ductile iron which saw a break rate of 0.04 breaks per mile of main from January 2012 to December 2016. The worst performing material was galvanized steel which had a break rate of 3.24 breaks per mile of main.



Another area reviewed in the main break data from January 2012 to December 2016 indicated that 52% of the breaks occur between November to February of each year with the lowest break period being during May and June. Analysis of the break reports would support that ground shift breaks cause the most failure of the pipe material and we would expect to see the ground shifts occur during the November to February time frame. It should be noted that the high break occurrence that is observed in July and August of 2012 is believed to be caused by ground shift breaks that occurred following high rain events during each of those months.



With ground shift breaks being 64% of the overall breaks that occurred during January 2012 to August 2015, this would correlate with pipe materials that are susceptible to ground movement or shifting being at greater risk than other materials. Cast iron and galvanized steel are not resilient to tension and bending forces that result in ground shifting and contribute to the higher break per mile numbers that the system has experiencing.

Cast iron and galvanized steel are good at controlling internal forces and crushing forces that were generally used during the design stage when this material was placed into service. However, the industry gained the knowledge that cast iron and galvanized steel were susceptible to bending forces and encouraged the introduction of other materials. Materials such as ductile iron and PVC handle these types of forces and as such are more resilient to this type of ground movement. This resulted in the water utility industry standardizing on ductile iron and PVC and moving away from cast iron and galvanized steel.

Current Replacement Effort

Following the Gannett Fleming report in 2009, the replacement effort was predominantly driven by mains that exhibit high break frequency, relocations and requests by operations to replace mains to address multiple repair trips to the same main. During the period of 2009 to 2013 the average spend on main replacement projects was $2.6 million per year. The main replacement projects replaced all types of material that were experiencing high break frequencies, but the majority of the type of main replaced during this period was cast iron main. With this effort the amount of cast iron main replaced in the system was 10.7 miles with an average of 2.1 miles a year.

In 2014 there was a renewed effort to review the distribution infrastructure and start to address the aging infrastructure needs of the system. During 2014 and through 2016 the average spend on main replacement projects was $3.7 million per year. Based on this current effort the amount of cast iron main replaced in the system from January 2014 through December 2016 was 11.2 miles with an average of 3.7 miles per year.

Since 2009 the main replacement work has replaced 21.9 miles of cast iron main from the system and replaced it primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.7 miles per year during the 8 year period including the accelerated rate of 3.7 miles per year over the past 3 years from 2014 and 2016. While this is making significant progress, it is still not enough to address the rapidity aging distribution system. At the current rate over the past few years it would take approximately 86.4 years to replace the reminaing 320 miles of the cast iron main in the distribution system. At the end of the 86 year period the possible age of a cast iron main could be 220 years old or over twice the life expectancy for this type of material.

Main Replacement Criteria Development

With the renewed effort to review the distribution system in 2014, Kentucky American Water analyzed the methodology for planning main replacement to ensure that the distribution system could meet the needs of its customers and developed ways to reduce the failure rate of mains. The previous method of determining main replacement was based on break history and requests from the operations group on which mains to replace was determined to be too limited in determining the most critical mains to replace.

With the understanding that continued enhancement of the Kentucky American Water system would require a systematic replacement plan to ensure that the right mains were being replaced at the right time, the company established a goal in 2013 to research and develop tools to assist in developing the plan.

The first step was to develop the criteria that would be used to assess the existing mains and develop a list of mains that were in critical need of being replaced. It was determined that a main replacement assessment standard would require adoption of several criteria to determine which mains would need to be replaced. Development of the assessment standard considered the inclusion of eight criteria that played a major role in providing reliable service and were a good indicator of the condition of the main. These criteria are included in Table 6.

During development of the criteria it was determined that several of the criteria had interrelationships with each other and contributed to the performance of a section of water main. One of the interrelationships was main size and fire flow. In addition, it was determined that leaks can also be related to the age and material of the mains, and material types can be related to the water quality aspect of the main.

Due to the interrelationships of the eight criteria, the team established relative weights for each criterion to ensure that the targeted drivers for the main are given greater consideration. Age, material type, low pressure, number of breaks and water quality were the primary criteria that would be used to determine main replacement. These criteria allowed the main replacement program to ensure that mains that were not meeting the needs of the community and customers were addressed quickly.

Along with the criteria weighting, the assessment contains a rating standards for each of the eight criteria. A numeric rating of between 1 and 5 was used for each criterion – with 1 being the better rating and 5 being the worst rating.

TABLE 6 - MAIN REPLACEMENT CRITERIA						
Criteria (Max. Points)	***Weight***	***Rating***				
		1	***2***	***3***	***4***	***5***
Low Pressure (75)	15x	50 psi or greater	50 psi to 45 psi	45 psi to 40 psi	40 psi to 35 psi	< 35 psi
Number of Breaks/Leaks (75)	15x	0 breaks/5-year avg.	1-2 breaks/5-year avg.	3-4 breaks/5-year avg.	5-6 breaks/5-year avg.	< 6 breaks/5-year avg.
Fire Flow (50)	10x	Greater than 1,500 gpm (Blue)	1,500 to 1,000 gpm (Green)	999 gpm to 500 gpm (Yellow)	Less than 500 gpm (Red)	Known problems
Age (75)	15x	1995 or later	1980 to 1994	1970 to 1979	1960 to 1969	1959 and prior
Material Type (75)	15x	DI/RCP	PVC/HDPE	Transite/AC	CI/CLCI	Gal. / Steel
Size of Main (50)	10x	8 inch and above	6 inch	4 inch	2 inch to 3 inch	Main smaller than 2 inch
Water Quality (75)	15x	Flushing but not routine	Monthly Flushing	Bi weekly Flushing	Weekly (or more frequent) Flushing	Continuous Flushing (w/ discussion)
Customer Impact (25)	5x	less than 2 customers	2 to 10 customers	11 to 20 customers	greater than 20 customers	School/Hospital (Critical Customer)

An electronic database was developed to assist in the assessment and prioritization of the replacement mains and subsequent development of replacement schedules. The database is designed to perform the necessary queries and calculations to determine the main section overall rating and ranking. Initially 62 mains were entered into the database as a pilot to ensure that the assessment tool was capturing the critical needs of the system and identified the more critical sections to replace.

During most of 2013 through 2016 this initial list has provided a schedule for which mains are in need of replacement and provided a schedule that has been used to guide the main replacement program.

As with any tool, there are still external drivers that influence the main replacement program. These external items such as roadway paving schedules, weather or construction considerations are combined with the results of the assessment tool to make adjustments in the replacement program. This combination of tools and subjective considerations allows for a more reactive replacement program that is in concert with the community and allows for efficient use of available resources.

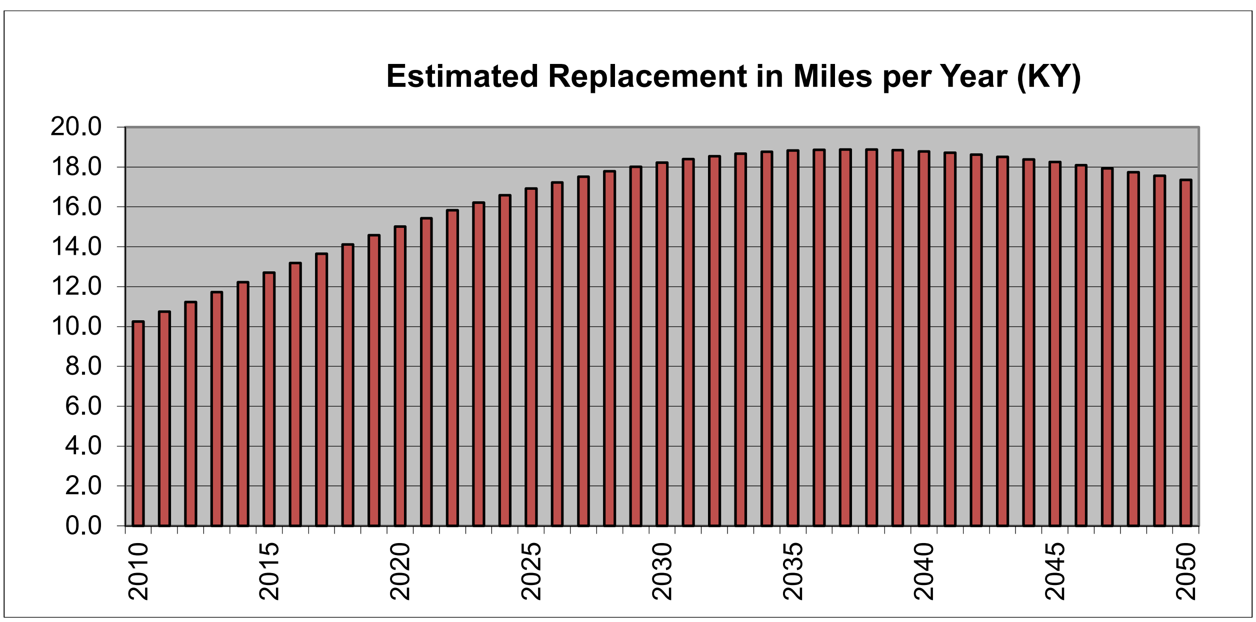
Nessie Model

While the assessment tool provides a numerical approach of determining the critical mains to replace, the company needed to determine the overall scope and financial impact over a longer planning horizon. The company looked for tools that could provide assistance in determining the capital needs for water main replacement in the coming years that considered the life expectancy of the infrastructure.

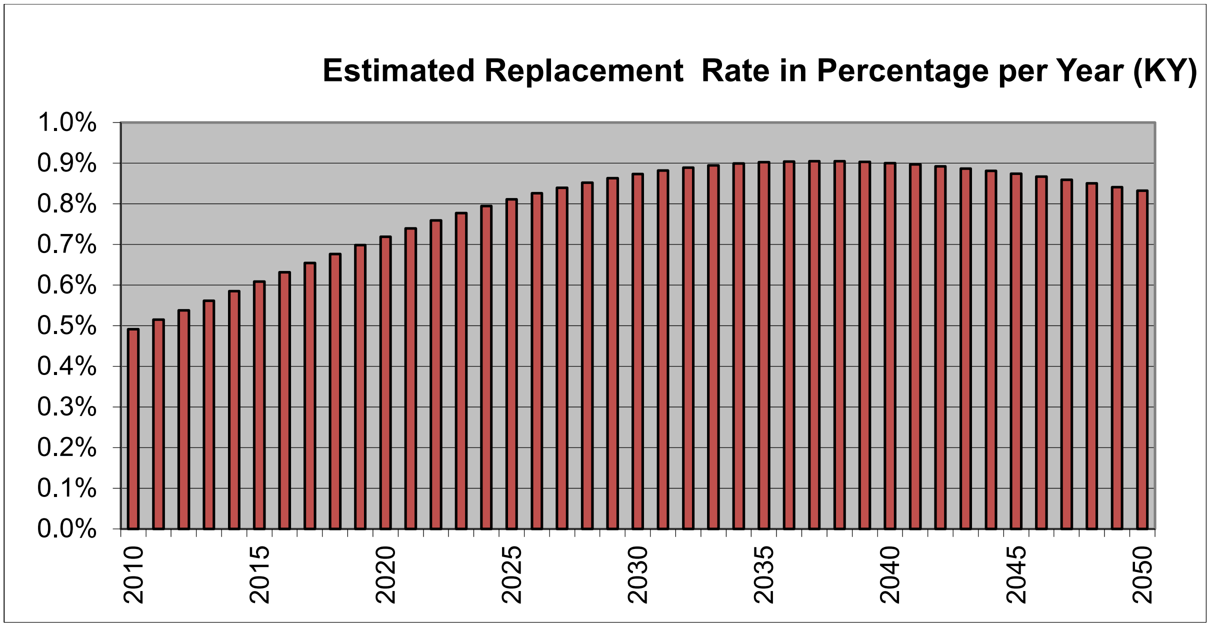
The American Water Works Association report “Dawn of the Replacement Era” developed a process that created a “Nessie Curve” for the 20 systems it reviewed in the report. The Nessie Curve, so called because the graph follows an outline this is likened to a silhouette of the Loch Ness Monster, provided a visual representation of the capital needs during a defined time frame to rebuild the underground infrastructure of the 20 systems. With the report “Buried No Longer,” AWWA further developed the analysis of the underground infrastructure and developed the “Nessie Model.”

The model uses pipe failure probability distributions based on past research with typical pipe conditions at different ages and sizes coupled with the indicative costs to replace each size and type of pipe, as well as the cost to repair the projected number of pipe breaks over time. The model projects the “typical” useful service life of the infrastructure based on pipe inventories of the system and estimates how much pipe of each type should be replaced in each of the coming 40 years.

Kentucky American Water utilized the model to provide an insight into the replacement rate suggested during the 40 year planning horizon. The chart below provides the estimated replacement in miles of main per year that peaks to 19 miles per year by 2034.

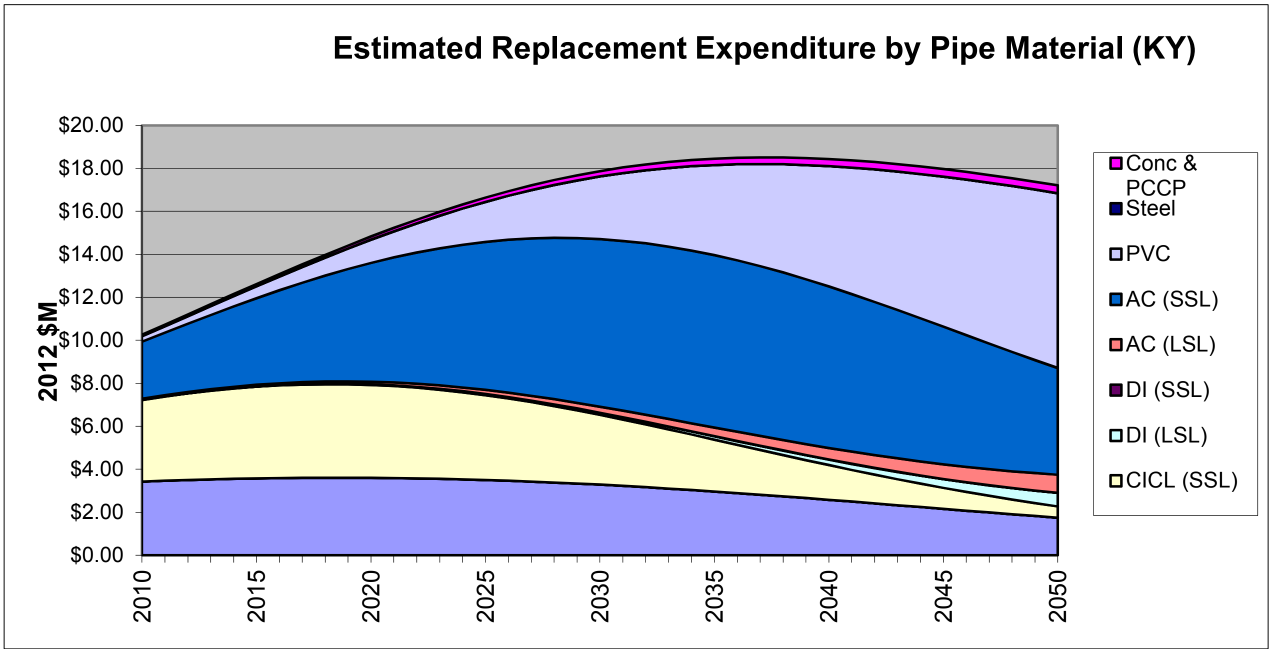


The analysis of the distribution system with the estimated replacement rate of 10 to 19 miles of main per year translates into a replacement rate of 0.49 to 0.90 as percent of the system per year. This estimated replacement rate in percentage of the distribution system per year from 2010 to 2050 is indicated on the chart below.



The model then combines the amount of infrastructure that should be replaced with the typical cost to replace the mains to create an estimate of the total investment cost for the 40 year planning horizon. The model represents this data through a series of Nessie Curves to depict the suggested amount of spending required to replace the main at the optimal life cycle for each material type.

The Nessie Model provides an insight on the amount of capital that is suggested to ensure that the distribution system is being replaced to account for the useful life of the distribution mains. The chart below provides the Nessie Curve developed by the model over a 40 year time frame of the estimated capital needed to replace the appropriate pipe material in the system based on the materials' useful life.



The model identifies that cast iron main is the material that needs to be replaced initially followed by asbestos cement. During the 40 year period the model projects that during the first 20 years approximately $6 to $8 million each year is needed for cast iron main replacement declining to $3 million during the final 20 years. At the same time the model suggests that asbestos cement main be replaced at a rate of $3 to $7 million each year during the 40 year period. In the outer years of the planning horizon, replacement of PVC main and ductile main begin to be shown as a need in order to address the life expectancy of those material types.

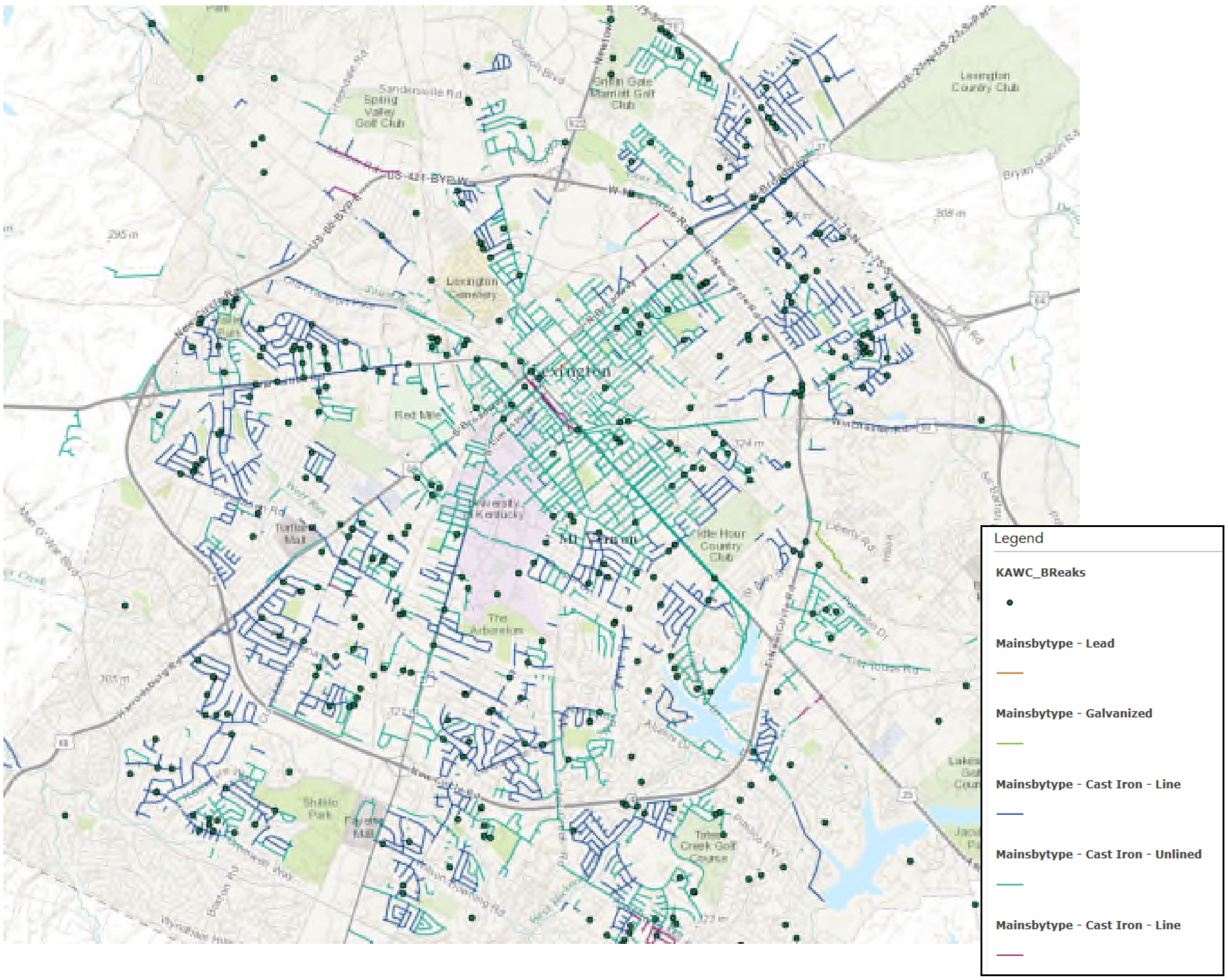
The curve reflects an “echo” of the original trends that shaped the development of the system starting in 1885. The identified capital needs is a reflection of the main installed nearly a century ago that have created a future obligation to replace the mains as they reach their useful life that is now coming due.

Proposed Accelerated Replacement Plan

Kentucky American recognizes that the past rate of replacement of aging mains the company has employed is not sufficient to address the increased replacement rate that will be required over the coming decades. The need to begin to rebuild the distribution infrastructure that was bequeathed to us by earlier generations is essential to maintain the needs of the community and customers.

Upon review of the distribution system and the material types used in the development of the system, Kentucky American believes that the first materials that need to be replaced in the system are cast iron main and galvanized steel. These two materials represent approximately 16.1% of the distribution system but account for approximately 61.4% of all main breaks in a given year.

The company utilized its Graphical Information System (GIS) to query the main breaks during the period of January 2012 to August 2015 against the main types in the system and found that empirical data from the database is depicted graphically. The following map shows the main breaks during the 2012 to 2015 period against cast iron and galvanized steel main.



The map identifies two items rather definitively. The first is that a majority of the cast iron main was installed during the first half of the development of Lexington. The map clearly shows that a majority of downtown Lexington remains cast iron and to the most extent unlined cast iron. In addition, with the development of the community away from downtown, the map shows those subdivisions during this period that cast iron was used as the predominate material to serve these areas. It is interesting to note that a majority of the development during the time was within the inner circle, with only small pockets of development along the outside of the circle.

The second item that the map shows is the correlation of the main breaks within the areas that are predominately cast iron and galvanized steel. The remaining main breaks shown on the map are scattered throughout the system and have no indication that there are significant trouble spots from the other distribution system material types at this time.

Based on the information reviewed by the company over the past few years and the data developed for this report, a majority of the mains that are susceptible to breaks are cast iron and galvanized steel. Kentucky American believes that the best course at this time is to target this type of pipe material over the next 25 years for replacement. The replacement of this type of material allows the company to address underperforming mains and reduce the impact of main breaks in the areas served by this type of material. A review of several replacement periods was reviewed and illustrated in Table 7, indicating that a 15 year plan would cost $20.2 to $12.6 million annually and a 30 year period would cost $9.6 to $6.3 million per year.

TABLE 7 - POSSIBLE REPLACEMENT RATES FOR CAST IRON				
Period Length	15 year	20 year	25 year	30 year
Miles Replaced per year	21 - 16	16 -12	13 - 10	10 - 8
Cost per year (million)	$20.3 to $12.6	$15.5 to $9.5	$12.6 to $6.9	$9.6 to $6.3

Analysis of the four possible replacement rates lead the company to believe that a 25 year replacement period was more realistic. The 30 year replacement rate would result in a greater overlap of replacement activity between the completion of the cast iron main replacement and the start of the asbestos cement main replacement period.

With the 15 year and the 20 year replacement periods the removal of the cast iron main was removed from the system quicker and allows for the effort to replace asbestos cement to begin sooner. However, the amount of capital required per year was a concern with respect to support from the community. In addition, the level of capital commitment per year for the 15 year and 20 year replacement rates could have a negative impact on Kentucky American’s ability to address other infrastructure replacement needs such as water treatment components at the water treatment plants that are also entering the end of their useful life.

Finally, the amount of mile of replacement main per year of 16 and 12 miles for the 15 year and 20 year replacement rates is a concern for the impact on available resources to complete the construction each year. The 15 year replacement rate is a fourfold increase in the amount of main replaced during 2014 to 2016. This increase would be a significant strain on the available company and contractor resources and would require a substantial increase in labor and equipment creating a concern about sustainability.

Through a 25 year replacement period, the 320 miles of cast iron main will be replaced at a rate of 13 to 10 miles per year at an expected cost of $12.6 to 6.9 million per year. At the conclusion of the 25 year replacement period for cast iron, the company will start to focus on the replacement of the 339 miles of asbestos cement pipe, the earliest of which was installed during 1935, which will mean it will be entering its 105th year of useful life.

Conclusion

Thanks to the work of past generations that developed and built the water distribution system to support the growth of our community, we have enjoyed access to clean water and economic advantages that it has provided. Because these water mains last a long time, however, we have never had to replace a significant amount of pipe on a large scale. We are on the edge of the period when these mains are reaching their useful life and future generations will need to undertake large scale replacement efforts to ensure that we continue to benefit from our access to clean water.

It is important that instead of entering this period with a careless plan that only address the system as it fails, we undertake a prioritized renewal of the mains to ensure that our water infrastructure can reliably and cost-effectively support the public health, safety, and economic vitality of our community.

Kentucky American believes that with the replacement of cast iron and galvanized steel main through a 25 year replacement period is important to ensure the company can responsibly enter into the period of water infrastructure renewal. Through careful prioritization and looking at emerging technology, the cost of replacing main just prior to failure will be of significant benefit to the community. Through the reduction of the number of failures the system experiences, we can reduce property damage, disruption of businesses and the community, and waste of our water resources. We can help ensure our future generations continue to benefit from access to reliable clean water that will support the economic growth of the community.

Resources

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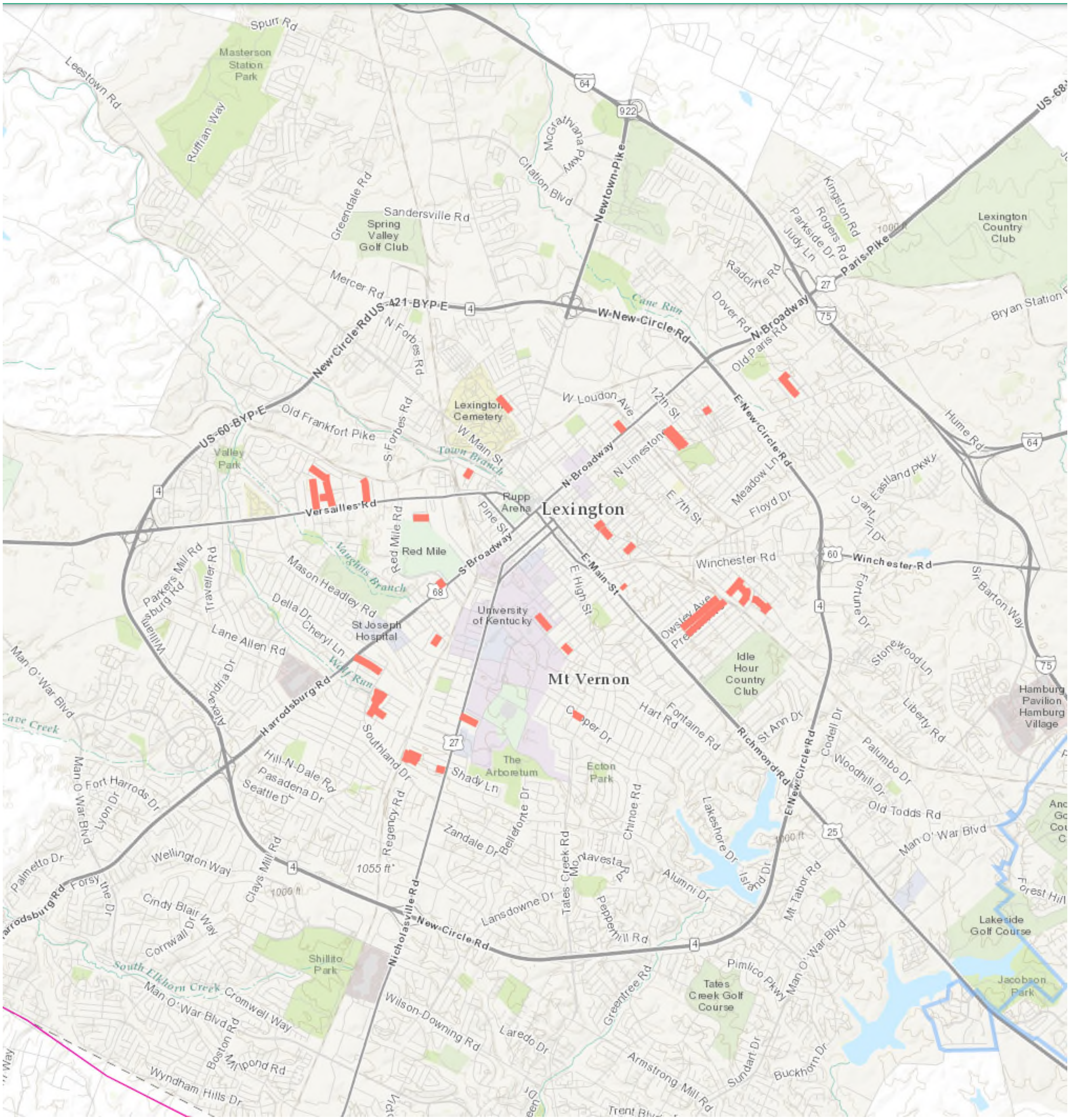
APPENDIX

KENTUCKY AMERICAN WATER

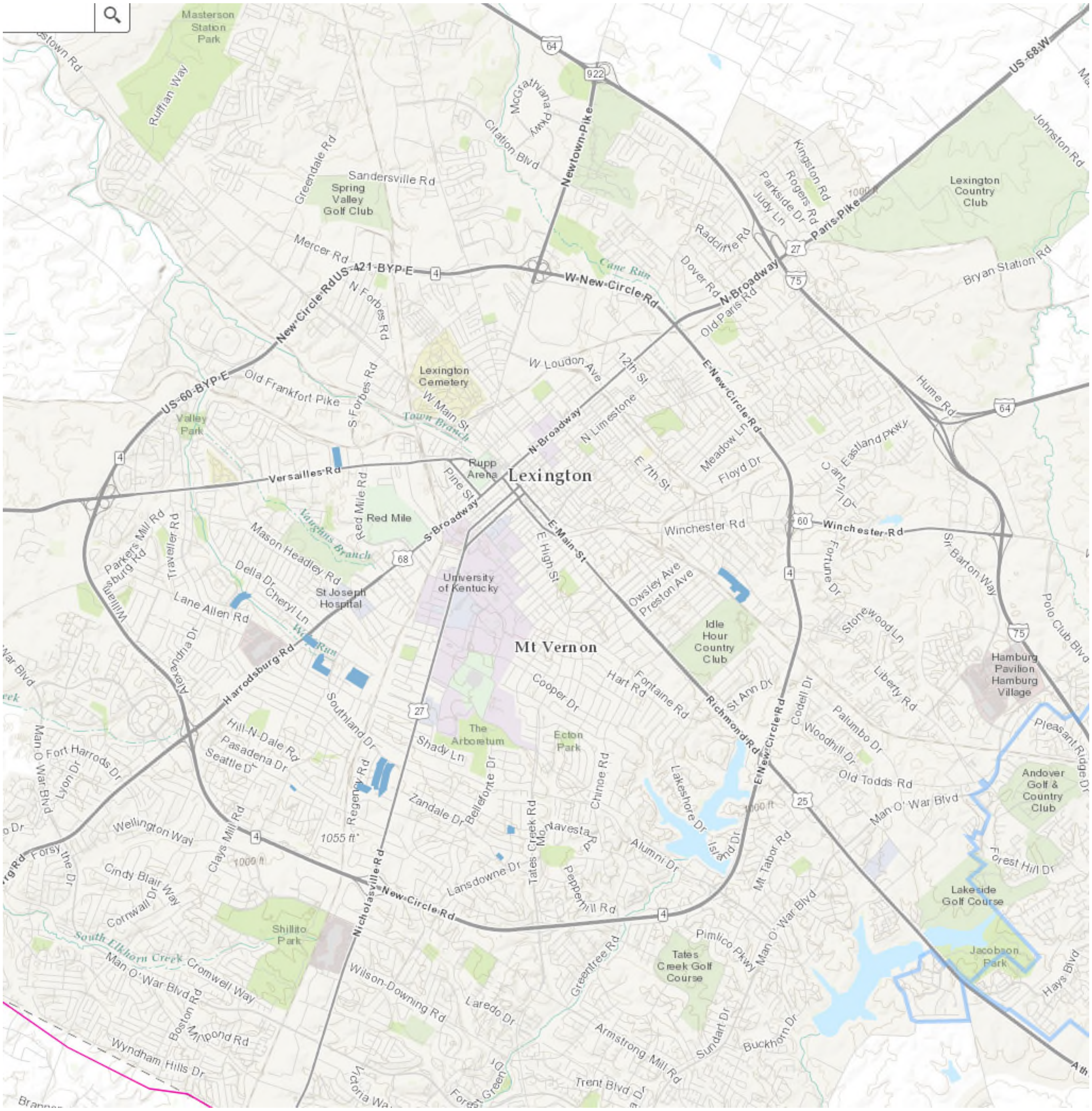
Projected Year One Projects
For Main Replacement Program



PROJECTED YEAR ONE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	600 BLOCK SAYRE AVE	212	$31,800
2	900 BLOCK WHITNEY AVE	1,030	$154,500
3	200 BLOCK PERRY ST	466	$69,900
4	1000 BLOCK KASTLE RD	512	$76,800
5	1200 BLOCK EMBRY AVE	536	$80,400
6	200 BLOCK SPRUCE ST	624	$93,600
7	200 BLOCK HAMILTON PARK	978	$146,700
8	300 BLOCK GUNN ST	184	$27,600
9	100 BLOCK SHAWNEE PL	568	$85,200
10	200 BLOCK WARNOCK ST	492	$73,800
11	600 BLOCK ORCHARD AVE	380	$57,000
12	100 BLOCK AVON AVE 100 BLOCK BURNETT AVE	1,340	$201,000
13	1400 BLOCK CAMDEN AVE	1,082	$162,300
14	100 BLOCK WABASH DR 1800 BLOCK PENSACOLA DR 200 BLOCK LACKAWANNA RD 180 WABASH DR 140 WABASH DR	3,160	$474,000
16	200 AND 300 BLOCK LINCOLN AVE	3,928	$589,200
17	200 TO 400 BLOCKS OF PRESTON AVE	2,452	$367,800
18	300 BLOCK RICHMOND AVE 200 BLOCK WHITE AVE	814	$122,100
19	300 BLOCK PENNSYLVANIA CT	1,422	$213,300
20	300 BLOCK STRATHMORE RD	1,436	$215,400
21	100 BLOCK GARRETT AVE	968	$145,200
22	200 BLOCK GARRETT AVE	1,508	$226,200
23	300 BLOCK N PICADOME PARK	1,648	$247,200
24	600 BLOCK COOPER DR	218	$32,700
25	1300 BLOCK WILLOWLAWN AVE	438	$65,700
26	400 BLOCK UHLAN CT	768	$115,200
27	100 DELMONT DR	1,052	$157,800
28	200 BLOCK E VISTA ST	1,260	$189,000
29	200 BLOCK W VISTA ST	1,204	$180,600
30	100 BLOCK E VISTA ST	1,502	$225,300
31	400 BLOCK MORRISON AVE	608	$91,200
32	200 BLOCK LINWOOD DR	948	$142,200
33	500 BLOCK MCCUBBING DR	2,290	$343,500
34	1100 BLOCK SPARKS RD	2,358	$353,700
35	600 BLOCK LAGONDA AVE	1,980	$297,000
36	7OO BLOCK APPLETREE LN	980	$147,000
37	1600 BLOCK CLAYTON AVE	1,644	$246,600
ANTICIPATED YEAR TOTAL		42,990	$6,448,500

KENTUCKY AMERICAN WATER

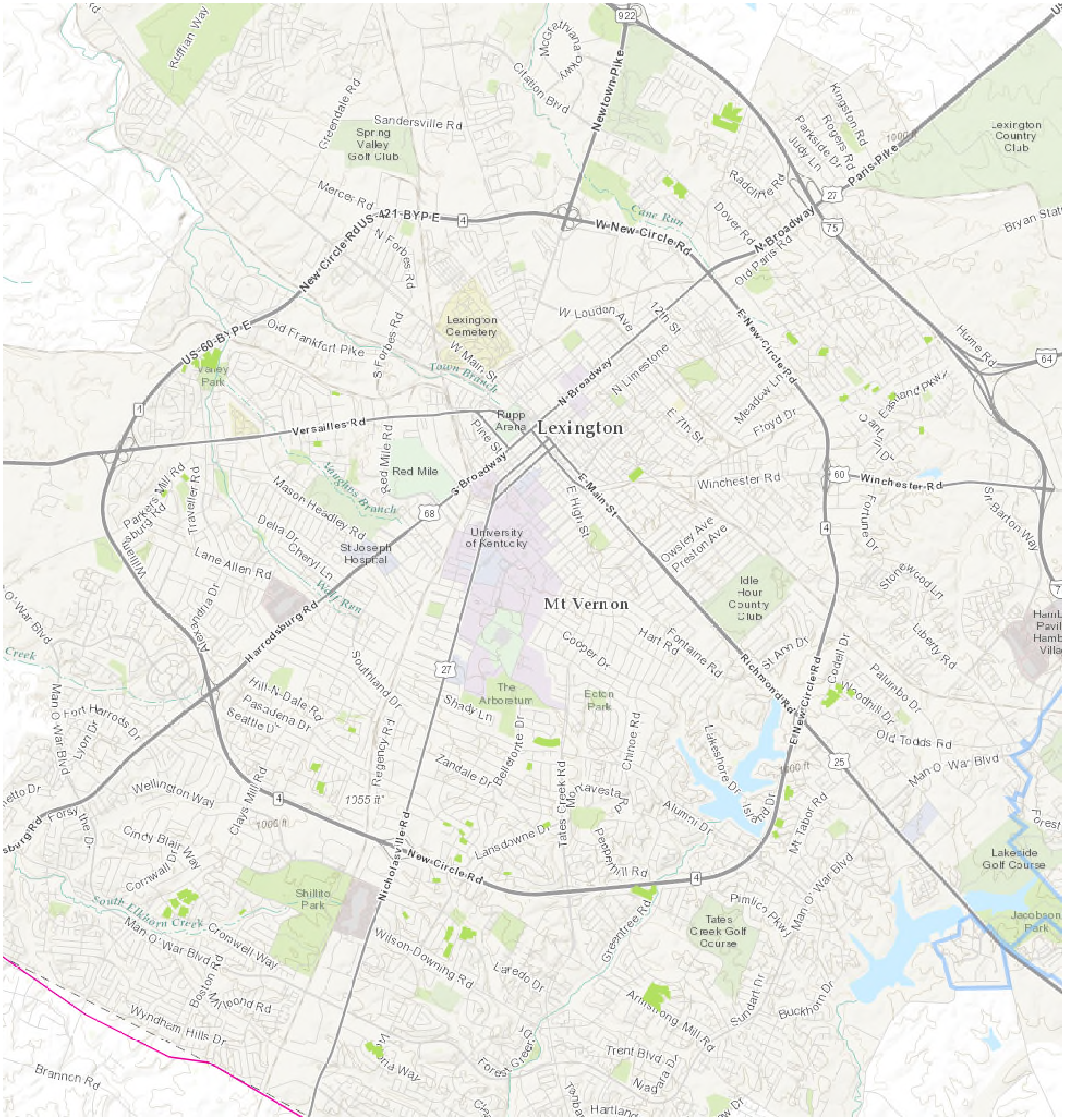
**Projected Year Two Projects
For Main Replacement Program**



PROJECTED YEAR TWO PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	1600 BLOCK COURTNEY AVE	1,490	$223,500
2	EMERY CT	2,058	$308,700
	1600 BLOCK COURTNEY AVE		
3	600 BLOCK BLUE ASH DR	940	$141,000
4	200 BLOCK KOSTER DR	1,860	$279,000
5	200 BLOCK NORWAY ST	1,702	$255,300
6	100 BLCOK HALLS LANE	1,626	$243,900
7	LONE OAK DR	3,468	$520,200
8	2000 BLOCK RAINBOW RD	1,508	$226,200
	200 BLOCK DERBY DR		
	2000 BLOCK REBEL RD		
9	4800 BLOCK BOONE LN	3,762	$564,300
10	1100 BLOCK N CLEVELAND RD	5,356	$803,400
11	5400 BLOCK BRIAR HILL RD	4,280	$642,000
12	4400 BLCOK HALEY RD	50	$7,500
13	4600 BLOCK TODDS RD	3,496	$524,400
14	3500 BLOCK ROLLING HILLS CT	610	$91,500
15	5000 BLOCK SULPHUR LN	1,462	$219,300
16	5200 BLOCK WINCHESTER RD	5,423	$813,450
17	5400 BLOCK WINCHESTER RD	230	$34,500
18	1900 BLOCK BEACON HILL RD	1,576	$236,400
19	3100 BLOCK BRECKENWOOD DR	356	$53,400
20	LAMONT CT	226	$33,900
21	700 BLOCK LANDSDOWNE CIR	314	$47,100
22	3500 BLOCK MADDOX LN	2,732	$409,800
ANTICIPATED YEAR TOTAL		44,525	$6,678,750

KENTUCKY AMERICAN WATER

**Projected Year Three Projects
For Main Replacement Program**

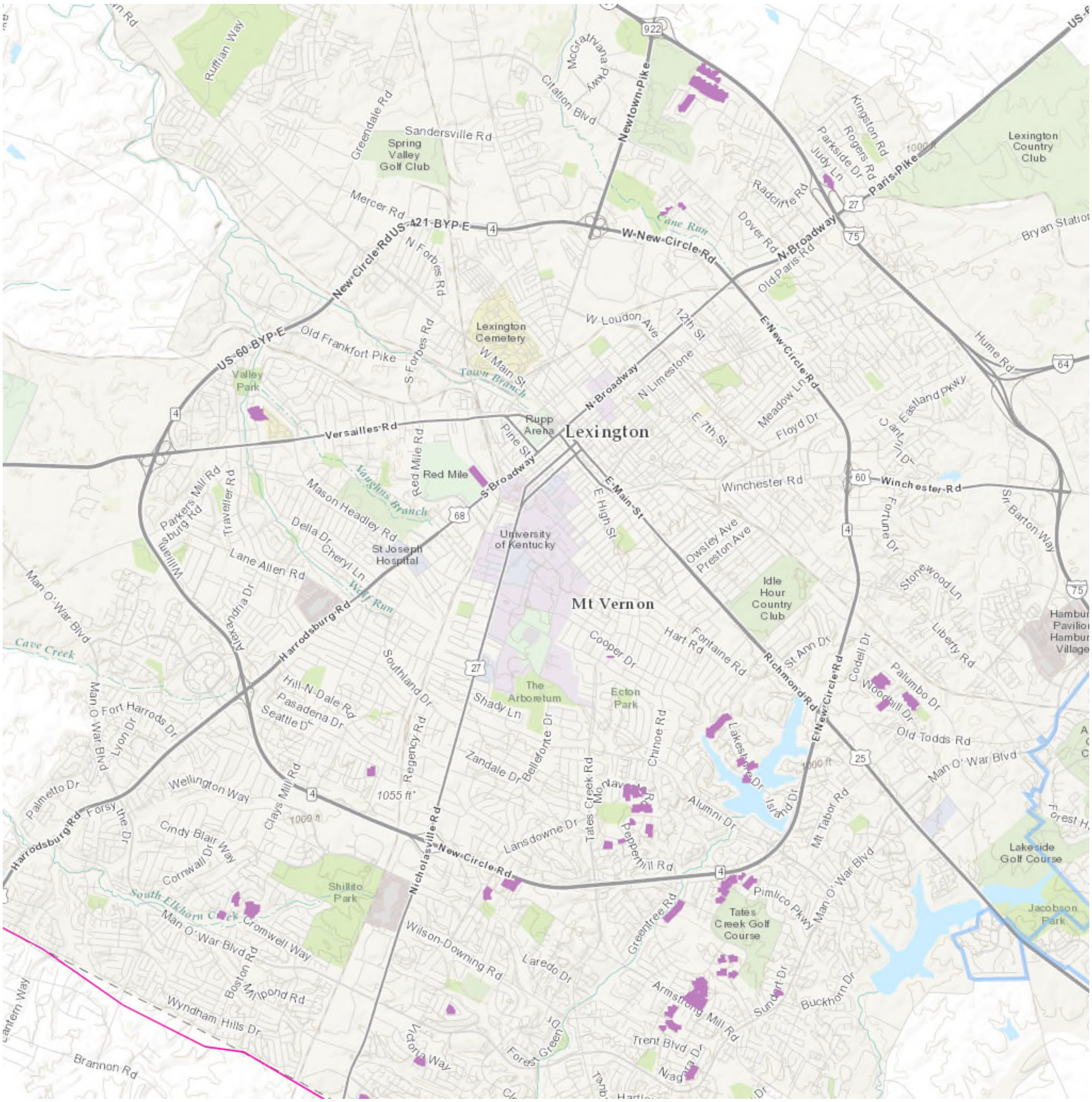


PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	100 BLOCK NEW ZION RD	2,302	$345,300
2	SAMUEL LN	1,156	$173,400
3	TILLYBROOK CT	624	$93,600
4	3200 BLOCK RAVEN CIRCLE	360	$54,000
5	MALABU CT	1,556	$233,400
	HUNTER CIRCLE		
	HEATHER CT		
	300 BLOCK BELVOIR DR		
6	200 BLOCK BRADFORD CIR	352	$52,800
7	SHIRLEE CT	372	$55,800
8	OLD DOBBIN RD	482	$72,300
9	DELMONT CT	168	$25,200
10	1300 BLOCK HIALEIAH CT	1,682	$252,300
	1300 BLOCK HOT SPRINGS CT		
	1300 BLOCK KEENELAND CT		
11	CROSS KEYS CT	490	$73,500
12	200 BLOCK LEWIS ST	260	$39,000
13	THISTLETON CIRCLE	522	$78,300
14	EDINBURGH CT	258	$38,700
15	CROYDEN CT	942	$141,300
	SHEFFIELD CT		
16	100 BLOCK GENTRY RD	176	$26,400
17	100 BLOCK N CLEVELAND RD	238	$35,700
18	7300 BLOCK OLD RICHMOND RD	646	$96,900
19	WILLIAMSBURG CT	368	$55,200
20	WOODSIDE CIRCLE	304	$45,600
21	600 BLOCK TATESWOOD DR	340	$51,000
22	RANGE CT	672	$100,800
23	GREENLAWN CT	1,438	$215,700
	JADE CIRCLE		
	KIMBERLITE CT		
	GRANITE CIRCLE		
24	DURHAM CT	504	$75,600
25	100 BLOCK COLLEGE ST	1,098	$164,700
26	GAYLE CIRCLE	388	$58,200
27	SAYBROOK CT	282	$42,300
28	WAYCROSSE CIRCLE	676	$101,400
	SHILOH CT		
29	KELSEY CT	1,694	$254,100
	KELSEY PL		
	YARMOUTH CT		
	1100 BLOCK KILRUSH DR		
30	CRICKLEWOOD CT	340	$51,000
31	1100 BLOCK APPIAN CROSSING WAY	978	$146,700
32	600 BLOCK CARDIGAN CT	1,416	$212,400
	3500 BLOCK BERWIN CT		
	3400 BL0CK IPSWICH CT		
33	3400 BLOCK FLINTRIDGE CIRCLE	426	$63,900
34	500 BLOCK FOLKSTONE DR	302	$45,300
35	1100 BLOCK GREENTREE CT	1,252	$187,800
	GREENTREE PL		
	GREENTREE CIRCLE		

PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
36	KING ARTHUR CT	1,272	$190,800
	3400 BLOCK KING ARTHUR DR		
37	PADDOCK CT	436	$65,400
38	TANNER CT	438	$65,700
39	PENWAY CT	438	$65,700
40	400 BLOCK PLAINVIEW RD	248	$37,200
41	100 BLOCK TORONTO DR	1,286	$192,900
	4000 BLOCK VICTORIA WAY		
	4000 BLOCK VICTORIA WAY		
	200 BLOCK TORONTO RD		
42	2600 BLOCKI WINBROOKE LN	408	$61,200
43	2800 BLOCK MIDDLESEX CT	778	$116,700
44	700 BLOCK HILL RISE CT	542	$81,300
45	1500 BLOCK HALSTED CT	2,420	$363,000
	KILDARE CT		
	KIRK CT		
46	800 BLOCK GENTRY LN	1,236	$185,400
47	200 BLOCK MULBERRY RD	1,148	$172,200
	OSAGE CT		
	2500 BLOCK BUTTERNUT HILL CT		
48	BLACKARROW CT	730	$109,500
49	BARBADOS LN	2,508	$376,200
	3100 BLOCK TABAGO CT		
	2700 BLOCK MARTINIQUE LN		
50	1800 BLOCK COLCHESTER DR	2,484	$372,600
	FELTNER CT		
	1800 BLOCK BOWEN CT		
	1800 BLOCK BARKSDALE DR		
	1800 BLOCK COLCHESTER DR		
51	HAVELOCK CIR	1,614	$242,100
	600 BLOCK SAGINAW CT		
	3400 BLOCK ALDERSHOT DR		
52	KILKENNY CT	932	$139,800
ANTICIPATED YEAR TOTAL		43,982	$6,597,300

KENTUCKY AMERICAN WATER

**Projected Year Four Projects
For Main Replacement Program**

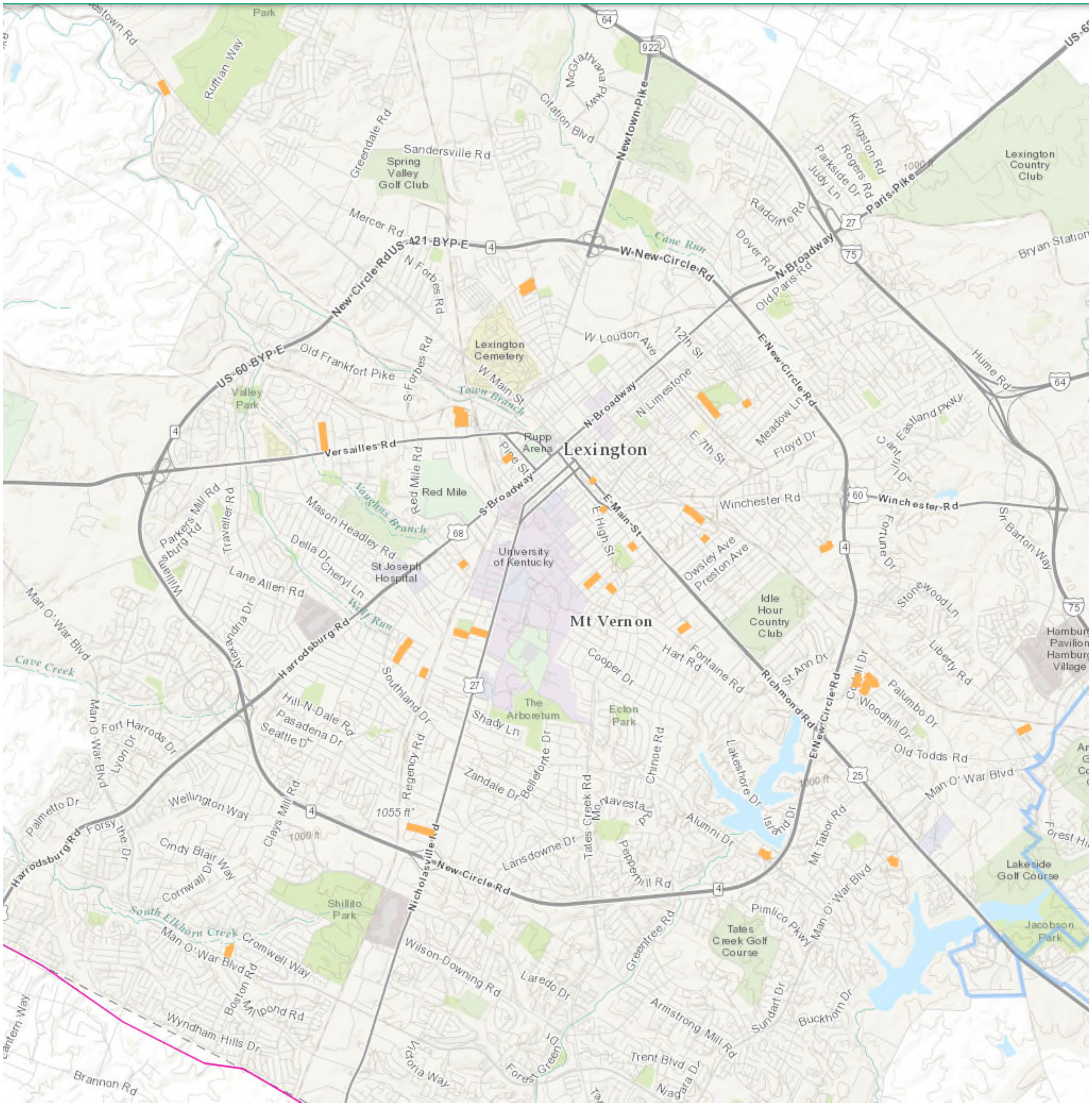


PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	3100 BLOCK OLD CROW CT 3100 BLOCK CLAIR RD MONTAVESTA CT	1,916	$287,400
2	2000 BLOCK CUMMINS CT 2000 BLOCK DANIEL CT	758	$113,700
3	400 BLOCK CURRY AVE	468	$70,200
4	4000 BLOCK LILYDALE CT 4000 BLOCK WHITEMARK CT	1,634	$245,100
5	3500 BLOCK ORMOND CIR	636	$95,400
6	1900 BLOCK RITTENHOUSE CT	328	$49,200
7	2400 BLOCK PLUMTREE CT 2400 BLOCK THORNBERRY CT	1,236	$185,400
8	1200 BLOCK MAYWOOD PARK 1200 BLOCK OAKLAWN PARK 1200 BLOCK TANFORAN DR 1200 BLOCK NARRAGANSETT PARK LATONIA PARK 3200 BLOCK WATERFORD PARK	2,744	$411,600
9	200 BLOCK KELLY CT	1,352	$202,800
10	600 BLOCK FOGO CT 600 BLOCK CREWE CT 3400 BLOCK FRASERDALE CT 3400 BLOCK BIRKENHEAD CIR	2,020	$303,000
11	LOOKOUT CIR 2900 BLOCK MONTAVESTA RD	866	$129,900
12	WEM CT	562	$84,300
13	4100 BLOCK WINNIPE CT	630	$94,500
14	400 BLOCK WOODLAKE WAY	250	$37,500
15	3200 BLOCK WOOD VALLEY CT	256	$38,400
16	3500 BLOCK SUTHERLAND DR	1,020	$153,000
17	3500 BLOCK NIAGRA DR	688	$103,200
18	3300 BLOCK MOUNDVIEW CT	434	$65,100
19	LISA CIR MONA CT	912	$136,800
20	MARGO CT KAREN CT	1,846	$276,900
21	VERSIE CT JANNELLE CT	1,270	$190,500
22	200 BLOCK HEDGEWOOD CT	512	$76,800
23	TAMMY CT LAVERNE CT GREVEY CT HARRIS CT	2,726	$408,900
24	GRANT CT HOLLOW CREEK CT GRANT PL	1,034	$155,100
25	GRAIG CT	626	$93,900
26	LYNNWOOD CT WOODSTON CT CLEARWOOD CT	1,746	$261,900
27	3600 BLOCK CAYMAN LN JAMAICA CT	1,574	$236,100

PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
28	WATERS EDGE PL 2000 BLOCK HARMONY CT 2100 BLOCK BRIDGEPORT DR	1,580	$237,000
29	1600 BLOCK COSTIGAN DR 1900 BLOCK LEITNER CT 1900 BLOCK BEDINGER CT 1900 BLOCK COBYVILLE CT 900 BLOCK VALLEY FARM DR 1900 BLOCK CHRIS DR	3,536	$530,400
30	3400 BLOCK BELLMEADE RD 3400 BLOCK WARWICK CT	884	$132,600
31	1300 BLOCK OX HILL DR BASS CT	758	$113,700
32	1200 BLOCK ASCOT PARK 1200 BLOCK BEULAH PARK 1300 BLOCK ATOKAD PARK 1300 BLOCK GOLDEN GATE PARK 1200 BLOCK AK-SAR-BEN PARK	1,594	$239,100
33	BRANDON CT	418	$62,700
34	SWOONALONG CT PERSONALITY CT 1300 BLOCK CANONERO DR GUNBOW CT PERSONALITY CT	2,350	$352,500
35	3500 BLOCK GINGERTREE CIR	484	$72,600
36	KENIL CT	138	$20,700
37	2000 BLOCK VON LIST WAY	2,156	$323,400
ANTICIPATED YEAR TOTAL		43,942	$6,591,300

KENTUCKY AMERICAN WATER

**Projected Year Five Projects
For Main Replacement Program**



PROJECTED YEAR FIVE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**
1	TREPASSEY CT	808	$121,200
2	100 BLOCK WESTGATE DR	2,022	$303,300
3	100 BLOCK MOORE DR	170	$25,500
4	3300 BLOCK PITTMAN CREEK CT	634	$95,100
5	4700 BLOCK HUFFMAN MILL PIKE	56	$8,400
6	300 BLOCK ROBERTSON ST 1100 BLOCK MARTIN AVE 300 BLOCK FERGUSON ST 300 BLOCK ANDERSON ST 300 BLOCK ROBERTSON ST	3,476	$521,400
7	3200 BLOCK BRACKTOWN RD	1,946	$291,900
8	400 BLOCK BRADLEY CT	1,602	$240,300
9	100 BLOCK CASTLEWOOD DR	1,152	$172,800
10	800 BLOCK CAMPBELL LN	1,184	$177,600
11	600 BLOCK CENTRAL AVE	362	$54,300
12	100 BLOCK CHELAN CT	700	$105,000
13	700 BLOCK E EUCLID AVE	378	$56,700
14	200 BLOCK E MAIN ST	478	$71,700
15	200 BLOCK SOUTHPORT DR	2,672	$400,800
16	TIMBERHILL CT ELDERBERRY CT	858	$128,700
17	HEATON CT 2400 BLOCK MIRAHILL DR 2400 BLOCK WINDWOOD CT	1,042	$156,300
18	1400 BLOCK ELIZABETH ST 100 BLOCK FOREST PARK RD	2,352	$352,800
19	200 BLOCK WESTWOOD CT	1,364	$204,600
20	100 BLOCK WESTWOOD DR	1,640	$246,000
21	1100 BLOCK FERN AVE	1,896	$284,400
22	1000 BLOCK FLOYD DR	232	$34,800
23	400 BLOCK GREENWOOD AVE	1,280	$192,000
24	800 BLOCK JOHNSDALE DR	552	$82,800
25	3200 BLOCK HALEY RD	1,616	$242,400
26	500 BLOCK LONGVIEW DR	94	$14,100
27	400 BLOCK MACADAM DR 600 BLOCK ROSEMILL DR	2,604	$390,600
28	3400 BLOCK MCFARLAND LN	3,650	$547,500
29	500 BLOCK MCKINLEY ST	308	$46,200
30	500 BLOCK MERINO ST	542	$81,300
31	300 BLOCK MEMORY LN	396	$59,400
32	600 BLOCK MONTGOMERY AVE	226	$33,900
33	700 BLOCK NATIONAL AVE 900 BLOCK NATIONAL AVE	1,242	$186,300
34	1100 BLOCK OAK HILL DR	470	$70,500
35	300 BLOCK OLD VINE ST	162	$24,300
36	2100 BLOCK PAIGE CT	358	$53,700
37	400 BLOCK PARK AVE	634	$95,100
38	500 BLOCK PINE ST	382	$57,300
39	200 BLOCK RIDGEWAY RD	556	$83,400
40	1400 BLOCK RUSSELL CAVE RD	210	$31,500
ANTICIPATED YEAR TOTAL		42,306	$6,345,900

Replacement Program Report 2018

2018

Kentucky-American Water Company

Contents

Introduction

Kentucky-American Water Company's infrastructure provides a critical service in providing clean and safe water that is essential to our customers and the survival of the communities that we serve. Similar to other water utilities, the infrastructure of treatment plants, pipes, storage tanks and pumps are starting to age past their useful life. Kentucky-American Water has embarked on a plan to prioritize and undertake drinking water infrastructure renewal investments to ensure that our water utilities can continue to reliably and cost-effectively support the public health, safety, and economic vitality of our communities. If we do not effectively plan the investment in our infrastructure, we will incur the haphazard and growing costs of living with aging and failing drinking water infrastructure and place in jeopardy all of the work that past generations have undertaken in building our system and communities.

The water distribution system of Kentucky-American Water is beginning to reach the end of its expected life. Even though the company has made investments in the replacement of the aging infrastructure, existing infrastructure continues to reach the end of its useful life at a quicker pace than the work to replace the outdated mains and supporting facilities occurs.

One of the major challenges that water utilities face is that their distribution systems were installed to support community growth that varied over time. The mains installed during the high growth periods reach their life expectancy at the same time, resulting in sections of communities that need all of the mains replaced in a short time period.

In addition, during the periods of system expansions, different pipe materials were used as they were introduced as an alternative to the existing main materials. With each pipe material, the life expectancy of the main is different. Unfortunately, that results in periods when pipes of different materials that were installed at different times in the past reach the end of their useful lives at the same time, increasing the number of mains that need to be replaced throughout the system in a compressed timeframe.

Although Kentucky-American has made investments in the replacement of mains over the past decades, the amount of main replaced cannot keep up with the expected amount of main requiring replacement that will occur in the coming decades.

Along with aging infrastructure, Kentucky-American Water is facing the impact of climate variability and its effects on the resiliency of the system. Updating infrastructure to keep up with the increase in extreme weather and ensure that adequate service can be maintained for extended time periods after an extreme event is just as important as addressing the aging infrastructure.

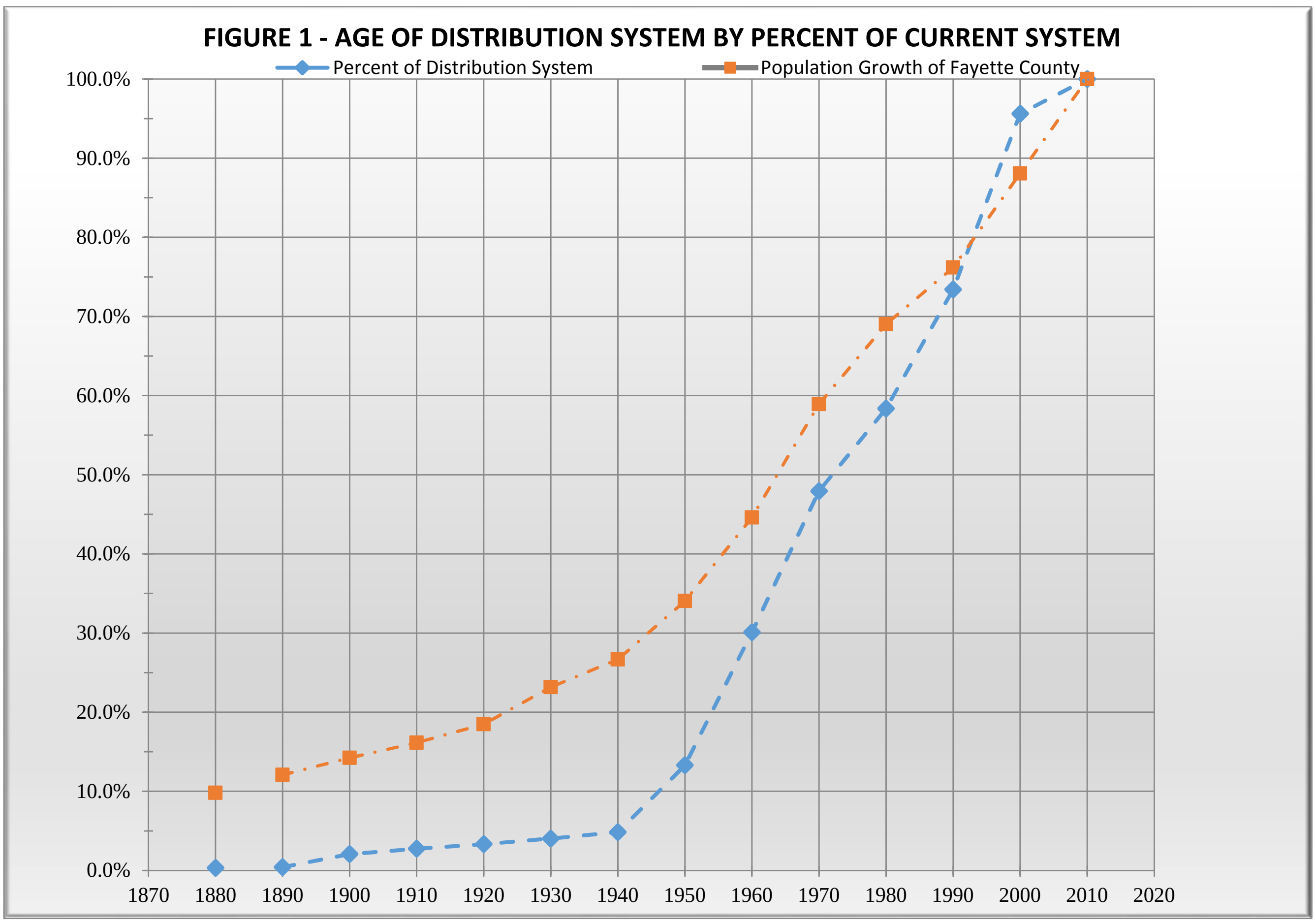
System Background

Kentucky-American Water first began operation as the Lexington Hydraulic and Manufacturing Company providing water to Lexington in 1885. The company was started by three local businessmen who saw a need for a water system to help fight fires and prevent disease. During the early 1970s the name changed from the Lexington Water Company to the current Kentucky-American Water Company.

Since 1885 the system has grown from serving approximately 200 customers to about 130,000 customers within 14 counties, including Fayette County. With that growth the distribution system has expanded to include approximately 2,038 miles of water mains various sizes and material types.

History of the Growth of the Distribution System

Kentucky-American's water distribution system growth mirrors the growth of the City of Lexington and Fayette County. Figure 1 shows the percent of the water distribution system that was installed within each of the decades from 1880 to present.



From the start of the system in 1885 through the 1940s, the area had predominately an agricultural economy and growth was steady. Main installed during that period was cast iron. Today, approximately 63 miles of the cast iron main that was installed during this period remains, representing approximately 3% of the current distribution system. This amount used to be greater; however, during the 1980s, 1990s and 2010s the Company undertook a concerted effort to replace this era of cast iron main.

Following World War II, Lexington experienced an increased growth rate due to the move away from agriculture and the baby boom. During the 1950s and 1960s, the distribution system also grew substantially to keep up with this expansion. Main installed during that period was cast iron, both cement lined and unlined. During this period, asbestos cement pipe was introduced for the first time into the distribution system. The main installed during this period represents 25% of the current distribution system (514 miles of main).

The Lexington system underwent its greatest growth from the 1970s through the housing boom of the first part of 2000. During this period, Lexington grew due to industry and service companies locating and growing in Fayette County. At the same time, Kentucky-American acquired several outlying systems by growing into the counties surrounding Fayette County. Also during this period, the main extension from Kentucky River Station Two to the Lexington distribution system was placed into service. During this period of time approximately 1,290 miles of main was installed, which represents 63% of the current distribution system. Asbestos Cement pipe was the predominate material installed during the first part of this period, with Ductile Iron pipe and PVC becoming the predominant materials during the 1980's.

From 2010 to present, the distribution system has seen a much slower growth rate, with additions representing little more than 3% (80 miles) of the current distribution system. Currently, the predominant materials installed are Ductile Iron with some PVC pipe.

Pipe Materials in Distribution System

The Kentucky-American distribution system contains mostly five major material types. Those types are Ductile Iron, PVC, Asbestos Cement, Cast Iron Lined and Cast Iron Unlined. The period that the system was growing determines the areas and the amount of each material type in the system. Table 2 provides a listing of the major material types in the distribution system along with the amount of each material in miles and percentage of that material within the system:

Table 2 – Distribution System Material Types		
	Miles of Material	Percentage of System
Ductile Iron	897.8	44.1
PVC	441.1	21.6
Asbestos Cement	338.2	16.6
Cast Iron Unlined	176.8	8.7
Cast Iron Lined	133.5	6.6
Prestressed Concrete	34.8	1.7
Galvanized	3.2	0.2
Other (Brass, Lead, Steel)	2.4	0.1
Unknown	10.0	0.5

Distribution of Pipe Material by Decade

When the material type is compared to the timeline of growth of the distribution system, certain periods were dominated by particular pipe materials. During the first part of the system development, from 1885 to 1950, Cast Iron Unlined and Lined were the predominant materials. During 1950 to 1980, Asbestos Cement pipe was used along with Cast Iron pipe, and Ductile Iron pipe was introduced into the system. After 1980, Ductile Iron pipe was the predominant material type used to meet system growth. PVC pipe use in new water main was not prevalent in the distribution system except for small diameter pipe. During the 1980s, 1990s and 2000s with the acquisition of systems, PVC was introduced into the Kentucky-American distribution system that included PVC that was installed during the 1960's and 1970's. Table 3 provides a breakdown by decade of the material types used in the expansion of the distribution system.

Table 3 – Miles of Existing Material Types Installed by Decade							
Decade	Material Types						
	Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized[2]	Other[1]
1881 - 1890	6.8						
1891 - 1900	1.9						
1901 - 1910	16.0	0.2					
1911 - 1920	11.9	0.7					
1921 - 1930	8.9	2.1					
1931 - 1940	7.7	6.4	0.1				
1941 - 1950	2.8	5.2	14.1				
1951 - 1960	21.4	51.6	76.6	4.7	0.5	1.7	9.2
1961 - 1970	50.9	64.1	102.2	64.7	51.9	1.4	13.9
1971 - 1980	48.2	3.3	130.6	140.1	40.3	0.1	24.1
1981 - 1990			14.6	37.6	171.7		
1991 - 2000				28.7	292.3	0.1	
2001 - 2010				149.4	274.7		
2011 -				15.9	66.5		

1 – Other represents Lead Pipe, Reinforced Concrete Pipe and PEP Pipe
2- In most cases the Galvanized Pipe indicated on this table occurred during acquisitions during these periods

Expected Life of Pipe Material

Based on information developed by the American Water Works Association for the "Buried No Longer" report released in February 2012, Table 4 provides an estimated expected service life for pipes of varying material. The expected life was determined based on operating experiences of water utilities and insight from research and professional experiences with typical pipe conditions, according to pipe material, at different ages and sizes.

Table 4 – Average Expected Life of Pipe Material						
Material Types						
Cast Iron Unlined	Cast Iron Lined	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
110 yrs	100 yrs	90 yrs	55 yrs	80 yrs	70 yrs	105 yrs

This table is a simplification, since, in Kentucky-American's experience, pipe life depends on many variables, such as soil conditions, installation practices and climate conditions, in addition to the age of the pipe itself. The company has had many pipes last longer than the typical service life indicated, but it also has had other pipes fail sooner than expected. For the purpose of this report, in view of the lack of specific data that allows the company to develop an understanding of each condition that affects each pipe segment in the system, the average life expectancy provides a reasonable approximation of the replacement rate.

Using the average expected life for Kentucky-American's distribution system indicates that the pipe that has been installed over the past 130 years will need to be replaced over the next 85 years to ensure that the system is maintained within the expected life of the system's pipe material.

Importance of Replacing Mains

Access to clean, reliable water is critical for the communities served and has become an intrinsic responsibility of those who manage the water infrastructure throughout the world. Safe drinking water is important to the health and economic welfare of a community. The ability to obtain clean water, free of contaminants, reduces sickness and related health costs. In addition, the ability to access a sufficient supply creates economic opportunities throughout the community.

As portions of the water distribution system begins to reach the end of its useful life, failures in the infrastructure begins to occur that impact the ability to provide safe and reliable service to the community. Neglecting this aging infrastructure will increase the frequency of water main breaks and leaks, corroding surrounding utility pipes, disrupting automobile, pedestrian and public transportation and stymieing local economic activity.

Although most of these breaks are minor, serious ruptures can and do occur. With these serious breaks the impact can be catastrophic due to flooding of streets and sidewalks, and in some instances flooding of local businesses and residences. In rare instances, the leaking water can undermine pavement or building foundations, which can result in significant property damage and the risk of serious injuries.

We have seen numerous examples of serious failures over the past few years that have affected major metropolitan areas. On June 18, 2015 Louisville Water Company experienced a break on a 60-inch water main that impacted 33,000 customers and caused the road to buckle, breaking apart huge pieces of pavement that floated and damaged vehicles in the area. The break also caused damage in adjacent parking lots and disrupted the local residents' activities.

This break followed a 48-inch water main break during April 24, 2014 near the intersection of Eastern Parkway and Baxter Avenue, which caused the intersection to be closed for at least 6 days. The break sent water cascading down Baxter Avenue, flooding Tyler Parks and nearby yards. In addition, the break flooded athletic fields on the University of Louisville campus and caused concern for athletic camp participants that were on the fields at the time of the break.

Nationally, one of the most significant breaks of 2015 was a water main break near the University of California in Los Angeles on July 29 that caused massive street flooding and damage on the campus. The break caused the loss of more than 20 million gallons during the three and one half hours required to turn off the main. The water flooded into the university campus and entered numerous buildings and structures, causing significant damage. Firefighters saved up to five people who were stuck in underground parking structures. The water trapped more than 730 cars, with half of the vehicles being entirely submerged.

Kentucky-American Water has not experienced dramatic main breaks like these over the past few years, but it has had several main breaks that have not only caused impact to the adjacent area that is surrounding the break but have also caused traffic disruptions and inconveniences due to repair activities. Some of these breaks have resulted in business disruptions and economic impact to the community.

The American Society of Civil Engineers study, “Failure to Act Closing the Infrastructure Investment Gap,” released in 2016, considered the economic impact of under-investing in our water and wastewater infrastructure. It estimated that remaining on the current track will cost American businesses and households $105 billion in increased costs to assist in filling the funding gap between 2016 and 2025, and the cumulative loss to our gross domestic product (GDP) will be $896 billion, all directly due to deteriorating water infrastructure. Without additional investment in the infrastructure, almost 489,000 jobs will be threatened due to unreliable water delivery and wastewater treatment services over the same period.

The impact of a water main break is mostly a localized impact, with the exception of large main breaks that impact a large portion of the community or cause the loss of the service to the entire community. In contrast, the loss of water through leaking pipe as the infrastructure ages affects the entire community, most of the time with no one knowing it is occurring. This loss of water typically manifests itself in an increase in “non-revenue water.” A high level of non-revenue water affects the financial viability of water utilities through lost revenues and increased operational costs. Although Kentucky-American Water’s non-revenue water is at or below the industry standard, there is concern that over time its ability to manage non-revenue water will deteriorate without a systematic approach to replacing aging infrastructure.

In addition to reducing pipe failure and loss of water, investing in the replacement of the infrastructure enhances the system’s ability to meet the service expectations of the customers. The ability to replace this aging infrastructure allows the company to provide improved service to the customer and usually improves fire protection. In addition, the areas of the system that are replaced are made more robust and are more resilient during periods of high demands, reducing the number of service disruptions.

The investment in infrastructure replacement allows for a more robust system, which enhances the ability of the community to compete for new business and industries. This is an important economic benefit to the community. According to the U.S. Conference of Mayors, every dollar invested in water infrastructure adds $6.35 to the national economy.

Previous Review of Network

During 2009, Kentucky-American Water commissioned Gannett Fleming to conduct an Analysis of Non-Revenue Water for the system as ordered by the Commission as part of Case No. 2007-00134. A part of that analysis was a determination if there was a correlation or trend in the occurrence of main breaks and leaks in the Central Division. The analysis was conducted on 1,927 main breaks reported from January 2000 to October 2008.

Review of the main break data indicated that a majority of breaks (82%) in the system during this period were reportedly caused by Ground Shift/Other. Age and Deterioration was reported to be the cause of approximately 10% of the breaks. Pressure Surge, Tree Roots, and Clamp Failure were reported to be collectively the cause of the remaining 8% of the breaks during the period of January 2000 to October 2008.

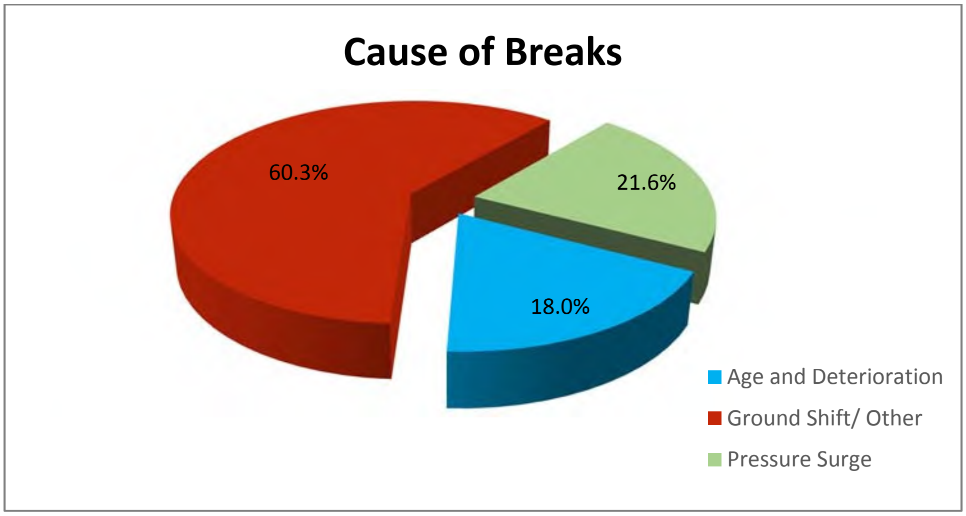
The main breaks that were reportedly caused by Age and Deterioration or Ground Shift/Other occurred on unlined cast iron main 53% of the time and, in particular, a significantly high percentage of reported breaks associated with Age and Deterioration -- 37% -- occurred on unlined cast iron mains. The analysis indicated that the highest percentage of breaks caused by Ground Shift/Other occurred on unlined cast iron main and asbestos cement main (34% and 26%, respectively).

The analysis by Gannett Fleming found that replacing specific main sizes or types of material that exhibit a high concentration of breaks would not have a substantial impact on reducing non-revenue water. Gannett Fleming concluded that other factors should be considered with regard to replacement of problematic main rather than trying to control non-revenue water. However, the study provided useful information regarding the types of main most susceptible to breaks.

During the review of the main break history, Gannett Fleming found that the highest concentration of reported main breaks occurred on unlined cast iron. The concentration of reported main breaks on galvanized steel main was also significantly higher than the system average of 0.9 breaks per mile of main. Gannett Fleming suggested that a main replacement program targeting unlined cast iron main and galvanized steel main, specifically those less than 4 inches in diameter, should be considered to reduce the occurrence of main breaks.

Current Review of Network

Review of the main break history from January 2012 to December 2017 indicated that there have been 953 breaks during this period, averaging about 159 per year. Similar to the finding of the 2009 Gannett Fleming report, the current break history indicates that 60% of the main breaks are caused by ground shift. This percentage decreased from 82%, while the age and deterioration breaks increased to 18% compared to 10% during the past review. Although the increase, it is an indication that the distribution system is aging, and we would expect to see an increase in these types of breaks as the age of the mains increase.

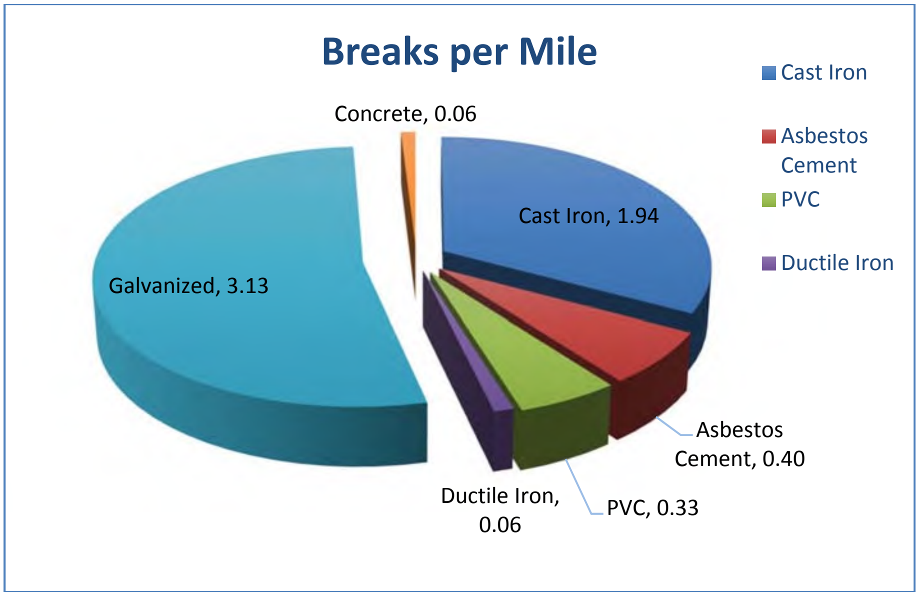


The average number of breaks per year has decreased from 222 per year for the period of January 2000 to October 2008 to 159 per year for January 2012 to December 2017. This reduction is indicative of the main replacement work conducted following 2008 that specifically targeted mains with numerous break incidents.

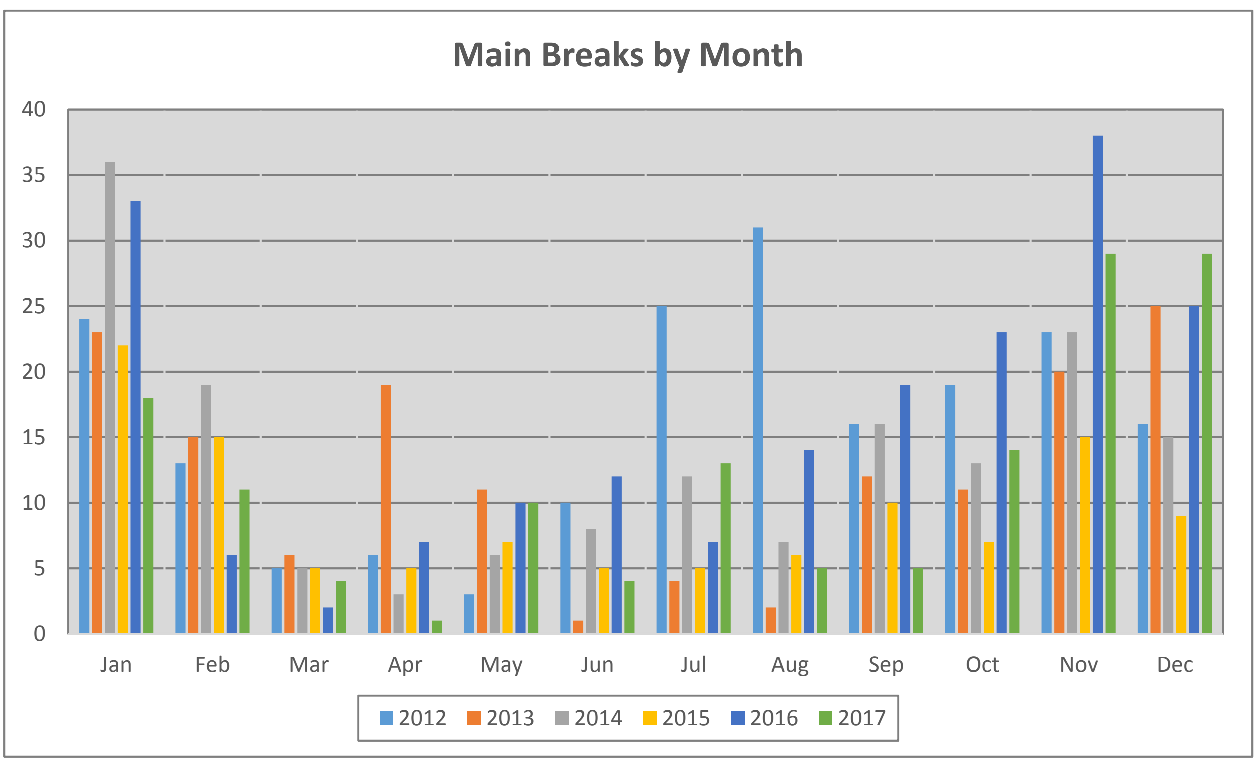
Review of the reported breaks from January 2012 to December 2017 indicated that main breaks on cast iron main represented 63.2% of all of the breaks. Since cast iron main lined and unlined material only represents 15.3% of the total inventory of mains in the ground, the break rate on this type of material is significantly higher than the other material in the system.

Table 5 – Breaks by Material					
Material Types					
Cast Iron	Asbestos Cement	PVC	Ductile Iron	Galvanized	Concrete
63.2%	14.3%	15.2%	6.1%	1.0%	0.5%

The break rate per mile of main shows that cast iron main had a break rate of 1.9 breaks per mile of main compared to ductile iron which saw a break rate of 0.06 breaks per mile of main from January 2012 to December 2017. The worst performing material was galvanized steel which had a break rate of 3.13 breaks per mile of main.



Another area reviewed in the main break data from January 2012 to December 2017 indicated that 52.7% of the breaks occur between November to February of each year with the lowest break period being during May and June. Analysis of the break reports would support that ground shift breaks cause the most failure of the pipe material and we would expect to see the ground shifts occur during the November to February time frame. It should be noted that the high break occurrence that is observed in July and August of 2012 is believed to be caused by ground shift breaks that occurred following high rain events during each of those months.



With ground shift breaks being 64% of the overall breaks that occurred during January 2012 to August 2015, this would correlate with pipe materials that are susceptible to ground movement or shifting being at greater risk than other materials. Cast iron and galvanized steel are not as resilient to the tension and bending forces that result from ground shifting, and this contributes to the higher break per mile numbers that the system has experienced.

Cast iron and galvanized steel are good at controlling internal forces and crushing forces that were generally used during the design stage when this material was placed into service. The industry gained the knowledge that cast iron and galvanized steel were susceptible to bending forces and encouraged the introduction of other materials. Materials such as ductile iron and PVC handle these types of forces and as such are more resilient to this type of ground movement. This resulted in the water utility industry moving away from cast iron and galvanized steel and standardizing on ductile iron and PVC.

Current Replacement Effort

Following the Gannett Fleming report in 2009, the replacement effort was predominantly driven by mains that exhibit high break frequency, relocations and requests by operations to replace mains to address multiple repair trips to the same main. During the period of 2009 to 2013 the average spend on main replacement projects was $2.6 million per year. The main replacement projects replaced all types of material that were experiencing high break frequencies, but the majority of the type of main replaced during this period was cast iron main. With this effort the amount of cast iron main replaced in the system was 10.7 miles with an average of 2.1 miles a year.

In 2014 there was a renewed effort to review the distribution infrastructure and start to address the aging infrastructure needs of the system. During 2014 and through 2017 the average spend on main replacement projects was $4.3 million per year. Based on this current effort the amount of cast iron main replaced in the system from January 2014 through December 2017 was 21.7 miles with an average of 5.4 miles per year.

Since 2009 the main replacement work has replaced 32.4 miles of cast iron main from the system and replaced it primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.7 miles per year during the 9 year period including the accelerated rate of 5.4 miles per year over the past 4 years from 2014 and 2017. While this is making significant progress, it is still not enough to address the rapidly aging distribution system. At the current rate it would take approximately 57.4 years to replace the remaining 310 miles of the cast iron main in the distribution system. At the end of the 57 year period the possible age of a cast iron main could be nearly 200 years old or over twice the life expectancy for this type of material.

Main Replacement Criteria Development

With the renewed effort to review the distribution system in 2014, Kentucky-American Water analyzed the methodology for planning main replacement to ensure that the distribution system could meet the needs of its customers and strategize ways to reduce the failure rate of mains. The previous method of determining main replacement was based on break history and requests from the operations group on which mains to replace, and this was determined to be too limited in identifying the most critical mains to replace.

With the understanding that continued enhancement of the Kentucky-American Water system would require a systematic replacement plan to ensure that the right mains were being replaced at the right time, the company established a goal in 2013 to research and develop tools to assist in developing the plan.

The first step was to develop the criteria that would be used to assess the existing mains and develop a list of mains that were in critical need of being replaced. It was determined that a main replacement assessment standard would require adoption of several criteria to determine which mains would need to be replaced. Development of the assessment standard considered the inclusion of eight criteria that played a major role in providing reliable service and were a good indicator of the condition of the main. These criteria are included in Table 6.

During development of the criteria it was determined that several of the criteria had interrelationships with each other and contributed to the performance of a section of water main. One of the interrelationships was main size and fire flow. In addition, it was determined that leaks can also be related to the age and material of the mains, and material types can be related to the water quality aspect of the main.

Due to the interrelationships of the eight criteria, the team established relative weights for each criterion to ensure that the targeted drivers for the main are given greater consideration. Age, material type, low pressure, number of breaks and water quality were the primary criteria that would be used to determine main replacement. These criteria allowed the main replacement program to ensure that mains that were not meeting the needs of the community and customers were addressed quickly.

Along with the criteria weighting, the assessment contains a rating standard for each of the eight criteria. A numeric rating of between 1 and 5 was used for each criterion – with 1 being the better rating and 5 being the worst rating.

TABLE 6 - MAIN REPLACEMENT CRITERIA						
Criteria (Max. Points)	***Weight***	***Rating***				
		1	***2***	***3***	***4***	***5***
Low Pressure (75)	15x	50 psi or greater	50 psi to 45 psi	45 psi to 40 psi	40 psi to 35 psi	< 35 psi
Number of Breaks/Leaks (75)	15x	0 breaks/5-year avg.	1-2 breaks/5-year avg.	3-4 breaks/5-year avg.	5-6 breaks/5-year avg.	< 6 breaks/5-year avg.
Fire Flow (50)	10x	Greater than 1,500 gpm (Blue)	1,500 to 1,000 gpm (Green)	999 gpm to 500 gpm (Yellow)	Less than 500 gpm (Red)	Known problems
Age (75)	15x	1995 or later	1980 to 1994	1970 to 1979	1960 to 1969	1959 and prior
Material Type (75)	15x	DI/RCP	PVC/HDPE	Transite/AC	CI/CLCI	Gal. / Steel
Size of Main (50)	10x	8 inch and above	6 inch	4 inch	2 inch to 3 inch	Main smaller than 2 inch
Water Quality (75)	15x	Flushing but not routine	Monthly Flushing	Bi weekly Flushing	Weekly (or more frequent) Flushing	Continuous Flushing (w/ discussion)
Customer Impact (25)	5x	less than 2 customers	2 to 10 customers	11 to 20 customers	greater than 20 customers	School/Hospital (Critical Customer)

An electronic database was developed to assist in the assessment and prioritization of the replacement mains and subsequent development of replacement schedules. The database is designed to perform the necessary queries and calculations to determine the main section overall rating and ranking. Initially 62 mains were entered into the database as a pilot to ensure that the assessment tool was capturing the critical needs of the system and identified the more critical sections to replace.

During most of 2013 through 2016 this initial list has provided a schedule for which mains are in need of replacement and provided a schedule that has been used to guide the main replacement program.

As with any tool, there are still external drivers that influence the main replacement program. These external items such as roadway paving schedules, weather or construction considerations are combined with the results of the assessment tool to make adjustments in the replacement program. This combination of tools and subjective considerations allows for a more reactive replacement program that is in concert with the community and allows for efficient use of available resources.

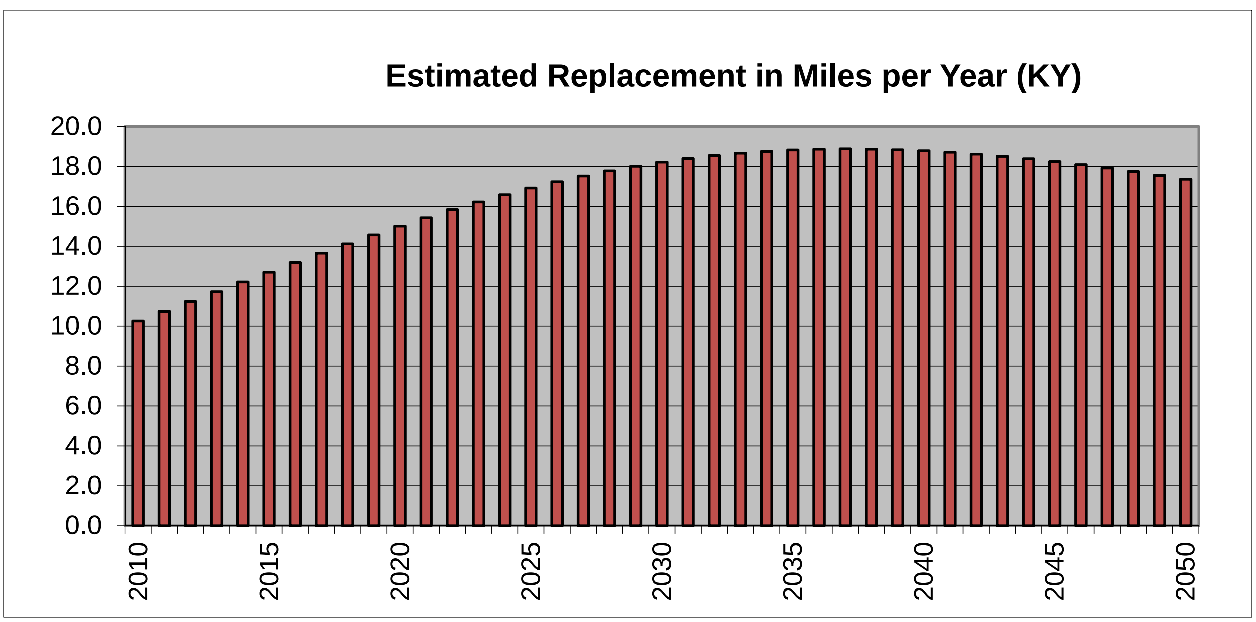
Nessie Model

While the assessment tool provides a numerical approach of determining the critical mains to replace, the company needed to determine the overall scope and financial impact over a longer planning horizon. The company looked for tools that could provide assistance in determining the capital needs for water main replacement in the coming years that considered the life expectancy of the infrastructure.

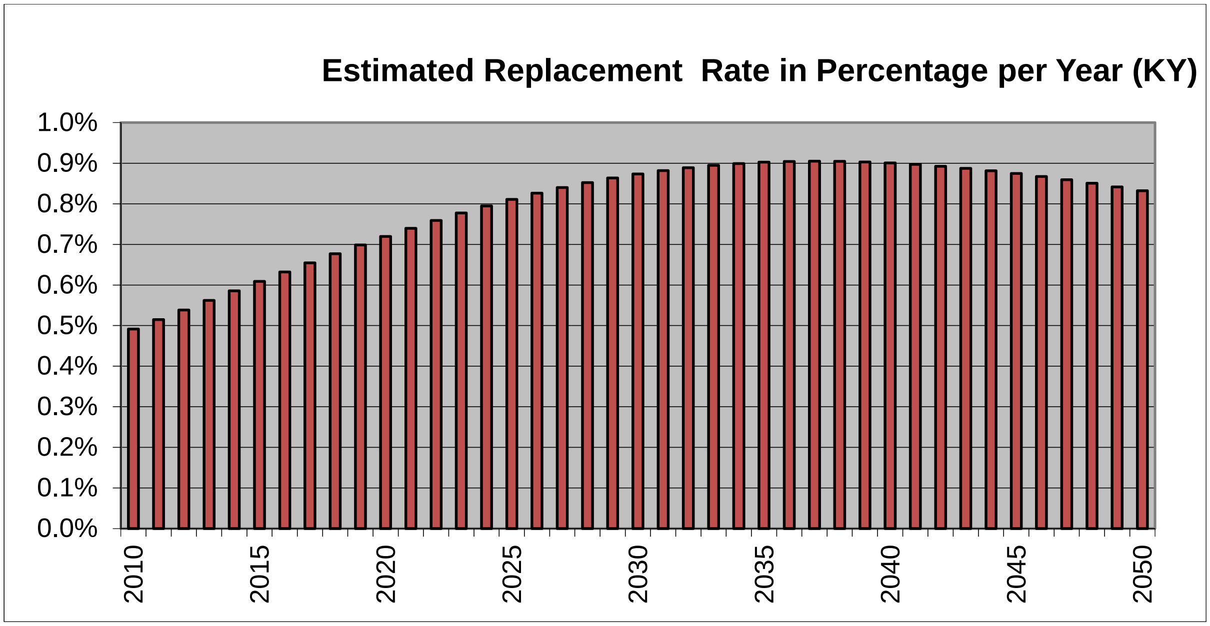
The American Water Works Association report “Dawn of the Replacement Era” developed a process that created a “Nessie Curve” for the 20 systems it reviewed in the report. The Nessie Curve, so called because the graph follows an outline this is likened to a silhouette of the Loch Ness Monster, provided a visual representation of the capital needs during a defined time frame to rebuild the underground infrastructure of the 20 systems. With the report “Buried No Longer,” AWWA further developed the analysis of the underground infrastructure and developed the “Nessie Model.”

The model uses pipe failure probability distributions based on past research with typical pipe conditions at different ages and sizes coupled with the indicative costs to replace each size and type of pipe, as well as the cost to repair the projected number of pipe breaks over time. The model projects the “typical” useful service life of the infrastructure based on pipe inventories of the system and estimates how much pipe of each type should be replaced in each of the coming 40 years.

Kentucky-American Water utilized the model to provide an insight into the replacement rate suggested during the 40 year planning horizon. The chart below provides the estimated replacement in miles of main per year that peaks to 19 miles per year by 2034.

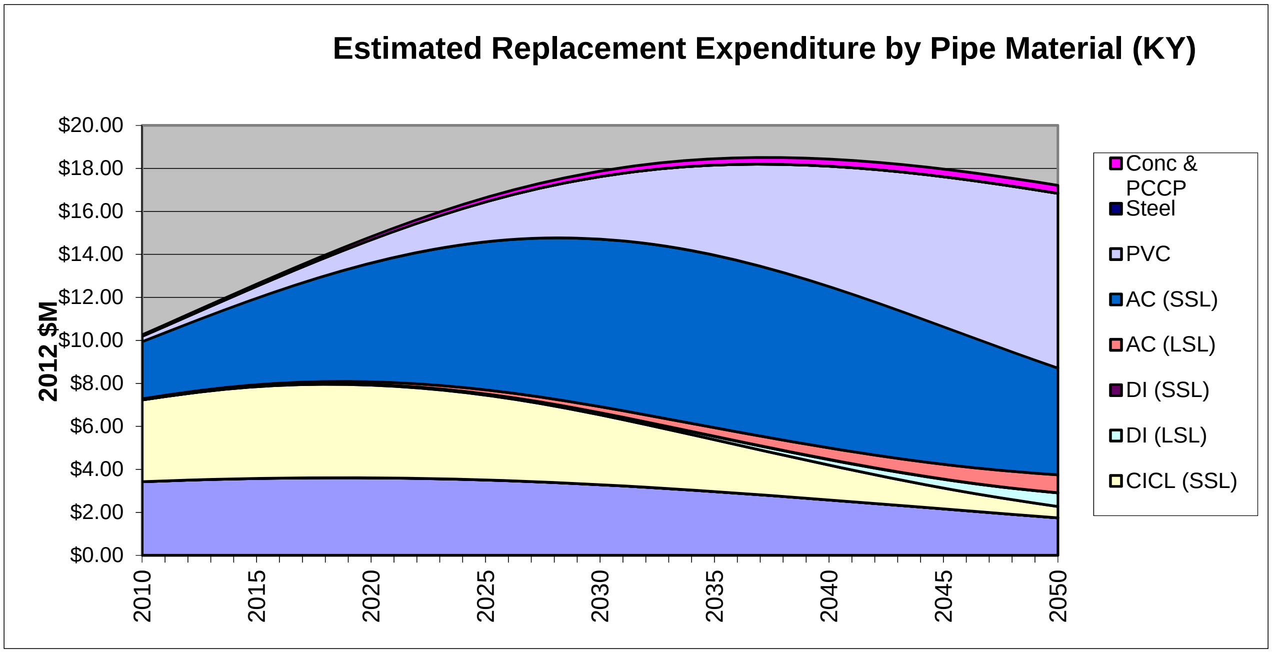


The analysis of the distribution system with the estimated replacement rate of 10 to 19 miles of main per year translates into a replacement rate of 0.49 to 0.90 as percent of the system per year. This estimated replacement rate in percentage of the distribution system per year from 2010 to 2050 is indicate on the chart below.



The model then combines the amount of infrastructure that should be replaced with the typical cost to replace the mains to create an estimate of the total investment cost for the 40 year planning horizon. The model represents this data through a series of Nessie Curves to depict the suggested amount of spending required to replace the main at the optimal life cycle for each material type.

The Nessie Model provides an insight on the amount of capital that is suggested to ensure that the distribution system is being replaced to account for the useful life of the distribution mains. The chart below provides the Nessie Curve developed by the model over a 40 year time frame of the estimated capital needed to replace the appropriate pipe material in the system based on the materials useful life.



The model identifies that cast iron main is the material that needs to be replaced initially followed by asbestos cement. During the 40 year period the model projects that during the first 20 years approximately $6 to $8 million each year is needed for cast iron main replacement declining to $3 million during the final 20 years. At the same time the model suggests that asbestos cement main be replaced at a rate of $3 to $7 million each year during the 40 year period. In the outer years of the planning horizon, replacement of PVC main and ductile main begin to be shown as a need in order to address the life expectancy of those material types.

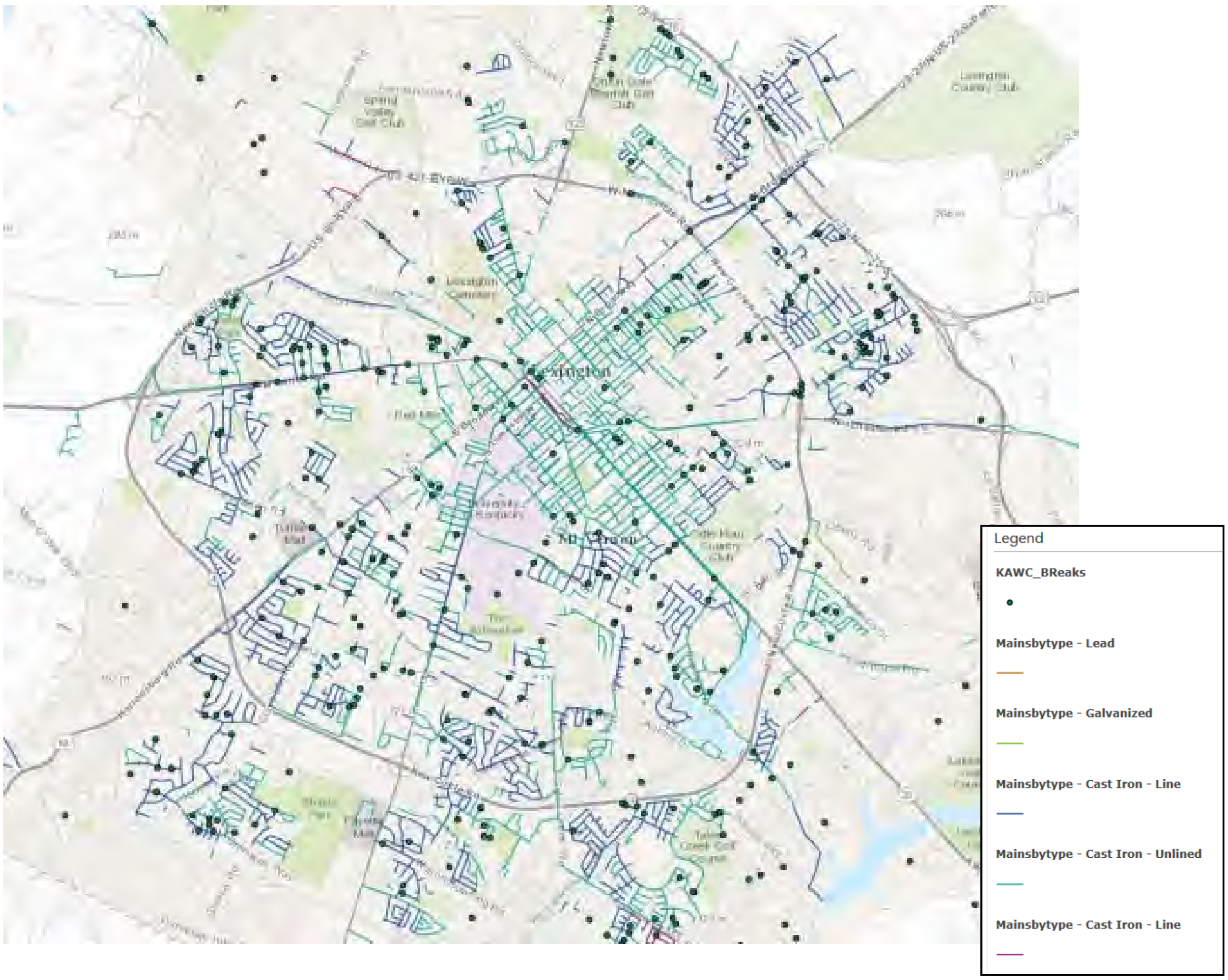
The curve reflects an “echo” of the original trends that shaped the development of the system starting in 1885. The identified capital needs is a reflection of the main installed nearly a century ago that have created a future obligation to replace the mains as they reach their useful life that is now coming due.

Proposed Accelerated Replacement Plan

Kentucky-American recognizes that the past rate of replacement of aging mains the company has employed is not sufficient to address the increased replacement rate that will be required over the coming decades. The need to begin to rebuild the distribution infrastructure that was bequeathed to us by earlier generations is essential to maintain the needs of the community and customers.

Upon review of the distribution system and the material types used in the development of the system, Kentucky-American believes that the first materials that need to be replaced in the system are cast iron main and galvanized steel. These two materials represent approximately 16.1% of the distribution system but account for approximately 61.4% of all main breaks in a given year.

The company utilized its Graphical Information System (GIS) to query the main breaks during the period of January 2012 to August 2015 against the main types in the system and found that empirical data from the database is depicted graphically. The following map shows the main breaks during the 2012 to 2015 period against cast iron and galvanized steel main.



The map identifies two items rather definitively. The first is that a majority of the cast iron main was installed during the first half of the development of Lexington. The map clearly shows that a majority of downtown Lexington remains cast iron and to the most extent unlined cast iron. In addition, with the development of the community away from downtown, the map shows those subdivisions during this period that cast iron was used as the predominate material to serve these areas. It is interesting to note that a majority of the development during the time was within the inner circle, with only small pockets of development along the outside of the circle.

The second item that the map shows is the correlation of the main breaks within the areas that are predominately cast iron and galvanized steel. The remaining main breaks shown on the map are scattered throughout the system and have no indication that there are significant trouble spots from the other distribution system material types at this time.

Based on the information reviewed by the company over the past few years and the data developed for this report, a majority of the mains that are susceptible to breaks are cast iron and galvanized steel. Kentucky-American believes that the best course at this time is to target this type of pipe material over the next 25 years for replacement. The replacement of this type of material allows the company to address underperforming mains and reduce the impact of main breaks in the areas served by this type of material. A review of several replacement periods was reviewed and illustrated in Table 7, indicating that with a 15 year plan would cost $20.2 to $12.6 million annually and a 30 year period would cost $9.6 to $6.3 million per year.

TABLE 7 - POSSIBLE REPLACEMENT RATES FOR CAST IRON				
Period Length	15 year	20 year	25 year	30 year
Miles Replaced per year	21 - 16	16 -12	13 - 10	10 - 8
Cost per year (million)	$20.3 to $12.6	$15.5 to $9.5	$12.6 to $6.9	$9.6 to $6.3

Analysis of the four possible replacement rates lead the company to believe that a 25 year replacement period was more realistic. The 30 year replacement rate would result in a greater overlap of replacement activity between the completion of the cast iron main replacement and the start of the asbestos cement main replacement period.

With the 15 year and the 20 year replacement periods, the removal of the cast iron is quicker and allows for the effort to replace asbestos cement to begin sooner. However, the amount of capital required per year was a concern with respect to support from the community. In addition, the level of capital commitment per year for the 15 year and 20 year replacement rates could have a negative impact on Kentucky-American to address other infrastructure replacement needs such as water treatment components at the water treatment plants that are also entering the end of their useful life.

Finally, the amount of miles of replacement main per year of 16 and 12 miles for the 15 year and 20 year replacement rates is a concern for the impact on available resources to complete the construction each year. The 15 year replacement rate is a fourfold increase in the amount of main replaced during 2014 to 2016. This increase would be a significant strain on the available company and contractor resources and would require a substantial increase in labor and equipment that Kentucky-American is concerned can be sustained over the period of the replacement program.

Through a 25 year replacement period, the 310 miles of cast iron main will be replaced at a rate of 10 to 13 miles per year at an expected cost of $6.9 to $12.6 million per year. At the conclusion of the 25 year replacement period for cast iron, the company will start to focus on the replacement of the 339 miles of asbestos cement pipe, which the earliest pipe installed during 1935, and at which point will be entering its 105th year of useful life.

Infrastructure Resilience

Whatever the debate may be concerning the causes of climate variability, it is hard to dispute that utilities face the reality of climatic variability and attendant stresses on water resources and system recovery. Although climate models for the Southwestern U.S. generally predict overall annual precipitation amounts to remain similar to average historical experience, increasingly intense storms and repeated, extended dry periods are anticipated. That means we can expect more droughts of varying degrees of severity and more frequent and intense high-precipitation events and floods, along with high damaging storm events – which impacts the ability of the distribution system to provide service.

As indicated in the Black & Veatch 2016 Strategic Directions: Water Industry Report, *"water utilities have a responsibility to anticipate and manage crises before they happen. Drought in the Southwestern U.S. and flooding in the Northeastern U.S. are two sides of the same coin. Changes in climate and weather patterns are highlighting the effects of why "kicking the can down the road" approaches to addressing infrastructure and maintenance needs do not work. Natural disasters in New Orleans and Houston, or the events in Flint, should serve as wake-up calls to water providers that resilience requires long term infrastructure, resources, financial planning, utility leadership and customer engagement."*

The effects of climate variability impacts the resilience of a system to withstand an event without interruption of providing service to the customers or, if service is interrupted, to restoring the service in a timely manner. Like all large users dependent on electricity from the grid, water utilities must plan for power outages and develop plans for maintaining continuity of operations when such outages occur. Nonetheless, recent weather patterns combined with the issue of aging infrastructure are causing utilities to review traditional planning and design criteria. The design standards for supplies, treatment plants, pump stations and tanks are taken together to achieve a level of zero service outages. The so-called new normal has led experts to look beyond traditional reliability and emergency planning into a world that needs the speed of recovery and resiliency for much more widespread and damaging events. Updating infrastructure to keep up with the increase in extreme weather and insuring that adequate service can be maintained for extended time periods after an extreme event is just as important as addressing the aging infrastructure.

Improvements for Infrastructure Resilience

The Kentucky-American Water's distribution system contains 22 storage facilities throughout its system with a combined volume of 27.25 million gallons. The system also contains 17 pump stations throughout the system that work in concert with the storage facilities to maintain the system's ability to meet the needs of the community.

A majority of the storage and pumping facilities were installed during its greatest growth during the 1970s through the housing boom of the first part of 2000. Ongoing maintenance and repainting of the storage facilities has allowed Kentucky-American to sustain its facilities, ensuring that the facilities will not need to be replaced until around 2050.

The pumping facilities are reaching a life of 20 to 40 years in service and are at or exceeding the typical useful life of 30 years. It is anticipated that over the next ten years, Kentucky-American water will be replacing the existing below grade pump stations and installing above grade pump stations. Through the systematic replacement of the pump stations Kentucky-American will be able to address the aging infrastructure and address work site conditions imposed by the existing below grade installations. In addition, Kentucky-American will be reviewing and adding or supplementing the standby generation to a majority of the pump stations to ensure adequate service can be maintained for extended time periods after an extreme weather events.

Conclusion

Thanks to the work of past generations that developed and built the water distribution system to support the growth of our community, we have enjoyed the access to clean water and economic advantages that it has provided. Because these water mains last a long time we have never had to replace a significant amount of pipe on a large scale. We are on the edge of the period when these mains are reaching the end of their useful life and future generations will need to undertake large scale replacement efforts to ensure that we continue to benefit from our access to clean water.

It is important that instead of a entering this period in with a careless plan that only addresses the system as it fails, we undertake a prioritized renewal of the mains to ensure that our water infrastructure can reliably and cost-effectively support the public health, safety, and economic vitality of our community.

Kentucky-American believes that the replacement of cast iron and galvanized steel main through a 25 year replacement period and its ability to replace other infrastructure facilities to address resilience issues within the system is important to ensure the company can responsibly enter into the period of water infrastructure renewal.

Through careful prioritization of projects and looking at emerging technology, the cost of replacing facilities just prior to failure will be of significant benefit to the community. Through the reduction of the number of failures the system experiences and the ability to recover from damaging events, we can reduce the negative effects of property damage, disruption of businesses and the community, and wasting of our water resources and thereby ensure our future generations continue to benefit from access to reliable clean water that will support the economic growth of the community.

Resources

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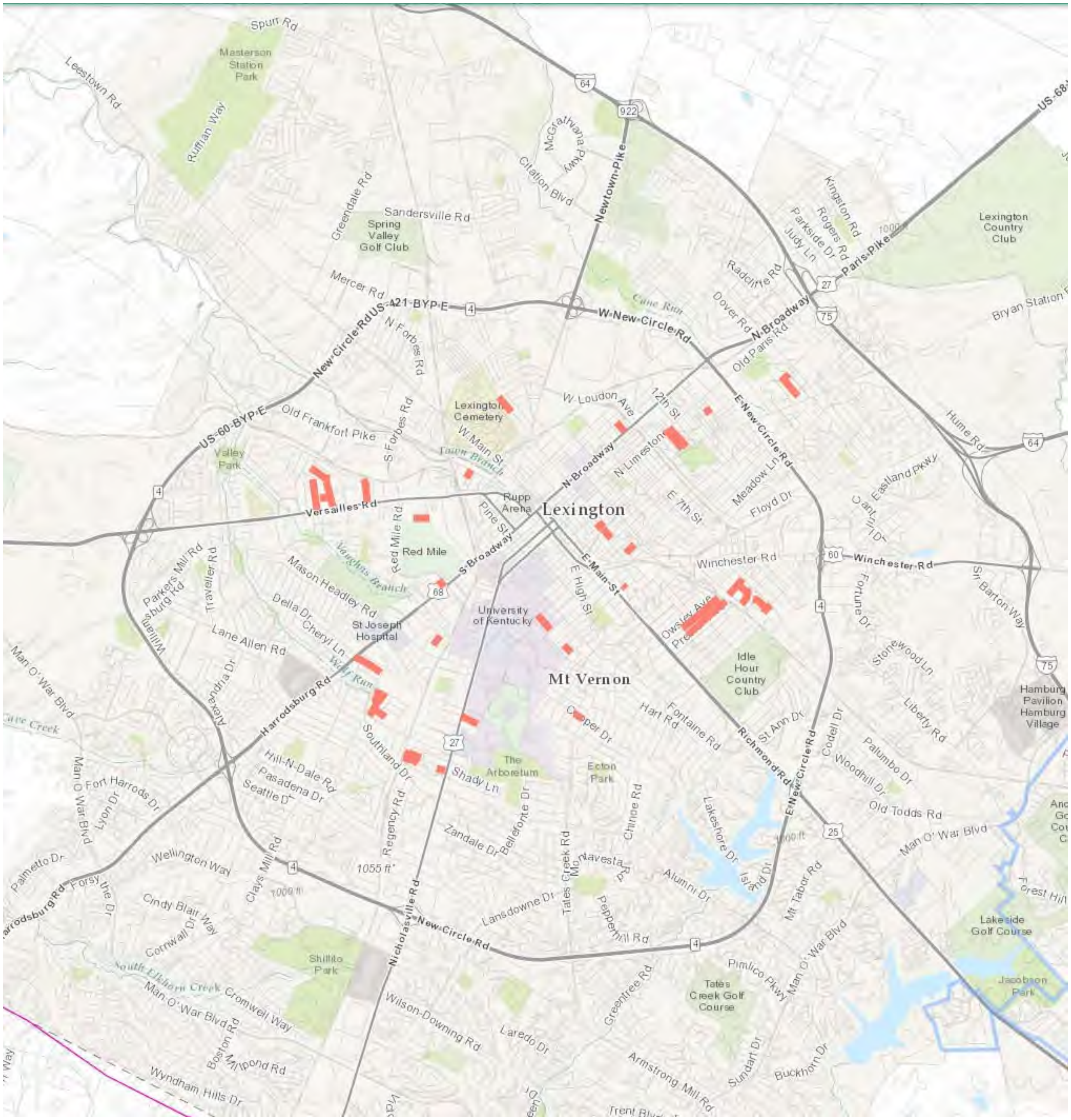
APPENDIX

KENTUCKY AMERICAN WATER

Projected Year One Projects
For Main Replacement Program



PROJECTED YEAR ONE PROJECTS FOR MAIN REPLACEMENT PROGRAM

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	600 BLOCK SAYRE AVE	212	$31,800
2	900 BLOCK WHITNEY AVE	1,030	$154,500
3	200 BLOCK PERRY ST	466	$69,900
4	1000 BLOCK KASTLE RD	512	$76,800
5	1200 BLOCK EMBRY AVE	536	$80,400
6	200 BLOCK SPRUCE ST	624	$93,600
7	200 BLOCK HAMILTON PARK	978	$146,700
8	300 BLOCK GUNN ST	184	$27,600
9	100 BLOCK SHAWNEE PL	568	$85,200
10	200 BLOCK WARNOCK ST	492	$73,800
11	600 BLOCK ORCHARD AVE	380	$57,000
12	100 BLOCK AVON AVE 100 BLOCK BURNETT AVE	1,340	$201,000
13	1400 BLOCK CAMDEN AVE	1,082	$162,300
14	100 BLOCK WABASH DR 1800 BLOCK PENSACOLA DR 200 BLOCK LACKAWANNA RD 180 WABASH DR 140 WABASH DR	3,160	$474,000
16	200 AND 300 BLOCK LINCOLN AVE	3,928	$589,200
17	200 TO 400 BLOCKS OF PRESTON AVE	2,452	$367,800
18	300 BLOCK RICHMOND AVE 200 BLOCK WHITE AVE	814	$122,100
19	300 BLOCK PENNSYLVANIA CT	1,422	$213,300
20	300 BLOCK STRATHMORE RD	1,436	$215,400
21	100 BLOCK GARRETT AVE	968	$145,200
22	200 BLOCK GARRETT AVE	1,508	$226,200
23	300 BLOCK N PICADOME PARK	1,648	$247,200
24	600 BLOCK COOPER DR	218	$32,700
25	1300 BLOCK WILLOWLAWN AVE	438	$65,700
26	400 BLOCK UHLAN CT	768	$115,200
27	100 DELMONT DR	1,052	$157,800
28	200 BLOCK E VISTA ST	1,260	$189,000
29	200 BLOCK W VISTA ST	1,204	$180,600
30	100 BLOCK E VISTA ST	1,502	$225,300
31	400 BLOCK MORRISON AVE	608	$91,200
32	200 BLOCK LINWOOD DR	948	$142,200
33	500 BLOCK MCCUBBING DR	2,290	$343,500
34	1100 BLOCK SPARKS RD	2,358	$353,700
35	600 BLOCK LAGONDA AVE	1,980	$297,000
36	7OO BLOCK APPLETREE LN	980	$147,000
37	1600 BLOCK CLAYTON AVE	1,644	$246,600
ANTICIPATED YEAR TOTAL		42,990	$6,448,500

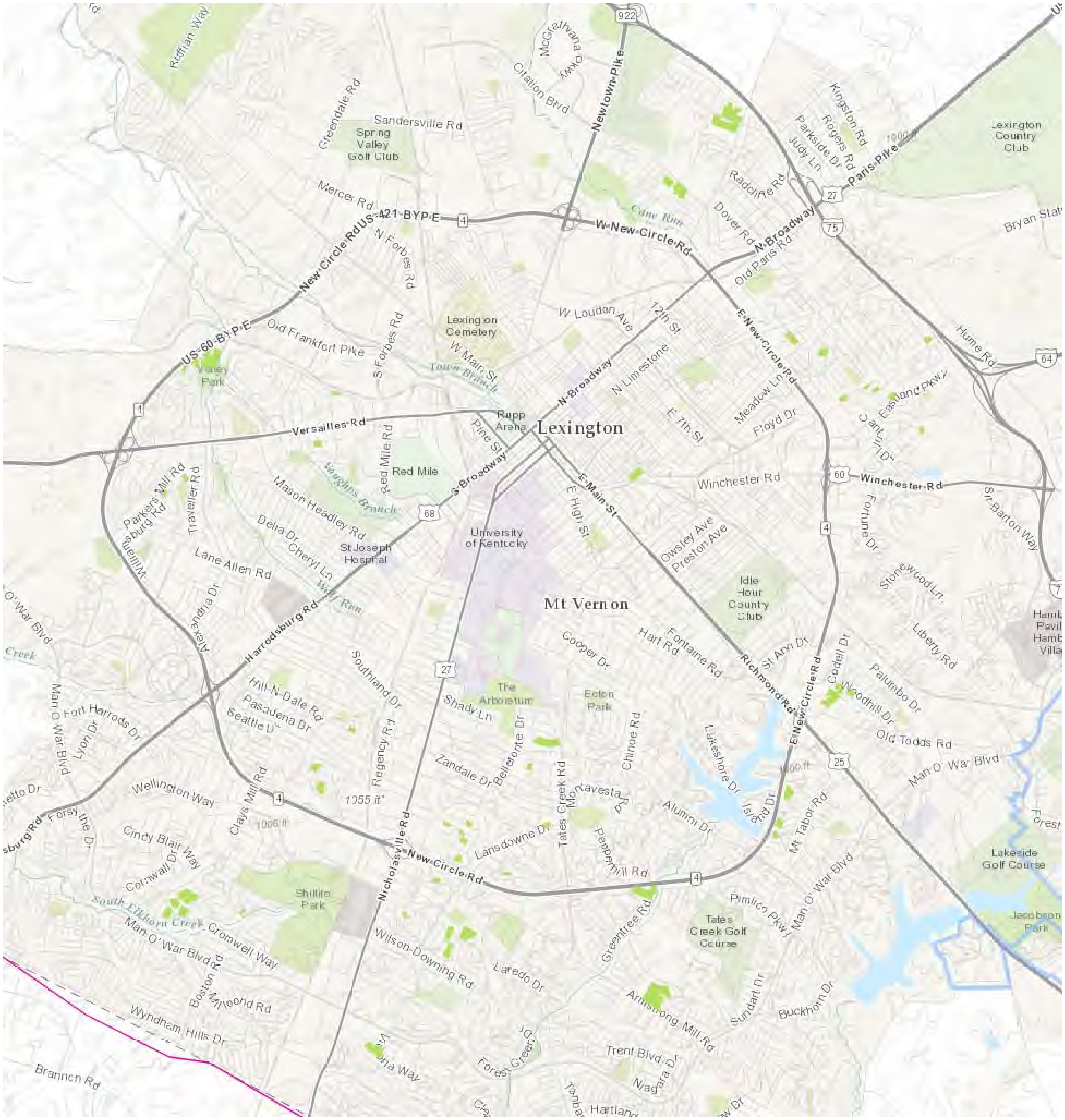
KENTUCKY AMERICAN WATER

Projected Year Two Projects
For Main Replacement Program

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	1600 BLOCK COURTNEY AVE	1,490	$223,500
2	EMERY CT 1600 BLOCK COURTNEY AVE	2,058	$308,700
3	600 BLOCK BLUE ASH DR	940	$141,000
4	200 BLOCK KOSTER DR	1,860	$279,000
5	200 BLOCK NORWAY ST	1,702	$255,300
6	100 BLCOK HALLS LANE	1,626	$243,900
7	LONE OAK DR	3,468	$520,200
8	2000 BLOCK RAINBOW RD 200 BLOCK DERBY DR 2000 BLOCK REBEL RD	1,508	$226,200
9	4800 BLOCK BOONE LN	3,762	$564,300
10	1100 BLOCK N CLEVELAND RD	5,356	$803,400
11	5400 BLOCK BRIAR HILL RD	4,280	$642,000
12	4400 BLCOK HALEY RD	50	$7,500
13	4600 BLOCK TODDS RD	3,496	$524,400
14	3500 BLOCK ROLLING HILLS CT	610	$91,500
15	5000 BLOCK SULPHUR LN	1,462	$219,300
16	5200 BLOCK WINCHESTER RD	5,423	$813,450
17	5400 BLOCK WINCHESTER RD	230	$34,500
18	1900 BLOCK BEACON HILL RD	1,576	$236,400
19	3100 BLOCK BRECKENWOOD DR	356	$53,400
20	LAMONT CT	226	$33,900
21	700 BLOCK LANDSDOWNE CIR	314	$47,100
22	3500 BLOCK MADDOX LN	2,732	$409,800
ANTICIPATED YEAR TOTAL		44,525	$6,678,750

KENTUCKY AMERICAN WATER

Projected Year Three Projects
For Main Replacement Program



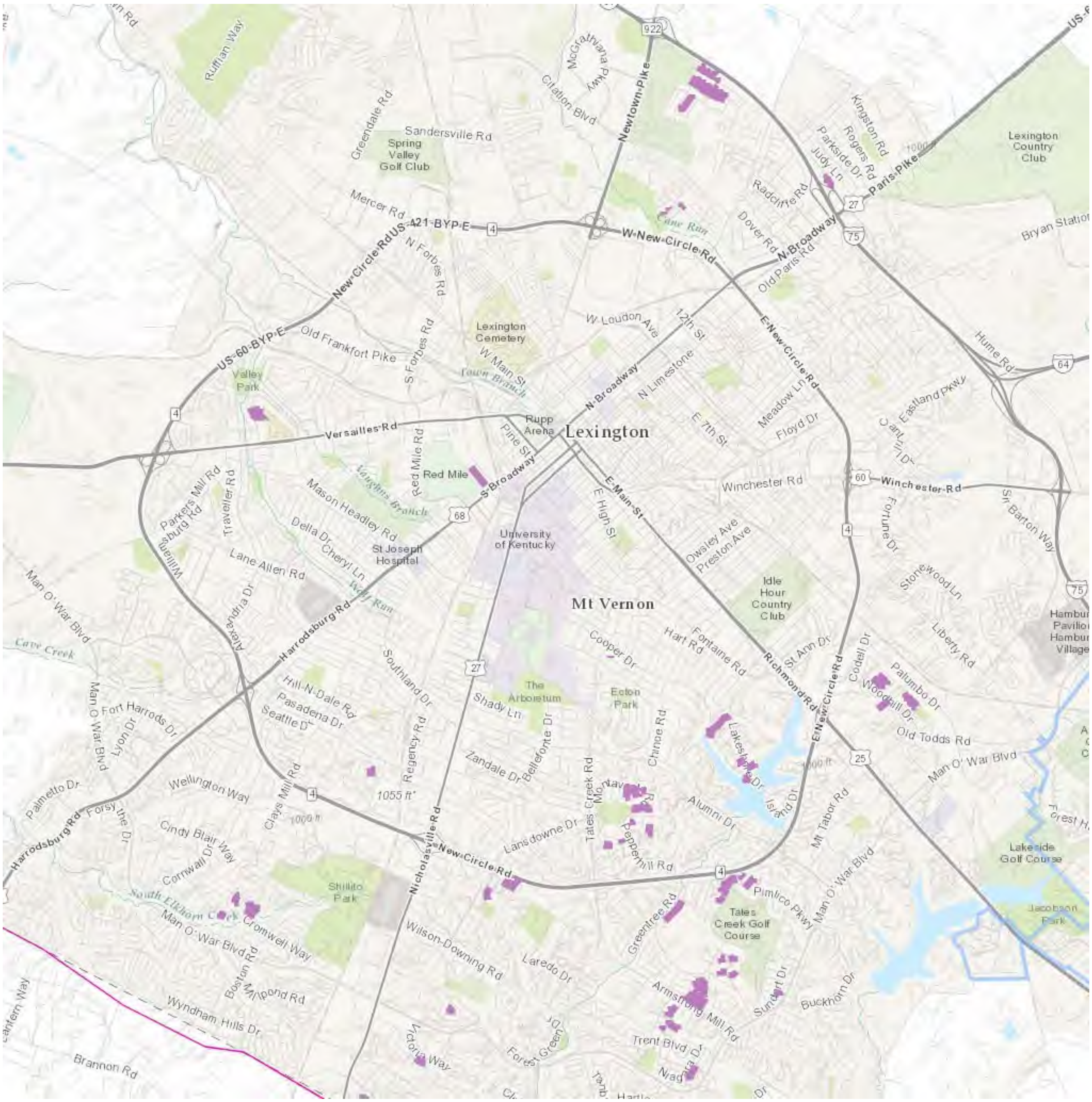
PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	100 BLOCK NEW ZION RD	2,302	$345,300
2	SAMUEL LN	1,156	$173,400
3	TILLYBROOK CT	624	$93,600
4	3200 BLOCK RAVEN CIRCLE	360	$54,000
5	MALABU CT HUNTER CIRCLE HEATHER CT 300 BLOCK BELVOIR DR	1,556	$233,400
6	200 BLOCK BRADFORD CIR	352	$52,800
7	SHIRLEE CT	372	$55,800
8	OLD DOBBIN RD	482	$72,300
9	DELMONT CT	168	$25,200
10	1300 BLOCK HIALEIAH CT 1300 BLOCK HOT SPRINGS CT 1300 BLOCK KEENELAND CT	1,682	$252,300
11	CROSS KEYS CT	490	$73,500
12	200 BLOCK LEWIS ST	260	$39,000
13	THISTLETON CIRCLE	522	$78,300
14	EDINBURGH CT	258	$38,700
15	CROYDEN CT SHEFFIELD CT	942	$141,300
16	100 BLOCK GENTRY RD	176	$26,400
17	100 BLOCK N CLEVELAND RD	238	$35,700
18	7300 BLOCK OLD RICHMOND RD	646	$96,900
19	WILLIAMSBURG CT	368	$55,200
20	WOODSIDE CIRCLE	304	$45,600
21	600 BLOCK TATESWOOD DR	340	$51,000
22	RANGE CT	672	$100,800
23	GREENLAWN CT JADE CIRCLE KIMBERLITE CT GRANITE CIRCLE	1,438	$215,700
24	DURHAM CT	504	$75,600
25	100 BLOCK COLLEGE ST	1,098	$164,700
26	GAYLE CIRCLE	388	$58,200
27	SAYBROOK CT	282	$42,300
28	WAYCROSSE CIRCLE SHILOH CT	676	$101,400
29	KELSEY CT KELSEY PL YARMOUTH CT 1100 BLOCK KILRUSH DR	1,694	$254,100
30	CRICKLEWOOD CT	340	$51,000
31	1100 BLOCK APPIAN CROSSING WAY	978	$146,700
32	600 BLOCK CARDIGAN CT 3500 BLOCK BERWIN CT 3400 BL0CK IPSWICH CT	1,416	$212,400
33	3400 BLOCK FLINTRIDGE CIRCLE	426	$63,900
34	500 BLOCK FOLKSTONE DR	302	$45,300
35	1100 BLOCK GREENTREE CT GREENTREE PL GREENTREE CIRCLE	1,252	$187,800
PROJECTED YEAR THREE PROJECTS FOR MAIN REPLACEMENT PROGRAM			
PROJECT NUMBER	**PROJECT LOCATION**	**AMOUNT OF MAIN TO BE REPLACED (FEET)**	**ANTICIPATED COST**

36	KING ARTHUR CT 3400 BLOCK KING ARTHUR DR	1,272	$190,800
37	PADDOCK CT	436	$65,400
38	TANNER CT	438	$65,700
39	PENWAY CT	438	$65,700
40	400 BLOCK PLAINVIEW RD	248	$37,200
41	100 BLOCK TORONTO DR 4000 BLOCK VICTORIA WAY 4000 BLOCK VICTORIA WAY 200 BLOCK TORONTO RD	1,286	$192,900
42	2600 BLOCKI WINBROOKE LN	408	$61,200
43	2800 BLOCK MIDDLESEX CT	778	$116,700
44	700 BLOCK HILL RISE CT	542	$81,300
45	1500 BLOCK HALSTED CT KILDARE CT KIRK CT	2,420	$363,000
46	800 BLOCK GENTRY LN	1,236	$185,400
47	200 BLOCK MULBERRY RD OSAGE CT 2500 BLOCK BUTTERNUT HILL CT	1,148	$172,200
48	BLACKARROW CT	730	$109,500
49	BARBADOS LN 3100 BLOCK TABAGO CT 2700 BLOCK MARTINIQUE LN	2,508	$376,200
50	1800 BLOCK COLCHESTER DR FELTNER CT 1800 BLOCK BOWEN CT 1800 BLOCK BARKSDALE DR 1800 BLOCK COLCHESTER DR	2,484	$372,600
51	HAVELOCK CIR 600 BLOCK SAGINAW CT 3400 BLOCK ALDERSHOT DR	1,614	$242,100
52	KILKENNY CT	932	$139,800
ANTICIPATED YEAR TOTAL		43,982	$6,597,300

KENTUCKY AMERICAN WATER

Projected Year Four Projects
For Main Replacement Program



PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	3100 BLOCK OLD CROW CT 3100 BLOCK CLAIR RD MONTAVESTA CT	1,916	$287,400
2	2000 BLOCK CUMMINS CT 2000 BLOCK DANIEL CT	758	$113,700
3	400 BLOCK CURRY AVE	468	$70,200
4	4000 BLOCK LILYDALE CT 4000 BLOCK WHITEMARK CT	1,634	$245,100
5	3500 BLOCK ORMOND CIR	636	$95,400
6	1900 BLOCK RITTENHOUSE CT	328	$49,200
7	2400 BLOCK PLUMTREE CT 2400 BLOCK THORNBERRY CT	1,236	$185,400
8	1200 BLOCK MAYWOOD PARK 1200 BLOCK OAKLAWN PARK 1200 BLOCK TANFORAN DR 1200 BLOCK NARRAGANSETT PARK LATONIA PARK 3200 BLOCK WATERFORD PARK	2,744	$411,600
9	200 BLOCK KELLY CT	1,352	$202,800
10	600 BLOCK FOGO CT 600 BLOCK CREWE CT 3400 BLOCK FRASERDALE CT 3400 BLOCK BIRKENHEAD CIR	2,020	$303,000
11	LOOKOUT CIR 2900 BLOCK MONTAVESTA RD	866	$129,900
12	WEM CT	562	$84,300
13	4100 BLOCK WINNIPE CT	630	$94,500
14	400 BLOCK WOODLAKE WAY	250	$37,500
15	3200 BLOCK WOOD VALLEY CT	256	$38,400
16	3500 BLOCK SUTHERLAND DR	1,020	$153,000
17	3500 BLOCK NIAGRA DR	688	$103,200
18	3300 BLOCK MOUNDVIEW CT	434	$65,100
19	LISA CIR MONA CT	912	$136,800
20	MARGO CT KAREN CT	1,846	$276,900
21	VERSIE CT JANNELLE CT	1,270	$190,500
22	200 BLOCK HEDGEWOOD CT	512	$76,800
23	TAMMY CT LAVERNE CT GREVEY CT HARRIS CT	2,726	$408,900
24	GRANT CT HOLLOW CREEK CT GRANT PL	1,034	$155,100
25	GRAIG CT	626	$93,900
26	LYNNWOOD CT WOODSTON CT CLEARWOOD CT	1,746	$261,900
27	3600 BLOCK CAYMAN LN JAMAICA CT	1,574	$236,100

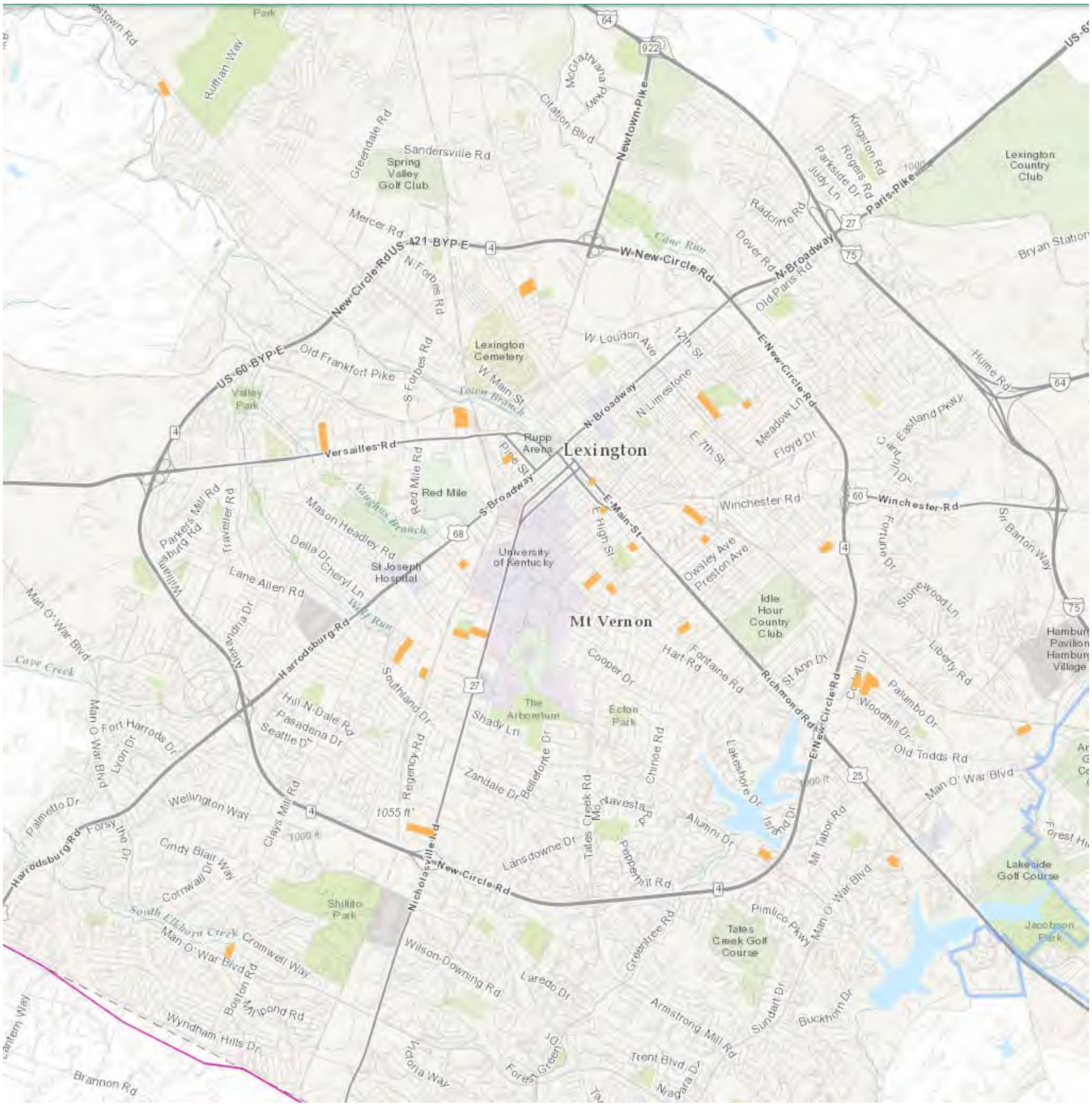
PROJECTED YEAR FOUR PROJECTS FOR MAIN REPLACEMENT PROGRAM

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST

28	WATERS EDGE PL 2000 BLOCK HARMONY CT 2100 BLOCK BRIDGEPORT DR	1,580	$237,000
29	1600 BLOCK COSTIGAN DR 1900 BLOCK LEITNER CT 1900 BLOCK BEDINGER CT 1900 BLOCK COBYVILLE CT 900 BLOCK VALLEY FARM DR 1900 BLOCK CHRIS DR	3,536	$530,400
30	3400 BLOCK BELLMEADE RD 3400 BLOCK WARWICK CT	884	$132,600
31	1300 BLOCK OX HILL DR BASS CT	758	$113,700
32	1200 BLOCK ASCOT PARK 1200 BLOCK BEULAH PARK 1300 BLOCK ATOKAD PARK 1300 BLOCK GOLDEN GATE PARK 1200 BLOCK AK-SAR-BEN PARK	1,594	$239,100
33	BRANDON CT	418	$62,700
34	SWOONALONG CT PERSONALITY CT 1300 BLOCK CANONERO DR GUNBOW CT PERSONALITY CT	2,350	$352,500
35	3500 BLOCK GINGERTREE CIR	484	$72,600
36	KENIL CT	138	$20,700
37	2000 BLOCK VON LIST WAY	2,156	$323,400
ANTICIPATED YEAR TOTAL		43,942	$6,591,300

KENTUCKY
AMERICAN WATER

Projected Year Five Projects
For Main Replacement Program



PROJECTED YEAR FIVE PROJECTS FOR MAIN REPLACEMENT PROGRAM

PROJECT NUMBER	PROJECT LOCATION	AMOUNT OF MAIN TO BE REPLACED (FEET)	ANTICIPATED COST
1	TREPASSEY CT	808	$121,200
2	100 BLOCK WESTGATE DR	2,022	$303,300
3	100 BLOCK MOORE DR	170	$25,500
4	3300 BLOCK PITTMAN CREEK CT	634	$95,100
5	4700 BLOCK HUFFMAN MILL PIKE	56	$8,400
6	300 BLOCK ROBERTSON ST 1100 BLOCK MARTIN AVE 300 BLOCK FERGUSON ST 300 BLOCK ANDERSON ST 300 BLOCK ROBERTSON ST	3,476	$521,400
7	3200 BLOCK BRACKTOWN RD	1,946	$291,900
8	400 BLOCK BRADLEY CT	1,602	$240,300
9	100 BLOCK CASTLEWOOD DR	1,152	$172,800
10	800 BLOCK CAMPBELL LN	1,184	$177,600
11	600 BLOCK CENTRAL AVE	362	$54,300
12	100 BLOCK CHELAN CT	700	$105,000
13	700 BLOCK E EUCLID AVE	378	$56,700
14	200 BLOCK E MAIN ST	478	$71,700
15	200 BLOCK SOUTHPORT DR	2,672	$400,800
16	TIMBERHILL CT ELDERBERRY CT	858	$128,700
17	HEATON CT 2400 BLOCK MIRAHILL DR 2400 BLOCK WINDWOOD CT	1,042	$156,300
18	1400 BLOCK ELIZABETH ST 100 BLOCK FOREST PARK RD	2,352	$352,800
19	200 BLOCK WESTWOOD CT	1,364	$204,600
20	100 BLOCK WESTWOOD DR	1,640	$246,000
21	1100 BLOCK FERN AVE	1,896	$284,400
22	1000 BLOCK FLOYD DR	232	$34,800
23	400 BLOCK GREENWOOD AVE	1,280	$192,000
24	800 BLOCK JOHNSDALE DR	552	$82,800
25	3200 BLOCK HALEY RD	1,616	$242,400
26	500 BLOCK LONGVIEW DR	94	$14,100
27	400 BLOCK MACADAM DR 600 BLOCK ROSEMILL DR	2,604	$390,600
28	3400 BLOCK MCFARLAND LN	3,650	$547,500
29	500 BLOCK MCKINLEY ST	308	$46,200
30	500 BLOCK MERINO ST	542	$81,300
31	300 BLOCK MEMORY LN	396	$59,400
32	600 BLOCK MONTGOMERY AVE	226	$33,900
33	700 BLOCK NATIONAL AVE 900 BLOCK NATIONAL AVE	1,242	$186,300
34	1100 BLOCK OAK HILL DR	470	$70,500
35	300 BLOCK OLD VINE ST	162	$24,300
36	2100 BLOCK PAIGE CT	358	$53,700
37	400 BLOCK PARK AVE	634	$95,100
38	500 BLOCK PINE ST	382	$57,300
39	200 BLOCK RIDGEWAY RD	556	$83,400
40	1400 BLOCK RUSSELL CAVE RD	210	$31,500
ANTICIPATED YEAR TOTAL		42,306	$6,345,900

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

58. Reference O'Neill Direct, page 38, where Mr. O'Neill discussed the impact of the QIP on O&M expenses over time. Has the Company estimated savings in O&M costs from the adoption of the proposed QIP? If so, provide these estimates, including supporting documentation and workpapers.

Response:

No. The Company has not estimated savings in O&M costs. O&M cost savings are influenced by a variety of factors, including QIP. Over the long-term, the Company may realize some reduction in pumping costs, electrical cost, and a reduction in non-revenue water and a reduction in unscheduled maintenance expense. See also KAWC response to Item 50 of the Commission Staff's Second Request for Information.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

59. Provide all projects that KAWC will include in its proposed QIP over the next 5 years. Include the cost of each project and the purpose of each project, i.e., pipe replacement, pumping station replacement, treatment plant replacement, etc.

Response:

Please see attached.

QIP STRATEGIC CAPITAL EXPENDITURE PLAN - 5 YEAR PROGRAM UPDATED

Business Unit Kentucky
Description KY QIP BP 2020-2024 SCEP
First Year of Plan 2020*

*2020 QIP Spending occurs following Future Test Year ending June 2020

Business Unit	Project ID	Project Title	Project Purpose	5-Year Total		2020* Total	2021 Total	2022 Total 2022	2023 Total 2023	2024 Total 2024
		RECURRING PROJECTS								
Kentucky	B	Mains - Replaced / Restored	Main Replacements other than Cast Iron/ Galvanized Main	**8,750,000**		750,000	2,000,000	2,000,000	2,000,000	2,000,000
Kentucky	B2	QIP - Mains - Replaced / Restored	Replacement of Cast Iron/ Galvanized Main	**46,250,000**		2,250,000	8,000,000	12,000,000	12,000,000	12,000,000
Kentucky	C	Mains - Unscheduled	Main Replacements	**4,050,000**		450,000	900,000	900,000	900,000	900,000
Kentucky	D	Mains - Relocated	Main Replacement caused by relocations	**1,825,025**		200,025	387,500	387,500	400,000	450,000
Kentucky	F	Hydrants, Valves, and Manholes - Replaced	Hydrant, Valves Replacement	**2,272,320**		249,480	501,960	504,960	507,960	507,960
Kentucky	H	Services and Laterals - Replaced	Service Line Replacements	**2,396,250**		266,250	532,500	532,500	532,500	532,500
Kentucky	J	Meters - Replaced	Meter Replacements	**5,008,475**		571,350	1,220,475	1,010,150	1,106,500	1,100,000
Kentucky	L	SCADA Equipment and Systems	Control System Replacements/ Redundancies	**1,746,500**		166,500	320,000	360,000	450,000	450,000
Kentucky	M	Security Equipment and Systems	Security System Redundancies/ Replacements	**607,000**		65,000	167,000	125,000	125,000	125,000
Kentucky	Q	Process Plant Facilities and Equipment	Water Treatment Equipment Replacements	**3,375,000**		375,000	750,000	750,000	750,000	750,000
		Total Recuring Projects				**5,343,605**	**14,779,435**	**18,570,110**	**18,771,960**	**18,815,460**

Business Unit	Project ID	Project Title	Project Purpose	5-Year Total	Anticipated In Service Date	2020* Total 2020	2021 Total 2021	2022 Total 2022	2023 Total 2023	2024 Total 2024
		INVESTMENT PROJECTS								
Kentucky	I12-020080	KRS1 Pump 10 and 11 Replacements	High Service Pump Replacement	**2,250,270**	9/30/2021	-	2,250,270	-	-	-
Kentucky	I12-020081	KRS1 Pump 14 Replacement	High Service Pump Replacement	**1,500,000**	6/30/2022	-	-	1,500,000	-	-
Kentucky	I12-020095	Mercer Road Booster Station	Pump Station Replacement	**1,000,000**	5/30/2021	-	1,000,000	-	-	-
Kentucky	I12-020096	Mt Horeb Booster Station	Pump Station Replacement	**750,000**	5/30/2023	-	-	-	750,000	-
Kentucky	I12-020097	Hall Booster Station	Pump Station Replacement	**750,000**	5/30/2022	-	-	750,000	-	-
		Total Investment Projects				**-**	**3,250,270**	**2,250,000**	**750,000**	**-**
		TOTAL QIP INVESTMENT				**5,343,605**	**18,029,705**	**20,820,110**	**19,521,960**	**18,815,460**

Cost of Removal

Business Unit	Business Unit No.	Project Title	Total 2020	Total 2021	Total 2022	Total 2023	Total 2024	Total
Kentucky	B	Mains - Replaced / Restored	300,000	600,000	769,995	769,995	769,995	3,209,985
Kentucky	C	Mains - Unscheduled	99,000	198,000	198,000	198,000	198,000	891,000
Kentucky	D	Mains - Relocated	20,003	38,750	38,750	40,000	40,000	177,503
Kentucky	F	Hydrants, Valves, and Manholes - Replaced	77,339	155,608	156,538	157,468	157,468	704,419
Kentucky	H	Services and Laterals - Replaced	82,538	165,075	165,075	165,075	165,075	742,838
Kentucky	J	Meters - Replaced	74,276	158,662	131,320	143,845	143,845	651,947

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

60. Provide copies of the documents cited in footnotes 7 through 11 of Mr. O'Neill's Direct Testimony.

Response:

Please see the documents attached to AG 1-56.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell

61. Provide the revenue requirement impact of the QIP during the first five years of its operation. This question seeks the quantification of the additional revenue requirement that would be flowed through the QIP to ratepayers each year. Provide supporting documentation and work papers with spreadsheet cell formulas intact.

Response:

The revenue requirement impact of the QIP during the first five years of its operation will depend on a number of variables. These variables could include such items as the outcome of the current case, the need for subsequent rate cases, the authorized cost of capital from this proceeding, the structure and mechanics of the authorized QIP, the future cost of labor and materials, future tax rates, and changes to capital spend levels (for regulatory requirements or newly identified project priorities). Notwithstanding these potential changes, the Company has prepared a sample revenue requirement calculation, which presumes that no rate case is filed during this period. The sample calculation also uses the current forecast for level of spend, the cost of capital requested in this proceeding, and presumes the QIP structure and mechanics as recommended by the Company. Please see the attached Excel file.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Patrick L. Bayrenbruch

62. Reference the Direct Testimony of Patrick L. Baryenbruch ("Baryenbruch Direct"), and the attached study.

a. Provide a citation to the portion of the analysis that compares the cost per customer of providing all utility service to KAWC customers and the cost(s) or average cost of providing the respective utility service to those customers of companies included in the "electric service company" and "combination electric/gas service company" designations.

b. Provide a citation to the portion of the analysis that compares the cost of market services as determined by using internal employees instead of outside service providers.

c. Provide a citation to the portion of the analysis that compares the cost of the services provided by the Service Company compared to the cost of the same services calculated using internal employees or outside service providers on a regional basis (i.e. a regional service company with Tennessee, Georgia, Kentucky, etc.).

Response:

a. Cost per customer comparisons are included in the following chapters of Mr. Baryenbruch's study that was attached to his direct testimony:
   - Chapter IV – Question 1 Reasonableness of Service Company Charges (pages 9-12)
   - Chapter VI – Question 3 Reasonableness of Customer Accounts Services Costs (pages 29-37)

b. The scope of Mr. Baryenbruch's study was test year charges from the Service Company to KAWC. The comparison of Service Company and outside service provider costs is shown in chapter V – Question 2 – Provision of Services at Lower of Cost or Market (pages 13-28) of Mr. Baryenbruch's study that was attached to his direct testimony. Mr. Baryenbruch did not compare the cost of work performed by KAWC internal employees to those of outside providers because these are not affiliate transactions.

c. As mentioned in 62.b above, Mr. Baryenbruch evaluated KAWC charges from its Service Company affiliate. He did not quantify the cost of the various restructuring scenarios conjectured by this question. This was unnecessary because he evaluated the cost of the Service Company arrangement that was in place during the test period and whose costs are included in this rate case.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Constance E. Heppenstall, Melissa L. Schwarzell

63. Reference the Direct Testimony of Ms. Constance E. Heppenstall ("Heppenstall Direct"), at pages 8–9, wherein she states she was directed by Company management to "move the rates for East Rockcastle and North Middletown to Service Area 1 rates."

a. Provide Ms. Heppenstall's cost of service results for East Rockcastle and North Middletown, separately.
b. Why did the Company provide the aforementioned guideline to Ms. Heppenstall?
c. Did the Company make promises or representations to anyone before, during, or after the consummation of either agreement transferring the assets of North Middletown or East Rockcastle that in the Company's next rate case the rates charged to those areas would move to Service Area 1 rates, or otherwise reduced from current rates?
d. Provide Ms. Heppenstall's basis for "support [for] the concept of single-tariff pricing and to maintain the consolidation of the rate divisions achieved in prior cases."
e. Explain Ms. Heppenstall's personal knowledge of the Company's prior separate rate divisions.

Response:

a. Cost of service results were not prepared for Eastern Rockcastle and North Middletown separately.
b. The Company recommended a rate structure applicable to all divisions because it finds that single tariff pricing is in the public interest. This is consistent with the Commission's finding in Case No. 2007-00143, as stated in the direct testimony of Melissa Schwarzell, page 38, lines 19-21.
c. KAW discussed and explained the single tariff pricing philosophy with each entity and advised we would request single tariff treatment. At no time during those discussions was a promise or guarantee made that single tariff pricing would be approved for either entity. It was clearly articulated in all discussions that the decision to approve single-tariff pricing rests solely with the Public Service Commission.

d-e. Unified rate structures or single tariff pricing is advantageous for the customers of Kentucky American Water as it spreads the costs across a larger a customer base creating economies of scale, eliminates the administrative burden of keeping multiple sets of books, and lowers administrative costs and regulatory costs. All of the above advantages achieve rate stability for all customers of Kentucky American Water.

In addition, there has been long support for single tariff pricing in the history of Kentucky American Water cases before the Commission. In the final order of its 2004 rate case (Case No. 2004-00103, Order dated February 28, 2005, page 76) the Commission acknowledged that the Company would be presenting unified rates in its next rate case. In Case No. 2005-00206, (Order dated July 22, 2005, page 6), the Commission placed the Company "on notice" that Company's next application for general rate adjustment should contain a proposal for a single rate schedule applicable to all its customers.

The next general rate case was Case No. 2007-00143. As directed by the Commission, the Company proposed unified rates. The unanimous settlement of that case included a move to unified rates for the Northern, Central, Tri-Village District acquisition and the City of Owenton acquisition. The Commission approved the settlement by Order of November 29, 2007 (page 4). The Commission has continued to approve unified rates in subsequent rate cases on the basis that a departure from unified rates "would discourage further water system consolidation." (Case No. 2012-00520, Order dated October 25, 2013, page 70).

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Constance E. Heppenstall

64. Reference Heppenstall Direct, page 9, lines 11–15.

a. Provide a description of "readiness to serve costs."

b. Are the costs described here used in the development of the service charge for all rate classes?

Response:

a. Readiness to serve costs are the minimum costs that the Company incurs to supply water to its customers. The calculation of this charge is shown in response to Commission Staff's Second Request for Information Number 78.

b. Yes, the costs are used in the development of the service charge for all rate classes, as each customer has a water connection.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Constance E. Heppenstall

65. Reference Heppenstall Direct, page 9, lines 16–25.

a. Explain the sentence "Also, the unrecovered portion of public fire costs are included as a part of the customers costs since these costs are fixed and do not vary with water usage."

b. Is the quote provided in subpart a., above, describing the inclusion of unrecovered public fire costs in the residential and commercial customer charges?

Response:

a. Revenues from Public Fire charges do not fully recover the Public Fire cost of service as explained in response to Lexington-Fayette Urban Count Government's First Request for Information #76. Therefore, the additional cost, or unrecovered cost, related to the Public Fire customer class is included in the calculation of the customer charge. These costs are fixed and do not vary with water usage and should be included in the calculation of the customer charge.

b. Yes, it is describing the inclusion of unrecovered public fire costs in customer charges for all classes. This is consistent with the calculation of customer charges in prior Cost of Service Studies provided by the Company.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Kurt Kogler

66. Reference Kogler Direct, page 4, lines 10–12. Explain the empirical basis for KAWC believing that using a combination of base and performance pay "is superior to setting base compensation targets at market median and not offering variable compensation."

Response:

Willis Towers Watson's 2018 General Rate Case Total Remuneration Study (dated October 26, 2018) indicates that practically all of Kentucky-American's peer organizations have performance-based plans. These plans place a portion of an employee's compensation contingent on financial performance, operation efficiency, safety and customer satisfaction.

The lack of variable compensation would remove an important management tool and diminish management's ability to reinforce, measure and reward improvements in efficiency, decreasing waste and boosting productivity. Performance based plans provide strong reinforcement since performance compensation is much more variable than base pay. Base pay rates typically do not fluctuate or increase marginally while performance pay is much more variable based on performance outcomes. The Company believes tying pay to performance outcomes is superior to fixed compensation independent of performance outcomes.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Kurt Kogler

67. Reference Kogler Direct, page 5, wherein he discusses the APP goals.

a. Provide the total test-year amount attributed to "Financial/Earnings Per Share" in the APP.

b. Further, explain where the amount identified above can be found in the Application or accompanying documents.

Response:

a. The Company's performance compensation plans align the interests of our customers, employees and shareholders. To achieve performance pay financial goals, such as targeted earnings per share ("EPS") performance, operating efficiency is paramount. That is, unless the utility controls or reduces its operating costs, it cannot achieve a targeted EPS. Well-grounded financial measures keep the organization focused on improved performance at all levels of the organization, particularly in increasing efficiency, decreasing waste, and boosting overall productivity, all of which benefit customers directly. The operational components measure performance that can most directly influence customer satisfaction, health and safety, environmental performance, and operational efficiency, which affect the Company's financial performance (e.g., long-term cost savings or avoided costs). The total test-year Kentucky American employee APP amount is $577,022.

b. See PSC 1-1. The file name is KAWC_2018_Rate Case – Labor and Related.xlsx. Within that file, see tab "Summary", Excel rows 10, 16 and 22 in Column D.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Kurt Kogler, James S. Pellock

68. Reference Kogler Direct, page 5, wherein he discusses the Company's LTPP.

a. Provide the total test-year amount attributed to the LTPP.
b. Further, explain where the amount identified above can be found in the Application or accompanying documents.

Response:

a. The test-year LTPP amount is $16,105 for KAWC employees.

b. See the response to PSC 1-1. The file name is KAWC_2018_Rate Case – Labor and Related.xlsx. Within that file, see tab "Summary", Excel row 23 in Column D.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Kurt Kogler

69. Reference Kogler Direct, generally.

a. Explain the process the Company went through to determine if the compensation and benefits proposed for recovery in this matter are in accordance and in-line with Commission precedent on these issues.

Response:

Mr. Kogler's direct testimony describes the process by which KAW sets its compensation and benefit levels. It discusses how KAW sets compensation levels such that, when performance pay is included, those levels are at or near market medians. In other words, KAW's goals is that total overall compensation is reasonable. As for benefits, Mr. Kogler's direct testimony explains the same philosophy – that KAW seeks to offer a package of retirement and welfare benefits that is reasonable in relation to KAW's competitive marketplace for employees. Not coincidentally, the Commission's precedent on compensation and benefit levels reflects that those levels must also be reasonable. Indeed, the Commission has stated on this issue, "the key word from the Commission's perspective is **reasonable.**"[1] Thus, KAW's goal of "reasonableness" is perfectly aligned with the Commission's "reasonableness" standard.

To ensure that KAW's compensation and benefits levels are reasonable as requested in this case, KAW commissioned Willis Towers Watson ("WTW") to assess those levels. Messrs. Mustich and Willig completed that study (it is attached to Mr. Mustich's testimony) and provided direct testimony in the case. That study and the accompanying WTW testimony prove that KAW's compensation and benefit levels are consistent with market, and, thus, by definition, are reasonable. Therefore, they are likewise consistent with Commission standards on this issue.

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[1] *Comments at the Kentucky Chamber of Commerce Energy Conference*, January 18, 2018, p 6, as reproduced on the Commission's website, www.psc.ky.gov, (emphasis in original).

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Kurt Kogler

70. Reference Kogler Direct, page 14. Explain why participants in the employee stock purchase plan ("ESPP"), who are currently able to acquire shares of American Water common stock at a discount of 10%, will be able to acquire those same shares at a discount of 15% beginning in May 2019.

Response:

The American Water Benefits Department regularly reviews our benefit offerings for competitive alignment. The employee stock purchase plan discount was changed after consulting a number of data sources and benchmarks such as the National Association of Stock Plan Professionals – one of the leading organizations for the stock and executive compensation professions.

We found that 15% discounts were very common – with approximately 72% of survey respondents offering this level of discount. We also looked at market data to understand the prevalence of the "lookback" feature (the practice of comparing the stock price at the beginning and end of the purchase period and selecting the lower of the prices). Although lookbacks are still common – we found that this option if less likely to be offered as the discount percentage increases. While there are examples of companies offering the "lookback" at a discount level of 15% - we made the decision to eliminate this feature as we increased the discount offering.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

71. Reference O'Neill Direct, page 3.

a. Explain why the Company has not completed a Comprehensive Planning Study since 2013.
b. Provide a copy of the most recent Comprehensive Planning Study.

Response:

a. The 2013 Comprehensive Planning Study (CPS) detailed the capital improvement recommendations for Kentucky American Water's water system for projection years 2013 through 2030. The study provided a strategy for facility improvements over the next 10 years that would ensure that the Company could continue to provide safe, adequate and reliable service to its customers.

Overall, the Comprehensive Planning Study provides a long-term plan for significant investments in the system over the course of 5 to 10 years. As such, the commissioning of an updated Comprehensive Planning Study will depend on factors such as system growth, water quality issues, regulatory requirements, condition and performance of existing infrastructure, regional opportunities, and the availability and relevance of prior planning studies. The level or type of planning will depend on the number, severity and extent of these factors and the relevance of recent planning work. Typically, the Company will update a Comprehensive Planning Study every 5 to 7 years. This allows the long-term strategy of the previous study to be completed and reduces the risk of changing objectives that could have an impact on the efficient deployment of financial resources.

b. Please see attached. The attachment is confidential and is being provided pursuant to a petition for confidential protection.

ATTACHMENT TO KAW_R_AGDR1_NUM071_012519
FILED UNDER SEAL PURSUANT TO THE PETITION FOR CONFIDENTIAL TREATMENT FILED ON
JANUARY 25, 2019

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

72. Reference O'Neill Direct, page 4, lines 4–9. Provide examples of recent and/or planned joint improvement projects with both municipalities and other utilities.

Response:

Over the past few years, Kentucky American Water has planned or performed several projects that were joint improvements with municipalities and/or with other utilities. Some of the projects are highlighted below:

West 3rd Street Main Replacement, between Blackburn Ave. and Broadway. Coordinated the improvements with Columbia Gas and shared in the cost of resurfacing following the project.

Jefferson Street Main Replacement, between West 4th Street and West 3rd Street. Coordinated the improvements with Columbia Gas and shared in the cost of resurfacing following the project.

Ross Avenue and Hampton Court Main Replacement. Coordinated the improvements with Columbia Gas and shared in the cost of resurfacing following the project.

Clays Mill Road Relocation. KAWC worked closely with Columbia Gas to identify relocations to accommodate both underground utilities in a restrictive right-of-way. Regular coordination meetings were held with LFUCG project managers, and drawings were provided between the two utilities throughout the design phase to assist with coordination. KAWC planned to share the cost of tree removal with Columbia Gas but LFUCG ultimately took on this task.

Clark County Main Extensions. KAWC coordinated extensively with the Clark County Road Department and the KY Transportation Cabinet to secure encroachment permits, street cut permits, and maintenance of traffic plans.

Town Branch Commons Relocation. KAWC met with LFUCG's utility coordination consultant firm on a bimonthly basis for approximately one year to develop relocation plans in conjunction with the many phases of the Town Branch Commons project. KAW also coordinated with Columbia Gas throughout the design phase to avoid creating new conflicts with this utility. We may potentially be sharing the cost of resurfacing with the gas company but it will depend on their construction schedule.

Georgetown NW Bypass Relocation. KAWC worked with a consultant to design utility relocation plans in conjunction with KYTC's planned bypass project. KAW also coordinated these relocations with GMWS. We will be sharing the cost of this relocation with KYTC.

Brannon Road Relocation. KAWC worked with a consultant to design utility relocation plans in conjunction with KYTC's planned roadway project. KAW also coordinated a portion of these relocations with an LFUCG sewer project occurring during the same time frame. We shared the cost of this relocation with KYTC.

East Hickman Water Main Extension. KAWC collaborated with LFUCG. An agreement was reached between KAWC and LFUCG that was mutually beneficial. LFUCG provided an easement/access to KAWC, In return for a new water main would be located to reduce the length of service line for LFUCG. This allowed for the lowering the capital costs of construction for both.

KAWC has had numerous main replacement projects that have been coordinated with the resurfacing plans of Lexington Fayette Urban County Government to reduce the amount of resurfacing required for the projects.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill / Kevin N. Rogers

73. Reference O'Neill Direct, page 5, lines 18–22.

a. In the last three years has the Company been found to be in violation of any regulations by the Commission?
b. If the response to subpart a, above, is in the affirmative, provide citations to same.
c. Are the "accepted . . . practices" the same as best practices?
d. If the response to subpart c, above, is in the negative, explain why the Company's engineering criteria is not based on best practices, and explain the basis for the different standard.
e. Explain what the Company means by "adequate capacity" and "appropriate levels of reliability."

Response:

a. The 2016 Periodic Water Inspection noted a deficiency for not having written inspections records for valves, meters and meter settings. KAW filed a formal petition requesting a deviation from this standard. KAW was able to demonstrate in the discovery and hearing that its automatic meter reading technology provides significantly more data on the health of the meter than a simple physical inspection would provide. KAW was also able to show its long standing valve inspection process has proven effective at keeping our valves in good working order in a manner that is cost effective for our customers. The Commission granted an order of approval for the deviation.

KAW received a warning letter dated November 16, 2017 for failure to report an electrical shock requiring medical treatment within two hours. In this particular situation the employee who received a shock delayed seeking medical treatment for more than two hours. KAW reported the shock when the employee requested medical treatment but unfortunately the two-hour reporting window had closed by the time the request was made. It was also noted that KAW failed to file the required written report within the required seven-day timeframe. However, KAW requested and was granted a filing extension within the seven-day timeframe in order to gather more information from external sources on the event. A follow up letter received January 16, 2018 acknowledged the filing extension had been granted within the seven-day reporting window.

b. See attached.

c. In most cases acceptable practices are considered the same as best practices. Accepted engineering standards are similar to the Recommended Standards for Water Works typically referred to as Ten State Standards since it was developed and is maintained by the Water Supply Committee of the Great Lakes – Upper Mississippi River Board of State and provincial Public Health and Environmental Managers that consist of 10 states.

d. The Company uses several sources for developing its practices, from learned knowledge of the Company and industry sources such as Ten State Standards and organizations such as American Water Works Association and others. Ultimately, engineering practices are developed that use the best practices that will meet regulation requirements and ensure the system provides reliable service to its customers.

e. The term adequate is used throughout the industry to ensure the system can meet the needs of its customer with respect to water quality, supply, flow and pressure. In these cases, to be adequate the system must demonstrate that it can meet the regulatory requirements. As examples, distribution system mains are considered adequate if they can meet customer demand at a minimum system pressure of 20 psi and storage facilities are considered adequate if the effective volume of the facility, or groups of facilities acting together, provide sufficient volume to meet equalization needs and a fire protection reserve during maximum day demand events.

Appropriate levels of reliability means the system's ability to supply safe water that meets all the regulatory requirements to its customers at all times, taking into account scheduled and reasonably expected unscheduled interruptions of system.

COMMONWEALTH OF KENTUCKY
PUBLIC SERVICE COMMISSION
UTILITY INSPECTION REPORT
Report Date: May 11, 2016
Report Number: KentuckyAmericanWaterCentralDivision-042716

BRIEF

Inspector:	Jason Pennell
Inspection Date:	April 27-28, 2016
Type of Inspection:	Periodic Regulatory Compliance Inspection
Type of Facility:	Water Treatment, Wholesaler, Purchaser, and Distribution System
Name of Utility:	Kentucky American Water
Location of Facility:	2300 Richmond Road Lexington, KY 40502
Purpose of inspection:	Periodic inspection of utility facilities operation and maintenance practices to verify compliance with PSC regulations.
Applicable Regulations:	KRS Chapter 278 and 807 KAR Chapter 5

INSPECTION

Description of Utility:	Water Treatment and Distribution System
Number of Customers:	127,750
Area of Operation:	Fayette, Jessamine, Scott, Woodford, Harrison, Bourbon, Clark, Gallatin, Grant, and Owen Counties.
Supply Source:	Kentucky River Station I and II, Richmond Road Water Treatment Plant, from Carroll County Water District #1, Gallatin County Water District, and Winchester Municipal Utilities.
Distribution Description:	Average daily consumption of approximately 33.3 million gallons; 2,011 miles of distribution line; total storage capacity of approximately 28.3 million gallons.
Workforce Summary:	132 Employees
Utility Reps. in Inspection:	David Shehee, Superintendent Water quality and Environmental Compliance, Justin Sensabaugh, Operations Manager-Production, Kevin Rogers, Vice President Operations, Jarold Jackson, Manger Field Opertations, Cody Brenneman, Operations Superintendent, Mitzi Combs, and Nathan Clark
Date of Last Inspection:	February 28, 2013
DTR from Last Inspection:	0
DTRs not Cleared:	

COMMONWEALTH OF KENTUCKY
PUBLIC SERVICE COMMISSION
UTILITY INSPECTION REPORT
Report Date: May 11, 2016
Report Number: KentuckyAmericanWaterCentralDivision-042716

FINDINGS

The Utility did not have annual written inspection records for its all of its valves or meter and meter settings as required by 807 KAR 5:006, Section 26 (6) (b).

ADDITIONAL INPECTOR COMMENTS

Utility management stated water loss was 14.3% for 2015.

During the inspection visit, the utility was made aware of the regulatory change to 807 KAR 5:006, Section 26 Section (3) which requires the addition of the date, time of inspection, and the person conducting the inspection onto inspection logs/forms of facilities. Commission Staff will verify this on the next inspection visit.

Kentucky American Water updates its leak detection program yearly to focus on older section of water lines in its system.

In 2014 Kentucky American Water received a CPCN, Case No. 2014-00258, to replace its existing filter building at the Richmond Road Water Treatment Plant with a new filter building.

In 2014 Kentucky American Water completed the connection of its Northern Division and Central Division.

Submitted by:

Jason Pennell
Utility Regulatory and Safety Investigator III

Division of Engineering
Water and Sewer Branch
Water Utility Inspection

TREATMENT FACILITY

1. **Source Water:**

The Utility's Kentucky River water treatment plant treats water from the Kentucky River (pool 9, the Kentucky River water plant II treats water from the Kentucky River (pool 3), and the Richmond Road water treatment plant treats water from the Kentucky River (pool 9) and the Jacobson Reservoir.

2. **Plant Capacity:**

The design capacity for the Kentucky River Station is 40 million gallons per day (MGD), the Richmond Road Station is 25 MGD Lexington Plants, and the Kentucky River Station II Owenton Plants is 20MGD.

3. **Avg. Amount Produced:**

Utility stated in 2015 it produced approximately 38.9 MGD.

4. **Plant Constructed:**

The Kentucky River Station treatment plant was constructed in 1958, the Richmond Road Station treatment plant 1885 and the Kentucky River Station II treatment plant 2010

5. **Plant Expansion (if any):**

None

DISTRIBUTION FACILITY

6. Source Water:

Utility's three water treatment plants provide water to its distribution system.

Utility also, purchases water from Carroll County Water District #1, Gallatin County Water District, and Winchester Municipal Utilities.

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7. Area of Operation:

Utility provides water to Fayette, Jessamine, Scott, Woodford, Harrison, Bourbon, Clark, Gallatin, Grant, and Owen Counties.

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8. Miles of Water Line

Utility stated it has approximately 2,011 miles of 2"-42" distribution line.

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9. Avg. Amount Purchased:

Utility stated in 2015 it purchased approximately 7,588,000 gallons per month.

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10. Yearly Avg. Loss:

Utility stated water loss for 2015 was approximately 14.3%.

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11. How does the utility control its water loss in the system?

The Utility stated it controls water loss by addressing known leaks in a timely manner, managing flushing, testing meters at required intervals, sizing meters appropriately and operating a full time leak detection program. Utility provides hydrant meters, temporary service installation, and water loading stations to discourage unauthorized usage.

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12. Does the utility have a proactive water loss prevention/leak detection program in place?

Yes, Utility updates its water loss prevention/leak detection program yearly.

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13. Is the utility limited by contract to purchase a minimum amount of water per month? If so, List the minimum amount:

No

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14. Is the utility limited by contract to a maximum amount of water per month? If so, what is the maximum amount allowed:

No

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15. Does the utility wholesale water to other utilities? If so, what utilities:

Utility stated it wholesales water to Georgetown Municipal Water and Sewer Service, City of Nicholasville, City of North Middletown, Bluegrass Station, Jessamine-South Elkhorn Water District, City of Midway, City of Versailles, East Clark County Water District, Harrison County Water Association, and Peaks Mill Water District.

Utility sold a total of 448.91 million gallons to its wholesale customers in 2015.

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16. List the number of customers last billing period:

Utility stated last billing period it had 127,750 customers.

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17. Number of customers listed in the last inspection:

According to the February 28, 2013, inspection the utility had 119,735 customers.

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18. List the number of potential customers not being served within your service boundary:

Utility stated it does not have any potential customers in its service area.

LAST INSPECTION FOLLOW-UP

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19. Date of last PSC inspection and number of deficiencies noted in the last report:

The last PSC inspection was February 28, 2013, and the Utility had no deficiencies.

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20. Did the utility respond to the deficiencies noted in the last inspection report?

N/A

OFFICE INFORMATION

21. Does the utility provide in its place of business a suitable area available to the public for inspection of its tariffs, rules and regulations, and statutes in accordance with 807 KAR 5:011, Section 12?

Yes

22. List any special contracts that establish rates, charges, or conditions of service not contained in the utilities tariff.

Utility stated that it has a contract with Lexington Fayette Urban County Government (LFUCG) in which the Utility provide water usage data and to perform termination of water service for delinquent sewer customers as identified by LFUCG.

23. Has the utility filed these contracts with the Commission in accordance with 807 KAR 5:011, Section13?

Yes

24. How many employees does the utility have?

As of October 2015, Kentucky American Water has 132 actual employees and is budgeted for 138 employees.

Utility Customer Relations
(807 KAR 5:006, Section 14)

25. Is the utility posting and maintaining regular business hours and providing employees to assist their customers in accordance with 807 KAR 5:006, Section 14(1)?

Yes, Utility's office is open from 8:00 a.m.-4:30 p.m. Utility also has a Customer Service Call Center that is available from 7:00 a.m.-7:00 p.m.

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26. Does the utility display its rates and conditions for service or a sign stating they are available for review in accordance with KRS 278.160(1)

Yes

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27. Is a telephone number published in all areas served (if service area extends to other counties) to permit customers to contact the utility in accordance with 807 KAR 5:006, Section 14(1)?

Yes

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28. List the employees that are designated to resolve disputes, answer questions, and negotiate partial payment plans in accordance with 807 KAR 5:006, Section14 (1)(a):

Utility stated Bethany Hungate, Deidra Hayden, Theresa Williams, and Joshua Riley are designated to resolve disputes, answer questions, and negotiate partial payment plans.

Information Available to Customers

(807 KAR 5:066, Section 2)

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29. Does the utility provide a schedule of rates for water service applicable to the service being rendered to the customer per 807 KAR 5:066, Section 2(2)?

Yes

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30. How does the utility provide information to customers on the method of reading meters per 807 KAR 5:066, Section 2(3)?

Utility provides customers with the information when the customer signs up for water.

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31. Does the utility have a history of the past meter reading of a customer for a period of two years per 807 KAR 5:066, Section 2(4)?

Yes

Customer Complaints

(807 KAR 5:006, Section 10)

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32. Is the utility keeping a record of all customer complaints in accordance with 807 KAR 5:006, Section 10?

Yes

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33. Does this record show the following in accordance with 807 KAR 5:006, Section10?

Name of complainant:
Address of complainant:
Date and nature of complaint:
Adjustment or disposition:

The complaint records contain the information outlined in 807 KAR 5:006 Section 10(2).

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34. Are complaint records kept for two (2) years from the date of resolution?

Customer complaints date back for at least 2 years.

---

35. When does the utility provide the complainant an oral or written notice of their right to file a complaint with the Commission including Commission's address and phone number for all complaints that are not resolved per 807 KAR 5:006, Section 10?

Utility stated it will provide the PSC contact information upon the request of a customer or if the customer is not satisfied with the Utility's response.

Inspection of Systems
(807 KAR 5:006, Section 26)

36. Has the utility adopted a written inspection procedure to assure safe and adequate operation of its facilities per 807 KAR 5:006, Section 26(1)?

Yes

37. Has the utility filed a copy of its inspection procedure with the Commission in accordance with 807 KAR 5:006, Section 26(1)?

Yes

38. Does the utility inspect all its facilities per 807 KAR 5:006, Section 26(6)(a), (b), and (c)?

Semiannually inspect supply wells, their motors and structures, including electric power wiring and controls for proper and safe operation.

Annually inspect all structures pertaining to purification for their safety, physical and structural integrity, and for leaks, including sedimentation basins, filters, and clear wells; chemical feed equipment; pumping equipment and water storage facilities, including electric power wiring and controls; and hydrants, mains, meters, meter settings and valves.

Monthly inspect construction equipment and vehicles for defects, wear, operational hazards, lubrication, and safety features.

No, Utility inspects large valves yearly and smaller valves every five years. Meter and meter settings are not being inspected yearly.

39. Do the inspection records identify the inspections made, deficiencies found and action taken to correct the deficiencies in accordance with 807 KAR 5:006, Section 26(3)?

Yes

40. Provide tank location, storage capacity, last inspection and maintenance performed on all storage facilities (provide copies of inspection):

	Tank and Location	Storage and Capacity Gallons	Last Inspection/ Maintenance Exterior	Last Inspection/ Maintenance Interior
1	Tates Creek Tank - Elevated	500,000	2016	2013
2	York Street Tank- Ground Storage	1,000,000	2016	2014
3	Cox Street Tank – Ground Storage	1,000,000	2016	2010
4	Cox Street Tank - Elevated	1,000,000	2016	2010
5	Mercer Road Tank - Elevated	2,000,000	2016	2010
6	Parkers Mill Road Tank - Elevated	3,000,000	2016	2015
7	Hume Road Tank – Ground Storage	3,000,000	2016	2015
8	Hall Tank - Standpipe	210,000	2016	2012
9	Muddy Ford Tank - Elevated	750,000	2016	2011
10	Sadieville Tank – Standpipe	380,000	2016	2014
11	Clays Mill Tank #1 – Ground Storage	3,000,000	2016	2015
12	Clays Mill Tank #2 – Ground Storage	3,000,000	2016	2015
13	Briar Hill Tank - Elevated	750,000	2016	1999
14	Russell Cave Tank – Ground Storage	1,000,000	2016	2005
15	Eastland Tank - Elevated	2,000,000	2016	2010

16	**Woodlake Tank – Ground Storage**	**3,000,000**	2016	**2015**
17.	**Perry Street Tank - Elevated**	**100,000**	2016	**2011**
18.	**Fairgrounds Tank - Elevated**	**400,000**	2016	**2011**
19.	**Long Ridge Tank - Standpipe**	**100,000**	2016	**Out of service**
20.	**Sparta Tank - Standpipe**	**50,000**	2016	**2007**
21.	**Elk Lake Tank - Standpipe**	**100,000**	2016	**Out of service**
22.	**Bromley Tank - Standpipe**	**177,000**	2016	**2015**
23.	**Monterey Tank - Standpipe**	**117,000**	2016	**Out of service**
24.	**Hesler Tank - Standpipe**	**237,000.**	2016	**Out of service**
25.	**New Columbus Tank - Standpipe**	**229,000.**	2016	**2010**
26.	**Wheatley Tank Standpipe**	**186,000**	2016	**2015**
27.	**Glencoe Tank - Standpipe**	**100,000**	2016	**Out of service**
28.	**Blue Moon Tank - Elevated**	**600,000**	2016	**2014**
29.	**Brock Tank - Elevated**	**300,000**	2016	**2014**

Kentucky American Water employees inspect the exterior of its water storage tanks on a quarterly basis and contracts with Tank Industry Consultants to inspect the interior and exterior of the water storage tanks every 5 years. Where it is possible Tank Industry Consultants will drain the water storage tanks to perform the inspection.

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41. Provide pump location, number of Pumps/GPM, last inspection and maintenance performed on all pumping facilities (provide copies of inspection):

	Pump Location	No. of Pumps GPM	Last Inspection/ Maintenance
1.	Parkers Mill	2 – 9 MG each	April 2016
2.	Cox Street	2 – 3 MG, 2.5 MG	April 2016
3.	Mercer Road	1 – 5 MG	April 2016
4.	Leestown Road	2 – 1.15 MG each	April 2016
5.	York Street	1 – 2.5 MG	April 2016
6.	Hume Road	3 – 6 MG, 3 MG, 3 MG	April 2016
7.	Mt. Horeb	2 – 1.15 MG each	April 2016
8.	Newtown	3 – 2 MG, 4 MG, 4 MG	April 2016
9.	Hall	2 – 0.576 MG each	April 2016
10.	Delaplain	1 – 0.864 MG	April 2016
11.	Clays Mill	2 – 9 MG each	April 2016
12.	Briar Hill	2 – 1.94 MG each	April 2016
13.	Russell Cave	3 – 1 MG, 3 MG, 3 MG	April 2016
14.	Mallard Point	2 – 0.144 MG each	April 2016
15.	Richmond Road Station	6 HS pumps – 6.5 MG, 12 MG, 4MG, 7 MG, 5.5MG, 4 MG	April 2016
16.	Kentucky River Station	6 HS pumps – 8 MG, 8 MG, 7.5 MG, 10 MG, 10 MG, 10 MG	April 2016
17.	Jacobson Reservoir	3 LS pumps – 6 MG, 6 MG, 16 MG	April 2016
18.	Kentucky River Transfer	2 T pumps – 20 MG each	April 2016

19.	Kentucky River Station	6 LS pumps – 14.4 MG each	April 2016
20.	Lake Ellerslie	2 LS pumps – 4 MG, 6 MG	April 2016
21.	Woodlake	3 – 10 MG each	April 2016
22.	Kentucky River Station II	4 HS Pumps 2 – 10 MG (VFD's) and 2 – 7 MG	April 2016
23.	Kentucky River Station II	4 LS pumps – 2 - 7 MG 2 – 10 MG VFD's	April 2016
24.	Highway 127 North	2 @ 225 GPM	April 2016
25.	127 and 227	2 @ 80 GPM	April 2016
26.	New Columbus Highway 607	2 @ 200 GPM	April 2016
27	Brock Tank Booster Station	3 @ 700 GPM VFD's	April 2016

Continuity of Service

(807 KAR 5:066, Section 4)

42. Does the utility have available dual/standby pumps capable of providing the maximum daily pumping demand of the system for use when any pump is out of service pursuant to 807 KAR 5:066, Section 4(3)

Yes

43. Will one pump meet the maximum daily demand?

No, but the pump stations that require more than one pump to meet demand have multiple pumps at the station.

44. Are both pumps operational at this time?

Utility stated all pumps are operational

45. How does utility ensure that both pumps are operational?

Preventative maintenance plans and site inspections.

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46. How does utility operate/control its pump stations?

SCADA

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47. Identify those locations of pumping stations in your system where standby pumps are not available, if any.

N/A

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48. List total storage capacity and the average daily consumption?

Utility stated its average daily consumption in 2015 was 33.3 million gallons per day and has a storage capacity of 28,286,000 gallons.

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49. Does the service interruption records contain the following information:

Date of interruption:
Cause of interruption:
Time of interruption:
Duration of interruption:
Remedy and steps taken to prevent recurrence:

Yes

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50. Does the utility inspect all service lines between the water meter and the place of consumption in accordance with 807 KAR 5:066, Section 9(3)?
If not, does the utility substitute its inspection for the inspection by an appropriate state health or local plumbing Investigator? And is proof provided to the utility?

The Utility requires a plumbing permit from the local health department for all new installations. State inspector inspects all installations.

Distribution Mains
(807 KAR 5:066, Section 8)

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51. Are all dead ends provided with a flushing device per 807 KAR 5:066, Section 8(2)? If no, how many need a flushing device?

Utility stated all dead ends are provided with a flushing device.

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52. Are all dead ends flushed at least annually per 807 KAR 5:066, Section 8(2)?

Yes

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53. Are all flush hydrants properly sized in accordance with 807 KAR 5:066, Section 8(2)?

Utility stated all flush hydrants are properly sized.

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54. Does the utility keep a maintenance record on its valves?

Yes, Utility will create a work order if a valve needs maintenance.

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55. How does the utility keep a record of its valves in its distribution system?

Utility stated that all valves have GPS points and have been assigned identification numbers.

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56. Does the utility have a periodic exercise program for its valves?

Yes

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57. How does the utility mark the location of its valves?

Utility stated valves are marked on the lid of a valve box, noting that it is a water valve. Valves are also marked with blue paint and with blue maker post in rural areas. Each valve has linear measurements associated with its physical location. GPS coordinates are also utilized.

Pressures
(807 KAR 5:066, Section 5)

58. Is the utility maintaining a recording pressure gauge in its distribution system at least one week per month per 807 KAR 5:066, Section 5(2)?

Yes, SCADA system records pressures, in parts of system, continuously. Utility also has a recordable pressure gauge that can be placed in different sections of its distribution system.

59. Do pressure charts show the date and time of beginning and ending of the test and the location at which the test was made per 807 KAR 5:066, Section 5(3)?

Yes, date and time stamps are available for all pressure recordings in SCADA system.

60. Does the pressure at any customer's service pipe anywhere in system area fall below (30) psi or exceed (150) psi per 807 KAR 5:066, Section 5(1)?

No

Access to Property
(807 KAR 5:006, Section 26)

61. Do all employees have identification that will identify them as an employee of the Utility in accordance with 807 KAR 5:006, Section 20?

Yes

62. Is the utility allowed access to all utility's equipment located on a customer's property during reasonable hours for operation and maintenance in accordance with 807 KAR 5:006, Section 20?

Utility stated it is allowed access to all its equipment located on a customer's property during reasonable hours for operation and maintenance.

Safety Program

(807 KAR 5:006, Section 25)

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63. Has the utility adopted and executed a safety program in accordance with 807 KAR 5:006, Section 25?

Yes

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64. Does the utility have on site a safety manual with written guidelines for safe working practices and procedures to be followed by utility employees in accordance with 807 KAR 5:006, Section 25(1)?

Yes, American Water has authored a Health and Safety Procedures/Practice Manual that is available to all employees. Contained within this document are safe working practices and procedures to be followed by employees.

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65. How does the utility instructed its employees in safe methods of performing their work per 807 KAR 5:006, Section 25(2)?

Kentucky American Water instructs its employees in safe methods of performing their work through a formal training program with specific training intervals.

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66. Are regularly scheduled safety meetings held? (Give schedule and last meeting date)

Yes, each department has weekly safety meetings the last meeting date was 4/25/16. American Water has implemented a near program where employees will report potential safety hazards.

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67. Do certain employees receive instruction in accepted methods of artificial respiration in accordance with 807 KAR 5:006, Section25 (3)?

Yes, all employees are certified in CPR.

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68. Identify the person responsible for the Utility's Safety Program?

Utility stated that Brad Kinckiner, Manager of Health and Safety Programs, is responsible for the Utility's Safety Program.

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69. List any work related accidents of the utility's employees within the last 12 months?

Utility provided the following summary of accidents in the past 12 months.

03/01/2016 (Report Only): Central Field Operations employee rolled ankle on uneven curb while exiting vehicle.

02/24/2016 (First Aid): Central Field Operations employee sustained a minor puncture wound to the neck from high tensile wire while moving shoring equipment.

02/02/2016 (First Aid): Central Field Operations employee sustained a minor laceration to the finger while attempting to remove tin foil from a catering container.

11/02/2015 (Report Only): Central Production employee slipped on stairs at 2400 Richmond Road and fell on knee.

10/26/2015 (Report Only): Central Field Operations employee was stung multiple times by a swarm of bees.

09/02/2015 (First Aid): Central Field Operations employee scraped arm against door hardware when entering warehouse.

08/2015 (First Aid): Central Field Operations employee slipped at worksite and sustained a laceration to leg.

08/11/2015 (OSHA Recordable): Central Field Operations employee was operating an 8" valve and sustained an acute elbow strain.

08/07/2015 (Report Only): Central Field Operations employee was stung by bees.

07/06/2015 (First Aid): Central Production employee was changing lawn mower blade when the wrench slipped, causing employee's thumb to make contact with blade and resulting in minor laceration.

06/15/2015 (Report Only): Central Field Operations employee was walking in garage when they stepped on a small rock, lost their footing, and fell.

04/28/2015 (OSHA Recordable): Central Production employee was guiding a 55 gallon barrel that was being hoisted out of the rail car at KRS I when their hand was pinched between the barrel and the rail car.

04/27/2015 (Report Only): Central Field Operations employee was lifting an excavator bucket when they dropped the bucket on their right foot.

METER READING

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70. How often and how are the utility's meters read?

Utility meters are radio read monthly by Kentucky American Water employees.

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71. Is the utility keeping a record of all meter reading information per 807 KAR 5:006, Section 7(5)?

Utility stated its meter reading information is stored in its billing software.

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72. Does the utility verify customer-read-meters at least once in a calendar year per 807 KAR 5:006, Section 7(5)(b)?

N/A

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73. Does the utility charge any flat rates for unmetered service per 807 KAR 5:006, Section 7(2)?

Flat rates are charged for public or private fire services that are unmetered. These rates are included in the Utility's tariff.

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74. Does your utility provide free or reduced rate service to any person or entity per KRS 278.170? If yes, who?

No

METER TESTING INFORMATION

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75. Does the utility make quarterly reports on forms prescribed by the Commission, of meter tests, number of customers and amount of refunds in accordance with 807 KAR 5:006, Section 4(4)?

Yes

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76. Does the utility test its own meters?

Yes

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77. Are utility employees certified by the Commission to do their own meter testing in accordance with 807 KAR 5:006, Section 17(4)?

Yes

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78. When was the last time the meter testing equipment was certified by the Public Service Commission?

October 2000

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79. Does the utility have an outside agency perform its meter testing per KAR 5:006, Section 17(2)? If yes, provide outside agency name:

Yes, Vanguard Utility Service, Inc. and ADS Environmental

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80. Has the Commission been notified?

Utility stated the Commission has been notified.

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81. Is the utility storing any or all of its meter test and historical data in a computer storage and retrieval system in accordance with 807 KAR 5:006, Section 18(4)?

Yes

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82. Does the utility keep a backup of this information? If so how often is this information backed up?

Yes, the Utility stated the information is backed up daily.

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83. Does the utility have installed at each source of supply, a suitable measuring device (master meter) per 807 KAR 5:066, Section 6(1)?

Utility stated that it has a meter at each source of supply.

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84. Who is responsible for the testing of the master meters?

Kentucky American Water is responsible for the testing of master meters.

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85. Identify master meter, location, size and date last tested.

	Master Meter Size (location)	Date Last Tested
	Venturis (KRS - N and S vaults) - 24" and 24"	11/2/2015
	Venturis (KRS II - Owenton N and S vaults) - 42" and 12"	11/13/2015
	Venturis (RRS - N and S vaults) - 24" and 24"	11/3/2015
	North Middletown (Clintonville) - 4"	4/9/2015
	North Middletown (Clintonville) - 2"	2013
	Georgetown Water and Sewer Service (Burton Rd) - 6"	5/5/2015
	Georgetown Water and Sewer Service (Burton Rd) - 2"	03/04/2013
	City of Nicholasville (Brannon Rd) - 6"	5/13/2015
	City of Nicholasville (Brannon Rd) - 1-1/2"	5/13/2015
	City of Nicholasville (Brannon Crossing) - 6"	5/13/2015
	City of Nicholasville (Brannon Crossing) - 1-	5/13/2015

	1/2"	
	City of Versailles (Huntertown Rd) - 4"	8/3/2015
	City of Versailles (Huntertown Rd) - 6"	8/3/2015
	Harrison Co. Water Assoc. (US 62) - 4"	5/15/2015
	Harrison Co. Water Assoc. (US 62) - 2"	11/3/2015
	Jessamine S Elkhorn Dist (Clays Mill Rd) - 6"	5/13/2015
	Jessamine S Elkhorn Dist (Clays Mill Rd) - 1-1/2"	5/13/2015
	Jessamine S Elkhorn Dist (Harrodsburg Rd) - 2"	02/18/2013
	Jessamine S Elkhorn Dist (Harrodsburg Rd) - 2"	02/28/2013
	City of Nicholasville (Whites Ln) - 4"	7/30/2015
	Spears Water Dist (#Spears) - 4"	07/31/2015
	City of Midway (US 421 and Winter St.) - 2"	04/18/2016
	City of Midway (US 421 and Winter St.) - 4"	4/16/2015
	East Clark Co. (Ralston Ln.) - 1	2012

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86. Is the utility testing all water meters periodically in accordance with 807 KAR 5:066, Section 16(1)?

Kentucky American Water is testing larger meters and the 5/8"x3/4" meters are being replaced every 15 years.

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87. Does the utility have a proactive written meter testing/replacement plan?

Yes

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88. In the past year, how many meters 1" and smaller has the utility tested?

Utility tested three 1" meters and 621 5/8" x 3/4" meters in 2016

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89. How does the utility insure that no 1" and smaller meter remains in service for ten years without being tested?

Utility has a deviation (Case No. 2009-00253) to test meters every 15 years. Utility stated that its Length of Service program includes reporting that will indicate which meters need to be changed. When meters are due to be changed out a service order will be generated.

Fire Departments/Fire Protection

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90. Does the utility have a tariff in place to require water users, for the purpose of fighting fires or training firefighters to any city, county, urban-county, charter county, fire protection district, or volunteer fire protection district, to maintain estimates of the amount of water used for fire protection and training, and to report this water usage to the utility on a regular basis per KRS 278.170(3)?

No, Kentucky American Water charges a monthly fee to the municipalities and home owners associations to use its fire hydrants.

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91. Do the local fire officials provide the utility with records of water used for fire protection per 807 KAR 5:095, Section 9?

Yes

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92. Does the utility provide fire hydrants for fire protection?

Yes

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93. Are fire hydrants constructed after 1992 certified as having adequate and reliable fire flows by a professional engineer with a Kentucky registration per 807 KAR 5:066, Section 10(2)(b)?

Yes

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94. Does fire protection adversely affect utility customers' service quality during use? If yes, how:

Utility stated customer's service quality is not adversely affected.

CONSTRUCTION

95. What was the last calendar year the utility performed any construction?

The last major construction project was in 2015

96. How was the project financed?

Utility stated that it self-financed the project

97. The construction project consists of:
Length of water line:
Number of pump stations:
Number of water storage facilities

The construction project consisted of a new filter building to replace the existing Richmond Road Water Treatment plant filter building.

98. Did the utility receive Commission approval for this project in accordance with KRS 278.020 or KRS 278.023?

Yes, Case No. 2014-00258

99. If yes, were as-built plans and a certified statement submitted to the Commission within 60 days of substantial project completion?

The Richmond Road Station Filter Building Replacement Project is still under construction.

100. If not, was a written opinion by Commission staff regarding ordinary course of business (807 KAR 5:001 Section 9) received by utility?

N/A

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101. Proposed construction projects:

Kentucky American Water provided the following proposed construction project information:

The major capital projects that are designated as Investments Projects (IP) that are planned to be undertaken during 2016 and 2017 are as follows:

I12-020021 Power Reliability at Remote Sites – This project includes the review of remote pumping sites and the installation of electrical power redundancy to improve reliability of critical remote pumping sites. It is expected the project will be placed in service by December 2017.

I12-020037 Chemical Storage and Feed Improvements - This project incorporates several components of chemical storage and delivery and total organic carbon (TOC) removal and will be designed to enhance the robustness and reliability of KRS I operations, and minimizing the risk of plant shutdown due to insufficient chemical storage and feed. The project is expected to enter design during 2016 and be placed in service by December 2018.

I12-020039 Georgetown Bypass and US 25 Area - This project will provide a second major supply line to Georgetown and Scott County. This project will increase the reliability of the system to these communities and allow KAWC to redirect service when the existing supply main is compromised in the future. The project also allows Georgetown and Scott County level of service to be maintained while required maintenance is performed on the Muddy Ford Tank, which is not possible with the current distribution system. The project will allow for enhanced reliability to the customers in the area including the industrial customer Toyota Manufacturing Facility. The project is expected to enter design during late 2016 and begin construction during 2017. The project is expected to be placed in service by July 30, 2018.

I12-020040 Kentucky River Station I Valve House Rehabilitation – Phase 2 - This project is the second phase of the renovation and rehabilitation of the Kentucky River Station Valve Houses. This project will make improvements to Valve Houses 3 and 4 that includes new valves and actuators; corrective measures to mitigate flooding; improved access for piping and valves; relocation of electrical panels, boxes and SCADA. The project is expected to be in service by December 31, 2016.

I12-020043 Athens Boonesboro Main Extension - This project is the replacement of several sections of main along Athens Boonesboro Road and the installation of a portion of main to complete a gap in the existing distribution system. The project will allow for more reliable service in the area and start the process that will permit KAWC to connect a portion of its service area that is currently served through a purchase water agreement with Winchester Municipal Utilities to the Company's distribution system. The project is expected to be in service by December 31, 2016.

I12-020049 Kentucky River Station I Raw Water Access – This project will install a new access to the Kentucky River Station I intake station that will replace the existing reliance on the tramway constructed in 1957. Concerns with future repair costs, ongoing maintenance cost and overall safety requires the review of the existing access and to determine additional options for gaining access for materials and personnel to the intake station. This project is expected to enter the research and design phase during late 2017 and be placed in service during 2018.

I12-020051 Kentucky River Station I High Service Pumps Replacement – The project will install replacement high service pumps at the Kentucky River Station I. The Company conducted a pumping efficiency study based on four perspectives – 1) operational perspective, 2) energy optimization, 3) energy efficiency and 4) energy demand. The analysis indicated there is room for improvement both operationally and from an energy perspective that will be addressed with the installation of the new high service pumps. The expected in service date is September 30, 2017.

I12-020055 New Circle Road Main Relocation - The Kentucky Transportation Cabinet District 7 will be performing a highway expansion/relocation on New Circle Road. The project will begin at the intersection of New Circle/Georgetown Road and will end at New Circle/Boardwalk. The project will require relocation of the 720' of 20" main and 1,135' of 12" main. The initial design of the project is complete and the Company is awaiting authorization from Kentucky Department of Transportation (KDOT) to commence construction. It is expected that the project will be placed in service by August 31, 2016 depending on the construction activities of KDOT.

WATER QUALITY/RECORDS

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102. Are all records required by PSC regulations kept in the office of the utility and available to staff of the PSC upon reasonable notice at all reasonable hours per 807 KAR 5:006, Section 24.

At the time of inspection the Utility was keeping all files at its office.

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103. Does utility have on file at its principal office an updated water distribution system map in accordance with 807 KAR 5:006, Section23?

Viewed map of utility's distribution system

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104. Does the utility have an Operation and Maintenance Manual per DOW's regulation 401 KAR 8:020, Section 2(13) and PSC regulation 807 KAR 5:066, Section 3(1)?

Yes

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105. Has the utility been in compliance with the water quality requirements of the Division of Water within the last twelve months per 807 KAR 5:066, Section 3(1)?

No

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106. If not, how many violations did the utility receive, and what were they?

According to the Division of Water website the Utility had 3 violations for electronic data upload error for bacteriological files, one HAA exceedance at an individual location, and discharge violation at the Kentucky River Station water treatment plant.

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107. Is the utility under an Agreed Order with the Division of Water?

No

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108. If yes, what are the issues?

N/A

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109. List all public notifications required by Division of Water regulations such as boil water advisories, notices, CCR, etc. that need to be reported to the Commission per 807 KAR 5:066, Section 3(4)(b)?

Utility is notifying the Commission on any notifications required by the Division of Water.

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110. Is a cross-connection prevention program available?

Viewed utility's cross connection program.

Water Shortage Response Plan
(807 KAR 5:066, Section 17)

111. Has the utility filed a Water Shortage Response Plan with the Natural Resources Cabinet?

Utility stated it has filed a copy of its Water Shortage Response Plan with the Natural Resources Cabinet.

112. Has the utility filed a copy of this plan with the Public Service Commission per 807 KAR 5:066, Section 17?

Utility has filed a copy of its Water Shortage Response Plan with the Commission.

Cyber Security

113. Has your utility developed a cyber-security strategy or written plan that includes assessing and mitigating vulnerabilities for critical infrastructure and essential business systems? Provide any available documentation.

Yes, the Utility has implemented the American Water Cyber and Information Security Policy which provides requirements for the secure use and management of all resources, technology systems and electronic communications systems.

114. Has your utility utilized any resources and/or personnel, internally or externally, specifically for assessing and/or analyzing cyber-security threats and vulnerabilities? Describe.

Utility stated that its Chief Security Officer is responsible for assessing cyber information, and data security risks.

115. Are cyber-security threats considered as part of your utility's overall continuity of service plan? Explain.

Utility stated cyber-security threats are considered part of its overall continuity of service plan.

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116. Has your utility experienced any cyber-attacks related to business or operational systems? Describe.

Utility stated it has not experienced any cyber-attacks.

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117. Identify personnel with specific responsibilities for cyber-security within your organization.

Nicholas Santillo, Vice President of Internal Audit and Chief Security Officer

Geoffrey Loftus, Manager of Information and Cyber Security

William Hill, Senior Cyber Security Analyst

Celeste Rolon, Cyber Security Analyst

Dean Graboyes, Cyber Security Analyst

James Holden, Cyber Security Analyst

Field Review: (System - Storage Tanks - Pump Stations)

Facilities Reviewed:

1.
Tank: Blue Moon
Capacity: 600,000
Condition: No Visible issues noticed

2.
Tank: Fair Grounds
Capacity: 400,000
Condition: No Visible issues noticed

3.
Tank: Bromley
Capacity: 177,000
Condition: No Visible issues noticed

4.
Tank: Eastland
Capacity: 2,000,000
Condition: No Visible issues noticed

5.
Tank: York
Capacity: 1,000,000
Condition: No Visible issues noticed

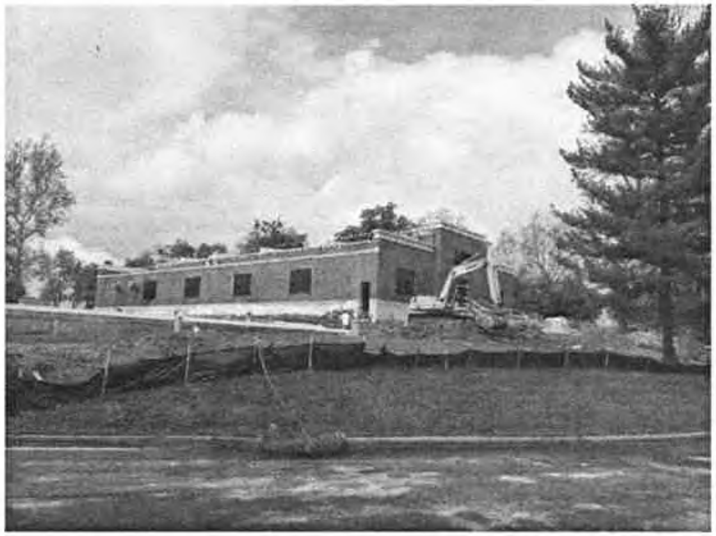
6.
Tank: Cox
Capacity: 1,000,000
Condition: No Visible issues noticed

7.
Tank: Parkers Mill

Capacity: 3,000,000
Condition: No Visible issues noticed

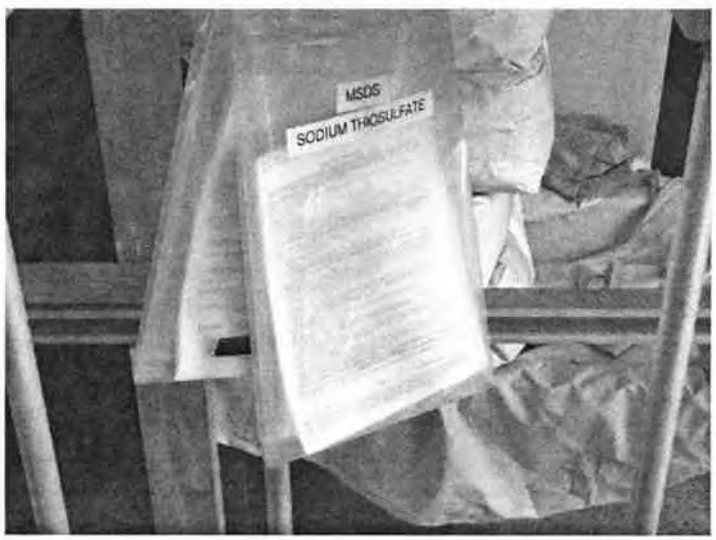
8.
Tank: Clay's Mill #1
Capacity: 3,000,000
Condition: No Visible issues noticed

8.
Tank: Clay's Mill #2
Capacity: 3,000,000
Condition: No Visible issues noticed

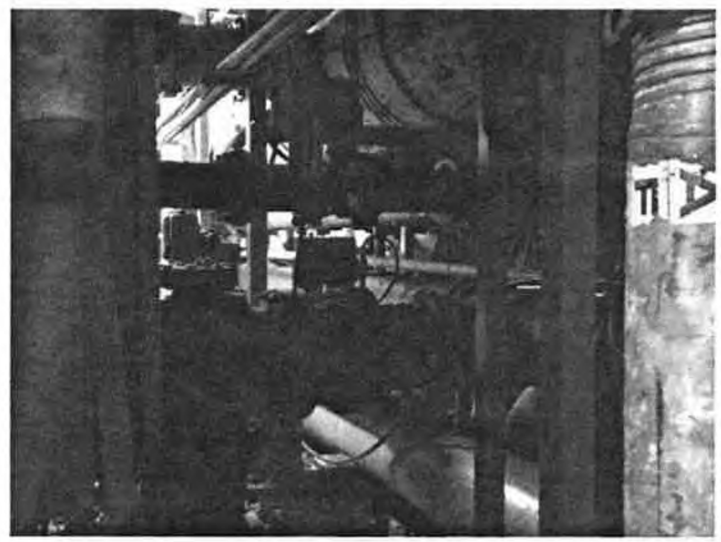


Richmond Road Water Treatment Plant New Filter Building

Richmond Road Water Treatment Plant Old Filter Building



MSDS at the Richmond Road Water Plant

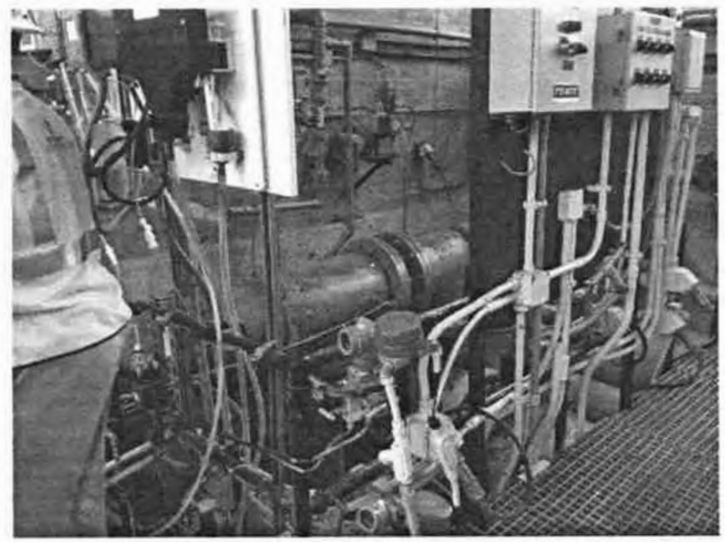


Pipe Gallery at Richmond Road Old Filter Building

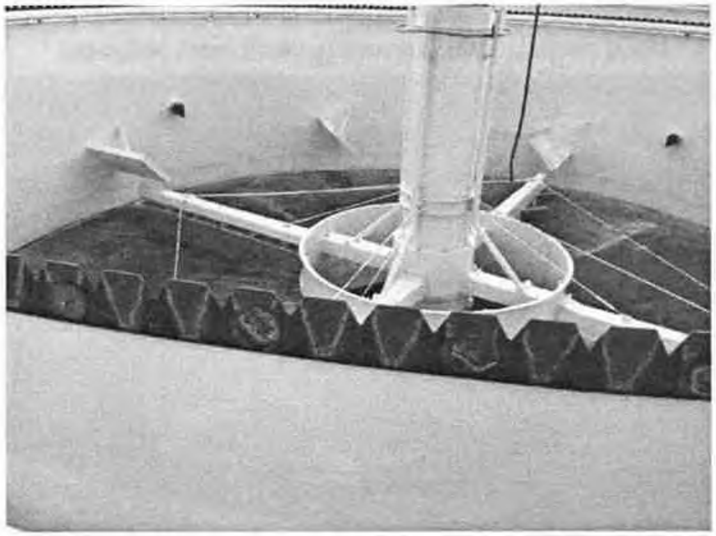
Pipe Gallery at Richmond Road New Filter Building

Raw Water Line at Kentucky River Station I Water Treatment Plant

Rehabbed Valve Room At Kentucky River Station I Water Plant



Old Valve Room at Kentucky River Station I Water Plant



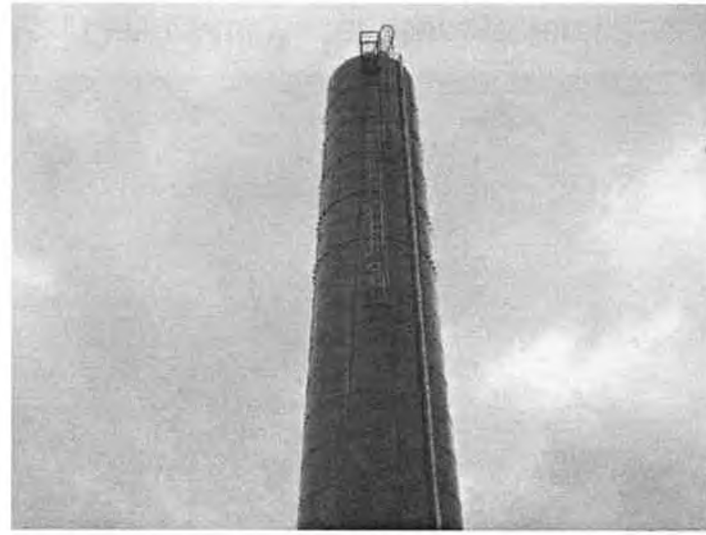
Filters at Kentucky River Station I Water Treatment Plant

Settling Basin at Kentucky River Station II Water Treatment Plant

MSDS at Kentucky River Station II Water Treatment Plant

Blue Moon Water Storage Tank

Fair Grounds Water Storage Tank



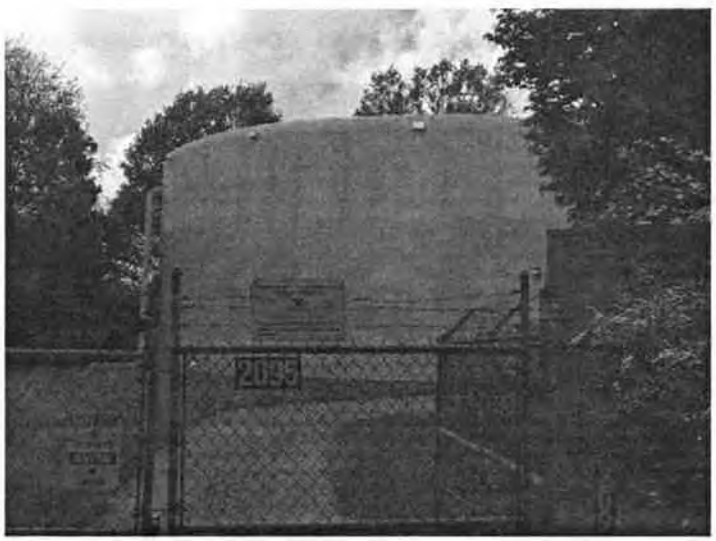
Bromley Water Storage Tank

Eastland Water Storage Tank

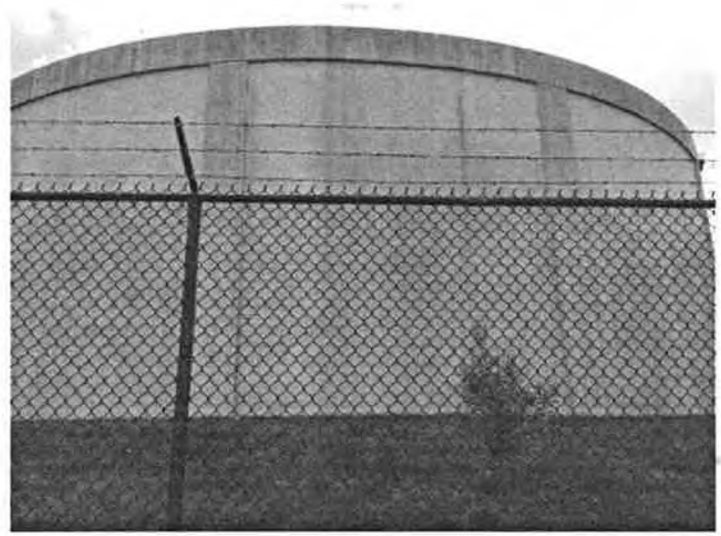
York Water Storage Tank

Cox Elevated Water Storage Tank

Parkers Mill Water Storage Tank



Clay's Mill Water Storage Tank 1



Clay's Mill Water Storage Tank 2

Matthew G. Bevin
Governor

Charles G. Snavely
Secretary
Energy and Environment Cabinet

Commonwealth of Kentucky
Public Service Commission
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Michael J. Schmitt
Chairman

Robert Cicero
Vice Chairman

Daniel E. Logsdon Jr.
Commissioner

August 5, 2016

Nick Rowe
Kentucky American Water Company
2300 Richmond Road
Lexington, KY 40502

Re: Periodic Water Inspection
Kentucky American Water Central Division water system
Fayette, Jessamine, Scott, Woodford, Harrison, Bourbon, Clark, Gallatin, Grant, and Owen Counties, KY

Dear Nick Rowe:

Public Service Commission staff performed a periodic inspection of the Kentucky American Water Millersburg water system on April, 28, 2016, reviewing utility operations and management practices pursuant to Commission regulations. The report of this inspection is enclosed with this letter.

Based on the inspector's observations, the following deficiencies were identified:

1. The Utility did not have annual written inspection records for its all of its valves or meter and meter settings as required by 807 KAR 5:006, Section 26 (6) (b).

For the one deficiency listed above, an explanation of why this deficiency occurred and how this deficiency will be remedied and prevented in the future needs to be provided. A letter addressing the organization's actions regarding this deficiency needs to be submitted within thirty days from the date of this letter.

Please review the enclosed inspection report in its entirety as you will find further information noted in regard to the inspection. If you have any questions regarding this inspection, feel free to contact Mark Rasche at 502-782-2614 or via email at Mark.Rasche@ky.gov.

Sincerely,

Talina R. Mathews

Talina R. Mathews
Executive Director
Public Service Commission

Enclosure(s)

COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION

IN THE MATTER OF:	)	
	)	
	)	
KENTUCKY-AMERICAN WATER COMPANY'S	)	
REQUEST FOR PERMISSION TO DEVIATE	)	**CASE NO. 2016-00394**
FROM 807 KAR 5:006, SECTION 26(6)(b)	)	
	)	

PETITION OF KENTUCKY-AMERICAN WATER COMPANY

In accordance with 807 KAR 5:006, Section 28, Kentucky-American Water Company ("KAW") hereby requests permission from the Commission to deviate from a portion of the requirements of 807 KAR 5:006, Section 26(6)(b). In support of this request, KAW states the following:

1. KAW is a corporation organized and existing under the laws of the Commonwealth of Kentucky with its principal office and place of business located at 2300 Richmond Road, Lexington, Kentucky 40502. KAW can be contacted by e-mail via the e-mail addresses of its counsel set forth below. KAW was incorporated on February 27, 1882, and is currently in good standing in the Commonwealth of Kentucky.

2. KAW is a wholly-owned subsidiary of American Water Works Company, Inc. ("American Water") and is engaged in the distribution and sale of water in its Central Division, consisting of Bourbon, Clark, Fayette, Harrison, Jessamine, Nicholas, Scott, and Woodford Counties and its Northern Division, consisting of Gallatin, Owen, and Grant Counties. KAW currently owns, operates, and maintains potable water production, treatment, storage, transmission, and distribution systems for the purpose of furnishing potable water for residential, commercial, industrial, and governmental users in its

service territory. KAW is also engaged in the collection of wastewater in Owen, Bourbon, Clark, and Franklin Counties.

3. Pursuant to 807 KAR 5:006, Section 28, KAW is requesting a deviation from the requirement in 807 KAR 5:006, Section 26(6)(b), requiring water utilities to annually inspect meters, meter settings, and valves. 807 KAR 5:006, Section 28 allows for deviations from 5:006 when “good cause” is shown. The overarching intent of the inspection requirements set forth in 807 KAR 5:006, Section 26 is to “assure safe and adequate operation of the utility’s facilities.”[1] KAW’s current system of inspecting meters, meter settings, and valves meets this objective, and requiring KAW to adhere to 807 KAR 5:006, Section 26(6)(b) would result in significant and unnecessary expenses. Thus, good cause exists to grant KAW’s requested deviation from annual inspection requirements for meters, meter settings, and valves.

4. Currently, KAW’s approximately 20,000 valves are inspected according to KAW’s valve inspection and exercising program. Plant valves and valves 30” and larger are inspected and exercised annually. Valves that are 16”-24” are inspected and exercised every two years and valves smaller than 16” are inspected and exercised every five years. These inspections include: confirming adequate access to valves; assessing the condition of the valve box, lid and operating nut; and exercising or turning the valves themselves. Any problems are identified and documented and a service request is created for the issue to be promptly resolved. Under this schedule, KAW has had a sound track record of ensuring outages are kept to a minimum and that customers receive safe and reliable service.

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[1] 807 KAR 5:006, Section 26(1).

5. Additionally, a valve failure does not present a problematic issue for several reasons. With over 2,000 miles of main, KAW has, on average, a valve every 530 feet. Therefore, in the event one valve fails to operate correctly, another valve located sufficiently nearby can be closed in the event of an emergency. Furthermore, KAW also has equipment necessary to install insertion valves in emergency situations where additional valves are not present.

6. KAW's current system of inspecting meters and meter settings also assures safe and adequate operations. All meters in KAW system are automatic meter read ("AMR") meters that are read using drive-by technology or manually read in the event of an issue with the AMR technology. The installation of AMR meters has eliminated the need for meter boxes to be accessed unless equipment failure occurs and the meter or radio requires repair or replacement. If meters and meter settings are not functioning properly, KAW would either be notified by the customer or be alerted by an abnormal change in a customer's usage. The KAW billing system has triggers in place to provide alerts of potential issues, including two consecutive estimates, three consecutive zero usage reads, or abnormal over or under usage on a bill. Thus, in essence, KAW acquires and analyzes meter functioning data as often as every month when meters are read.

7. In order to perform annual inspections of all valves, meters, and meter settings in accordance with 807 KAR 5:006, Section 26(6)(b), KAW would need significant additional staffing. As set forth in the attached estimate of labor costs alone, performing annual valve and meter inspections would increase the annual labor expenses by $514,149.12 and $274,050, respectively for a total of nearly $800,000. That amount

does not include additional expense that would be incurred as a result of increased transportation and administrative costs nor does it factor in increases that would occur when grossed up for taxes. Therefore, the major benefit that will result from allowing this deviation is a financial savings to customers. If the Commission does not allow this deviation, customers would shoulder nearly $800,000 in additional labor costs alone.

8. 807 KAR 5:006, Section 28 allows for deviations from 5:006 when "good cause" is shown. The Commission has allowed deviation from the requirements of 807 KAR 5:006 when the cost of adhering to a regulation would outweigh the benefit of adherence. For instance, in Case No. 2012-00491, the Commission approved LG&E's requested deviation from 807 KAR 5:006, Section 26(5)(b), which provides the required frequency of residential regulator inspections.[2] In that matter, LG&E stated that performing inspections that adhered to the Commission's regulation would add an incremental cost of approximately $3.5 million annually and instead proposed inspecting the regulators every one, three, or five years in conjunction with other maintenance activities.[3] The Commission noted that LG&E had "provided sufficient evidence that its proposal with regard to the regulator program will provide safe, reliable, and efficient service to its customers" and granted the deviation.[4] Similarly, in Case No. 93-435, the Commission granted a utility's request for deviation from a customer notice requirement in 807 KAR 5:006, finding that "good cause [had] been shown to support the deviation"

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[2] *In the Matter of: Application of Louisville Gas and Electric Company to Implement a Gas Regulator Inspection Program and Request for Deviation*, Case No. 2012-00491, Order at 1, 5 (Ky. PSC July 30, 2013).
[3] *Id.* at 4.
[4] *Id.*

because the utility had proposed an "adequate alternative" that was less costly than complying with the regulation.[5]

9. KAW asserts that good cause exists to grant a deviation from 807 KAR 5:006, Section 26(6)(b). KAW's current systems for inspecting meters, meter settings, and valves ensure safe, reliable, and cost-effective service. Requiring KAW to adhere with 807 KAR 5:006, Section 26(6)(b) would result in additional annual labor expense of nearly $800,000. The significant additional costs to customers to inspect valves, meters, and meter settings annually does not support the value added, and thus good cause exists to grant a deviation from the yearly inspection requirements.

WHEREFORE, KAW requests that the Commission approve its request for a deviation from the requirements of Section 26(6)(b) of 807 KAR 5:006 such that meters, meter settings, and valves may be tested using the inspection frequency set forth above.

[5] *In the Matter of: The Request of South 641 Water District for a Deviation from 807 KAR 5:006, Section 7(1)(c)*, Case No. 93-435, Order at 2 (Ky. PSC Nov. 23, 1993).

VERIFICATION

I, Kevin Rogers, Vice President of Operations for Kentucky-American Water Company, do hereby state that the statements made in this Petition are true and accurate to the best of my knowledge.

Kevin Rogers
Vice President of Operations
Kentucky-American Water Company

COMMONWEALTH OF KENTUCKY)

COUNTY OF FAYETTE)

Subscribed, sworn to, and acknowledged before me by, Kevin Rogers, Vice President of Operations for Kentucky-American Water Company, for and on behalf of said corporation, on this 17th day of November, 2016.

My Commission expires: 10/3/2020

NOTARY PUBLIC, State at Large, Ky.

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Lexington, Kentucky 40507-1801
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BY: ________________________________

Attorneys for Kentucky-American Water Company

CERTIFICATE

This certifies that Kentucky-American Water Company's electronic filing is a true and accurate copy of the documents to be filed in paper medium; that the electronic filing has been transmitted to the Commission on November 18, 2016; that a paper copy of the filing will be delivered to the Commission within two business days of the electronic filing; and that no party has been excused from participation by electronic means.

STOLL KEENON OGDEN PLLC

By________________________________

Attorneys for Kentucky-American Water Company

Kentucky American Water
Estimated Labor Costs for Additional Annual Asset Inspections

Meters - Central Division only	
Total Meters	125,518
Average Meters per Day	200
Number of Days to inspect all meters annually	628
Days per Full-time Equivalent ("FTE")	220
Total FTEs required	2.85

Central Division Valves		
Criticality	Current	Increase to Annual
High (Currently inspected annually)	0.17	0.17
Medium (Currently inspected every 2 years)	0.33	0.66
Low (Currently inspected every 5 years)	1.50	7.50
Total FTEs required	2.00	8.33

Meter Inspections	
	Proposed
Estimated Hourly Rate for Meter Maintenance	$ 38.88
Annual Hours	2,080
Estimated Annual Labor Cost	$ 80,870.40
Additional FTEs - Central	2.85
Additional FTEs - Northern	0.50
Additional Estimated Labor Cost for Annual Meter Inspections	$ 270,915.84

	Valve Inspections	
	Current	Increase to Annual
Estimated Hourly Rate for Valve Maintenance	$ 38.88	$ 38.88
Annual Hours	2,080	2,080
Annual Cost	$ 80,870.40	$ 80,870.40
Additional FTEs - Central	2.00	8.33
Additional FTEs - Northern	0.25	0.25
Additional Estimated Labor Cost for Annual Valve In:	$ 181,958.40	$ 693,868.03

Total Estimated Labor Cost Increase **$ 782,825.47**

Assumptions:
1) Costs only include labor and labor overhead for field services personnel
2) Labor Overhead rate is assumed to be 50% of hourly rate of pay
3) Estimated costs do not include additional transportation, supervisory or administrative expenses
4) Northern Division Meter and Valve Inspections have not been estimated on a per unit calculation due to the increased rural area

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

ELECTRONIC KENTUCKY-AMERICAN WATER COMPANY'S REQUEST FOR PERMISSION TO DEVIATE FROM 807 KAR 5:006, SECTION 26(6)(B)	))))	CASE NO. 2016-00394

ORDER

On November 18, 2016, Kentucky-American Water Company ("Kentucky-American") filed a Petition for Deviation ("Petition"), pursuant to 807 KAR 5:006, Section 28, through which it requests a deviation from the inspection requirements of 807 KAR 5:006, Section 26(6)(b).

On July 25, 2017, the Commission entered an Order that, among other things, set this matter for an August 22, 2017 hearing to take evidence on Kentucky-American's request for deviation.

On August 2, 2017, Kentucky-American filed a motion to reschedule the hearing date. The Commission granted the motion and entered an Order on August 7, 2017, rescheduling the hearing to October 31, 2017.

On April 28, 2016, prior to the filing of this request for deviation, Kentucky-American was cited on a Commission inspection report for failing to comply with the annual inspection requirement for meters, meter settings, and valves contained in 807 KAR 5:006, Section 26(6)(b).

Kentucky-American also filed on May 19, 2017, a Petition for Confidential Treatment of the Response to Item 1 of Commission Staff's Second Request for Information.

Kentucky-American responded to two rounds of discovery in this matter. The Commission held an evidentiary hearing on October 31, 2017, and Kentucky-American filed its responses to post-hearing data requests. The matter now stands submitted to the Commission for a decision.

BACKGROUND

807 KAR 5:006 Section 26(6)(b) requires that "[t]he utility shall annually inspect all structures. . .including meters, meter settings and valves. . . ." However, Kentucky-American currently does not have regularly scheduled physical inspections of its meters. In 2013, Kentucky-American completed a transition to an automatic meter read ("AMR") system. Prior to this, Kentucky-American meters were inspected monthly when the meters were read for billing purposes. Once the transition to an AMR meter system was complete, the monthly meter readings were performed remotely by technicians.

Regarding valves, Kentucky-American states that prior to 2015, all valves 16 inches or larger were inspected every two years, and all valves smaller than 16 inches were inspected every five years. In 2015, Kentucky-American changed the policy so that valves 16–24 inches were inspected every two years, and valves larger than 24 inches were inspected every year. The more frequent inspections of the largest valves were instituted as an acknowledgement of the critical role these valves play in the safe operation of the system.[1]

Before the 2015 change, Kentucky-American had followed the same valve-inspection schedule since at least the early 1970s.[2] When presented with a document on file with the Commission purporting to be an outline of inspection procedures for valves and meters which stated inspections were performed annually, Kentucky-American claimed it had no evidence that it had prepared or filed such a document and had no knowledge of how the Commission came to be in possession of the document.[3]

DISCUSSION

At the hearing on October 31, 2017, witnesses testified regarding Kentucky-American's current and proposed inspection procedures for its meter, meter settings and valves.

Kentucky-American has asserted that the current AMR meters do not need regularly scheduled physical inspections. When the meters are read remotely through a monthly drive-by, data from the meter is collected and analyzed, and work orders are issued immediately for any issues arising from analysis of the data. Work orders are also issued if customers call in with concerns about their meters.[4] Linda Bridwell, manager of

[1] Kentucky-American's Response to Commission Staff's Second Request for Information, (filed April 20, 2017) Item 1.

[2] Id. at Item 3.c.

[3] Id. at Item 3.a.

[4] Kentucky-American's Response to Commission Staff's First Request for Information, Item 2.a.

rates and regulations for Kentucky-American, testified that there is no significant information about the meters that could be collected from a physical inspection that is not collected from a monthly drive-by reading of the meter. Ms. Bridwell asserted that the drive-by remote readings provide more data about the proper functioning of the meters than would a physical inspection.[5]

During cross-examination, the Commission expressed concern that a utility as large as Kentucky-American had been out of compliance with the regulation since at least the 1970s, and there had been no effort made to correct the situation either by instituting policies to bring the company into compliance or by applying for a deviation. Kentucky-American provided no acknowledgment that it was out of compliance regarding this issue.

When asked about these concerns, Ms. Bridwell testified that Kentucky-American is working to develop internal processes to monitor which agencies regulate Kentucky-American, including but not limited to the Commission, and to monitor compliance with all applicable regulations. She testified that Kentucky-American would be willing to file a copy of its new policies and procedures to ensure compliance with the Commission once this internal review had been completed.[6]

Ms. Bridwell also addressed the requested deviation regarding valves. She testified that Kentucky-American believed its current valve inspection schedule met the intention of the regulation by balancing cost to customers with safety.[7] She emphasized

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[5] Video transcript of Hearing ("VTH") at 9:19:57.

[6] Id. at 9:25:55.

[7] Id. at 9:09:25.

that Kentucky-American places valves at intervals frequent enough that if one valve were to fail, there would be another nearby that could be used to shut off water flow.[8]

Kevin Rogers, vice-president of operations for Kentucky-American, testified that in 2015, Kentucky-American determined that valves 24 inches or larger needed to be inspected annually because "the risk versus the probability of failure was such that it warranted increasing a step and going to an annual inspection."[9] Prior to this, all valves larger than 16 inches were inspected every two years,[10] and valves smaller than 16 inches were inspected every five years.[11] Kentucky-American had kept this inspection schedule since at least the 1970s.[12] Mr. Rogers provided no reason as to why Kentucky-American had never been in compliance with the regulatory requirement of annual inspections for all valves, or for why it had not asked for a deviation from this requirement.

Mr. Rogers testified that there was no evidence that the appropriate regulations were consulted as a starting point in 2015, when Kentucky-American was reviewing its inspection procedures for valves larger than 24 inches.[13] Again, there was no explanation for why the regulations were not used as the logical starting point for a review of this type.

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[8] Id. at 9:30:45.
[9] Id. at 10:09:00

[10] Kentucky-American's Response to Commission Staff's Second Request for Information, Item 1.

[11] Id. at Item 3.c.

[12] Id.

[13] VTH at 10:08:04.

Kentucky-American President Nick Rowe, testified that up to this point, Kentucky-American had relied on individual regulatory agencies to alert it to a change in existing regulations. He stated that the company was planning to put into place more internal monitoring procedures so that it would no longer depend solely on outside notification of regulatory changes.[14]

FINDINGS

Based upon a review of the evidence and being otherwise sufficiently advised, the Commission finds that Kentucky-American is not in compliance with 807 KAR 5:006, Section 26(6)(b), and, in fact, may never have been in compliance. However, Kentucky-American has shown good cause, pursuant to 807 KAR 5:006, Section 28, to be permitted to deviate from this requirement.

Kentucky-American is performing monthly drive-by, remote readings of its AMR meters, which provide Kentucky-American with more frequent information on meter functioning than would an annual physical inspection. Kentucky-American is inspecting its largest and most important valves according to regulatory requirements. Concerns about less-frequent inspections of smaller valves are offset by Kentucky-American's practice of placing valves at frequent enough intervals so that if one fails, there is another close by.

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[14] Id. at 10:26:41.

CONFIDENTIALITY

On May 19, 2017, Kentucky-American filed a petition, pursuant to KRS 61.878 and 807 KAR 5:001, Section 13, requesting that the Commission grant confidential treatment of information provided by Kentucky-American in its Response to Item No. 1 of Commission Staff's Second Request for Information ("Item No.1"). The designated material is more specifically described as confidential information provided by Kentucky-American's inspection procedures used to assure safe and adequate operation of the utilities facilities.

As a basis for its request, Kentucky-American states that its valve-inspection procedures are a product of extensive time and money invested by Kentucky-American's parent company, American Water Works Company, Inc. ("AWWC"). Disclosing this information would provide an unfair commercial advantage to Kentucky-American's and AWWC's competitors. Kentucky-American has requested and been granted confidential treatment for this information in previous cases.

Having considered the petition and the material at issue, the Commission finds that the designated material contained in Item No. 1 is generally recognized as confidential or proprietary, and therefore meets the criteria for confidential treatment and is exempted from public disclosure pursuant to KRS 61.878(1)(a) and 807 KAR 5:001, Section 13.

IT IS THEREFORE ORDERED that:

1. Kentucky-American's Motion for a deviation from 807 KAR 5:006, Section 26(6)(b), on inspection of meters and meter settings is granted.

2. Kentucky-American's Motion for a deviation from 807 KAR 5:006, Section 26(6)(b), on inspection of valves is granted.

3. Kentucky-American shall file with Commission a copy of its inspection procedures within ten days of the date of this Order. These procedures shall conform to the inspection procedures and schedules testified to at the hearing held on October 31, 2017.

4. Kentucky-American shall file with the Commission its written policies or procedures relative to how it will ensure future compliance with the Commission's statutes and regulations within 30 days of the issuance of this Order.

5. Kentucky-American's petition for confidential protection for the designated material contained in Item 1 is granted.

6. The designated material contained in Item 1 shall not be placed in the public record or made available for public inspection until further Orders of this Commission.

7. Use of the material in question in any Commission proceeding shall be in compliance with 807 KAR 5:001, Section 13(9).

8. Kentucky-American shall inform the Commission if the material in question becomes publicly available or no longer qualifies for confidential treatment.

9. If a non-party to this proceeding requests to inspect the material granted confidential treatment by this Order, the Kentucky-American shall have 20 days from receipt of written notice of the request to demonstrate that the material still falls within the exclusions from disclosure requirements established in KRS 61.878. If Kentucky-

American is unable to make such demonstration, the requested material shall be made available for inspection. Otherwise, the Commission shall deny the request for inspection.

10. The Commission shall not make the requested material available for inspection for 20 days following an Order finding that the material no longer qualifies for confidential treatment in order to allow Kentucky-American to seek a remedy afforded by law.

By the Commission

ENTERED

DEC 12 2017

KENTUCKY PUBLIC
SERVICE COMMISSION

ATTEST:

Executive Director

*Honorable Lindsey W Ingram, III
Attorney at Law
STOLL KEENON OGDEN PLLC
300 West Vine Street
Suite 2100
Lexington, KENTUCKY 40507-1801

*Kentucky-American Water Company aka
2300 Richmond Road
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*Linda C Bridwell
Director Engineering
Kentucky-American Water Company aka Kentucky
2300 Richmond Road
Lexington, KY 40502

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

74. Reference O'Neill Direct, pages 6–7, where Mr. O'Neill states that the Company's capital budget is shared with the Service Company for review and suggestions. Explain why, in detail, the Company provides the capital budget with the Service Company.

Response:

Each year, each operating unit of American Water Works Company, Inc. ("American Water") develops a Capital Business Plan of specific capital investments for their operating unit that focuses on the upcoming year and extends into outer years. Kentucky-American Water performs this task and develops a specific Capital Business Plan that allows KAWC to meet its goals and ensures that it will continue to provide safe, reliable, efficient, and quality service to its areas that it services. There are numerous reviews throughout the process, with the final approval coming from American Water's executive leadership team as well as KAWC's board members. Service Company compiles the Capital Business Plan from all operating units for review by American Water.

American Water reviews each operating unit Capital Business Plans, including KAWC's, to ensure that the allocation of available financial resources are deployed efficiently to maintain a sound investment by the Company.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

75. Reference O'Neill Direct, page 6, where Mr. O'Neill discusses the "objective criteria" the Company uses to prioritize projects.

a. Provide these "objective criteria" and explain how they were formulated.

Response:

Over the years, American Water has found the ability to provide safe, reliable, efficient, and quality service to its areas that it services can be impacted significantly by capital investment. For example, plant improvements designed to meet water quality regulations will minimize the risk of NOVs and MCL violations. Projects aimed at addressing health and safety risks will minimize accidents and improve employee and customer safety. Projects designed to achieve energy efficiency can help to achieve the goals of improving the operational efficiency ratio and energy usage. Replacement of deteriorated assets can reduce the risk of system outages which helps enable high customer satisfaction.

With consideration given to being able to continue to strive to best serve our customers and the limited funds for capital investment, it became imperative that capital plans include projects that were prioritized according to the critical needs of the business.

Projects are typically prioritized based some of the following criteria:

- meet legal obligations
- reduce high risk health, safety and security vulnerabilities
- address failed or imminently failing critical assets
- address critical customer issues
- provide significant O&M efficiency with customer-beneficial revenue impact
- reduce lower risk health, safety, and security vulnerabilities
- address significant customer service issues
- enhance the reliability of critical assets
- enable the sustainable renewal of aging, failing infrastructure, supported by timely cost recovery
- reduce lower risk of service interruptions
- increase reliability
- proactively replace/repair less critical assets
- improve fire flows beyond minimum acceptable levels

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

76. Reference O'Neill Direct, page 7, where Mr. O'Neill discusses the Company's "strategic goals."

a. Explain these "strategic goals" and how they were determined.

Response:

The Company's strategic goals support its core vision of "Clean Water for Life." The vision, values and strategies were developed within the Company and provides a long-term road map of fulfilling the Company's core vision.

The strategies of American Water are:

Customers: Our customers are at the center of everything we do, helping us to shape our strategic priorities. We seek to provide them with reliable access to clean, safe, and affordable water, reflecting the value of water in everyday lives. Delivering exceptional service requires a regular dialogue with our customers to understand and meet their expectations.

Safety: The safety of our employees and our customers is the number one focus for American Water. We want every employee to choose safety on every job, every day, and for our customers to feel safe in the knowledge that their water supply is of the highest quality.

People: Maintaining an environment where our people feel valued, included and accountable is critical to our ability to serve our customers every day. We are working together to create an environment where every employee can live up to their fullest potential and feel confident that what they do directly contributes to helping the company stay strong and grow.

Operational Excellence: Our technology and operational efficiency strategy helps to ensure we are continually finding better ways to do business and providing the best services at affordable costs for our customers.

Growth: We believe that when companies grow, they can invest more in creating stable jobs, training, benefits, and infrastructure. It also ensures the owners of our company, our shareholders, continue to invest in our company.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

77. Reference O'Neill Direct, pages 13–18, where Mr. O'Neill discusses capital projects, particularly ones related to Kentucky River Station 1 and 2 ("KRS 1" and "KRS 2").

a. Briefly describe KRS 1 including its current capacity, current use, and the Company's future expectations for the station.
b. Briefly describe KRS 2 including its current capacity, current use, and the Company's future expectations for the station.
c. Provide the cost-benefit analysis that supports Investment project I12-020037-Kentucky River Station Chemical Storage and Feed Improvements.
d. Confirm that for the "major projects proposed during 2019 and 2020," all of the projects are supported by cost-benefit analyses and that the chosen solution was the least-cost option. If not so confirmed, explain in detail why not, including supporting documentation.

Response:

a. Kentucky River Station 1 was originally constructed in 1958 and is located approximately ten (10) miles southeast of the City of Lexington at the top of the Kentucky River bluff in Lock 9 Pool at river mile 167.45. Subsequent capacity upgrades in 1959, 1966 and 1980 bringing the facilities to its current rated reliable capacity to 45 mgd. The station is a conventional surface water treatment plant utilizing Aldrich purification units, which consist of upflow flocculation discharging to perimeter multi-media filters. It derives its total source of supply from the Kentucky River. Facilities to transfer raw water to the Richmond Road Station and/or Jacobson Reservoir are also located and operated at the Kentucky River Station. KRS1 is the facility with the greatest capacity for KAWC and is an integral part of serving a majority of the service area with an average daily pumping of 20 MGD between 2015 and 2017. KAWC anticipates that the facility will remain a crucial component of the system. However, as portions of the facility are reaching a life of 61 years, critical improvements will be needed to maintain the capacity and reliability of the facility.

b. The Kentucky River Station 2 (KRS-2) was constructed and placed into service in 2010 and is located approximately thirty (30) miles northwest of the City of Lexington on the Kentucky River Pool 3 at river mile 47.8. This is the newest addition to Kentucky American Water. KRS-2 has a rated (reliable) capacity of 20 mgd, with the potential for future expansion to 25 mgd. The station is a conventional surface water treatment plant utilizing flocculation, sedimentation with plate settlers, and filters. It is connected to the KAW distribution system by approximately 31 miles of 42 inch transmission main and a booster station. The water plant has flexibility to operate at variable flow ranges with the VFDs that have been installed on the pumps. The plant allows KAWC to provide reliable service to the southeastern portion of the system and provides added redundancy to the system during drought conditions and withdraw restrictions that affect KRS1 on Pool 9. KRS2 allows the KRS1 facility to operate on a lower pumping head reducing the amount of electricity that the facility uses and allowing the distribution system to operate more effectively. During 2015 to 2017, KRS2 had an average daily pumpage of 8 MGD. KAWC anticipates KRS2 to continue to improve the performance of the distribution system and be a key component in the ability to make the necessary improvements to KRS1.

c. Investment Project I12-020037 Kentucky River Station Chemical Storage and Feed Improvement Project. This project incorporates several components of chemical storage and delivery to enhance the robustness and reliability of Kentucky River Station (KRS I) operations by minimizing the risk of plant shutdown due to insufficient chemical storage and feed. A major component of the project is the transition from chlorine gas and anhydrous ammonia to the safer liquid sodium hypochlorite and aqueous ammonia. This technology has been in use effectively throughout the water industry for over 100 years, and KAWC employs best practice design and operations standards to ensure safety and reliability. However, certain gaseous chemicals can be toxic to an employee or the public if an accident occurs, and the Company seeks to move to technologies that pose less risk to employees, the public and the environment. A cost-benefit analysis was not performed on the entire project since a majority of the project is a replacement of the existing facilities that will lead to more efficient feeding of required chemicals and a safer working environment for the Company's employees. KAWC did conduct cost analysis on the change in chlorine, ammonia and caustic soda that is attached.

d. There are three additional investments proposed at KRS1 during 2019 and 2020:

I12-020076 KRS1 - Replace Incline Car: This project will replace the existing incline car at the KRS 1 that was installed in 1956. The incline car is the main means for operators and maintenance personnel to gain access the KRS 1 low service intake pumps and structure. The project will replace the existing incline car with a new installation that will address safety concerns and increase the capacity for moving personnel and equipment to the low service intake pumps and structure. A study of the improvements along with alternatives was conducted and is attached.

I12-020099 KRS1 Pump #13 Replacement: The project will replace high service pump 13 with a new high efficiency vertical turbine pump. This will enhance the ability of the KRS1 facility to match flows with system demand and improves the efficiency of the high service pumps to utilize power. A study of the cost benefit of improving the pump efficiency was conducted and is attached.

I12-020071 KRS1 Valve House Rehabilitation (Phase 5): Renovations to Valve House 4 included the installation of new valves and actuators; improvement of access to piping and valves; relocation of electrical panels, boxes and SCADA; and improved safety for future maintenance work within the valve house. The renovations placed all of the operations of valves, actuators and water quality analyzers onto a single operating floor, eliminating the need of operators and maintenance personnel to climb up and down ladders and work in confined spaces. This renovation reduced the hazards of potential falls and improved access to equipment to allow maintenance to be carried out without ladders and impact of a congested work environment. A study of the benefits for the rehabilitation of the valve house due to the work being a replacement and rehabilitation of the existing facility was not conducted.

Hazen *Memorandum*

August 18, 2017

To: Adam Tilley, P.E., Project Engineer, Kentucky American Water (KAW)
Justin Sensabaugh, Operations Manager, KAW
Brent O'Neill, P.E., Director of Engineering, KAW

From: Michael Wang, PhD, P.E., BCEE
Sara Gibson, P.E.
Alana Loughlin, P.E.
David Laliberte
Bret Casey, P.E., BCEE

Re: Evaluation of Sodium Hypochlorite Alternatives

Kentucky American Water (KAW) provides water to over 500,000 customers. Its Lexington service area is serviced by three water treatment plants: Kentucky River Station I (KRS-1), Richmond Road Station (RRS), and Kentucky River Station II (KRS-2). KRS-1 has a rated capacity of 40 million gallons per day (mgd) and has source water from the Kentucky River. RRS has a rated capacity of 25 mgd and can also pull from the Kentucky River or Jacobson Reservoir.

KAW has retained Hazen and Sawyer to evaluate and upgrade identified chemical systems at both KRS-1 and RRS. Currently, KAW utilizes gaseous chlorine at both plants but has indicated interest in converting to a liquid alternative. Table 1 details the design criteria used for initial equipment sizing.

Table 1: Design Criteria for Chlorine Facilities

	Maximum	Average	Minimum
KRS-1 WTP			
Plant Flow	45	30	15
Dose, mg/L as Cl[1]	10.9	5.9	2.8
RRS WTP			
Plant Flow[2]	30	15	6.0
Pre Dose, mg/L as Cl[1]	14.1[3]	6.7	0.67
Post Dose, mg/L as Cl[1]	3.2	2.7	2.4

[1]MORs 2013 – 2017
[2]Plant rated capacity is 25 mgd; chemical design is based on 30 mgd
[3]99th percentile

This memo evaluates sodium hypochlorite alternatives of diluted bulk storage and on-site generation with considerations for chemical properties and safety, equipment needs, and cost.

Bulk Sodium Hypochlorite

Chemical Properties and Safety

In bulk hypochlorite facilities, sodium hypochlorite at a concentration of up to 15% (trade) is delivered into bulk storage tanks. The chemical can be fed at the concentration as delivered; however, it is usually immediately diluted, typically to a concentration of 5-7%, to minimize degradation of the chemical and the resulting chlorate production and off-gassing that can occur. The diluted hypochlorite is mixed and stored in bulk tanks and then transferred to a day tank as needed. The chemical is then fed to the application points using metering pumps. Table 2 details the chemical properties of 5% sodium hypochlorite.

Table 2: 5% Sodium Hypochlorite Chemical Properties

Property	Value
Chemical Formula	$NaOCl + H_2O$
%, trade	5
Color	Light yellow
Odor	Faint bleach odor
Specific Gravity	1.1
Available Cl, lb Cl / gal	0.42
pH	>11
Freezing Point, °F	21

Sodium hypochlorite is considered corrosive to eyes, skin, and mucous membranes. Adequate ventilation should be included in design to minimize any contact with off-gassing that results from degradation.

Precautions should also be made to prevent the chemical from mixing with incompatible chemicals as this can release toxic gases.

Equipment Needs

Each bulk sodium hypochlorite facility would consist of bulk storage tanks, air mixing, water softening, a day tank, and pumps, including transfer and metering pumps. American Water Engineering Standard T-2 indicates that sodium hypochlorite tanks greater than 1,000 gallons should be constructed of fiberglass reinforced plastic (FRP). Tanks that do not exceed 1,000 gallons can be FRP or polyethylene. Piping is typically PVC/CPVC. Viton, ETFE, PTFE, PVC, and ceramic may be installed for gaskets, seals, and pumping components. Table 3 below details the equipment requirements.

Table 3: Bulk Sodium Hypochlorite Equipment Requirements

	KRS-1 WTP	**RRS WTP**
Bulk Storage		
Recommended 15-day storage, gal[1]	53,100	42,300
Number of tanks	4	4
Capacity of tank, gal	15,000	15,000
Total capacity, gal	60,000	60,000

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	KRS-1 WTP	RRS WTP
Water Softener		
Number	1	1
Day Tank		
Recommended 24-hour storage, gal[2]	6,600 – 8,200	6,500 – 7,100
Number of tanks	1	1
Capacity of tank, gal	7,000	7,000
Pumps		
Number of transfer pumps	2 (duty / standby)	2 (duty / standby)
Application Points	Rapid Mix 10 Aldrich Units Pre-Clearwell Chemical Feed Vault, *2 Pipes*	Rapid Mix, *2 Chambers* Filter Inlet Box Filtered Water Control Structure Pre-Clearwell Chemical Feed Vault
Number of metering pumps	14[3]	6[4]

[1]Average flow, max dose (T-2 Recommendation)

[2]1.25 times max flow, average dose and average flow, max dose

[3]Pump for all application points plus backup for Aldrich Units. KAW will only feed one pipe at a time in chemical feed vault. Second pump for chemical feed vault will act as backup for pre-rapid mix and chemical feed vault application points.

[4]Pump for all application points plus one backup for primary application points.

The bulk hypochlorite storage and feed system is similar to other liquid chemical systems that KAW staff already have familiarity with. Compared to on-site generation, it has less equipment to maintain and is a simpler process.

The recommended design provides complete system redundancy. The 15,000 gallon tanks provide sufficient volume for dilution of 12.5% or 15% sodium hypochlorite (trade concentration) to 5%. Typical operation would involve rotating the four tanks in sequence, always switching to the tank with the oldest delivery time. At average flow and dose, one tank would be used in approximately four days. Thus, it is anticipated the sodium hypochlorite in a tank will begin to be used approximately 12 days after the delivery and dilution (under average flow and dose conditions).

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the sodium hypochlorite storage and feed alternative. At the conceptual design level, this corresponds to an expected accuracy range of -30% to 50%; as a result, 30% contingency was included in addition to contractor overhead and profit, engineering fees, and training and start-up. Details of the cost estimate are in Table 4 below.

Table 4: Sodium Hypochlorite AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000

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Item	KRS-1	RRS
Structural	$118,000	$118,000
Architectural / HVAC	$473,000	$473,000
Bulk Storage Tanks	$145,000	$145,000
Transfer Pumps	$32,000	$32,000
Day Tank	$26,000	$26,000
Metering Pumps	$423,000	$273,000
Piping	$90,000	$60,000
Water Softener	$33,000	$33,000
Pulsair Mixing	$65,000	$65,000
Electrical / Instrumentation	$163,000	$127,000
Subtotal Construction	**$1,593,000**	**$1,377,000**
Contingency (30%)	$478,000	$414,000
Contractor OH&P (15%)	$239,000	$207,000
Total Construction	**$2,310,000**	**$1,998,000**
Engineering (10%)	$231,000	$200,000
Training & Start-Up	$3,000	$3,000
Total Capital Project Cost	**$2,544,000**	**$2,201,000**

The bulk sodium hypochlorite facilities have several pieces of equipment that will require repair or replacement during the life cycle. Table 5 below details the items specific to the bulk sodium hypochlorite system with a total present worth for annual repair / replacement cost (0% Annual Inflation, 1.5% Annual Discount).

Table 5: Bulk Sodium Hypochlorite Present Worth of Annual Repair / Replacement Cost

Item	Frequency (years)	KRS-1		RRS	
		Number of Units	*Total Cost*	*Number of Units*	*Total Cost*
Metering Pump Rebuild[1]	1	14	$34,000	6	$15,000
Metering Pump Replacement	10	14	$326,000	6	$210,000
Tank Maintenance	10	1	$4,000	1	$4,000
Present Worth of Annual Replacement Cost			**$821,000**		**$425,000**

[1]No rebuild during pump replacement

Bulk sodium hypochlorite is readily available and supplied in Kentucky or a contiguous state by many manufacturers, including Brenntag Mid-South and Univar. Currently, the cost of 12.5% sodium hypochlorite from these suppliers ranges from $155 to $186 per wet ton. Table 6 estimates the annual O&M costs for both WTPs, including chemical costs ($176 per wet ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), labor ($20 per hour), and costs from Table 5.

Table 6: Bulk Sodium Hypochlorite System Annual Cost

Item	KRS-1	RRS
Sodium Hypochlorite[1]	$440,000	$302,000
Power	$1,100	$500
Labor	$3,700	$3,700
Equipment Repairs / Replacements[2]	$34,000 - $330,000	$15,000 - $214,000
Annual O&M Costs	**$478,800 - $774,800**	**$321,200 - $520,200**

[1]Average flow, average dose
[2]Cost of equipment replacements from Table 10, based on frequency

The 20-year life cycle costs for the bulk sodium hypochlorite facilities are estimated to be $11,010,000 and $7,890,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost includes annual replacement costs as detailed in Table 5.

On-Site Hypochlorite Generation

Chemical Properties and Safety

In on-site hypochlorite generation (OSHG) facilities, salt and softened water are mixed to form a brine solution. The brine solution is passed through an electrolytic cell where a low-voltage DC current is applied to convert the brine to a dilute solution of approximately 0.8% sodium hypochlorite. The dilute sodium hypochlorite is transferred to and stored in bulk tanks and fed to the application points using metering pumps. The dilute solution produced by OSHG is stable, leading to a longer shelf life, and ease of operation with respect to the chemical feed system. Table 7 details the chemical properties of 0.8% sodium hypochlorite.

Table 7: 0.8% Sodium Hypochlorite Chemical Properties

Property	Value
Chemical Formula	$NaOCl + H_2O$
%, trade	0.8
Color	Light yellow
Odor	Faint bleach odor
Specific Gravity	1.0
Effective Density, lb Cl / gal	0.067
pH	9.0
Freezing Point, °F	32

The safety precautions for the 0.8% sodium hypochlorite solution are the same as those discussed for 5% solution, although exposure symptoms are anticipated to be minimized.

There are several additional safety concerns for the OSHG system. Hydrogen gas is a byproduct from OSHG and presents an explosion hazard. Piping system vents and exhaust blowers are required to provide prevention for this. Additionally, the electrolyzer vessels could over-pressurize so the design must incorporate the appropriate safeguards.

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Equipment Needs

Each OSHG facility would consist of brine storage, water softening, hypochlorite generators, hypochlorite storage, and pumps, including brine and solution feed pumps. This is provided as a packaged system by several vendors, including Evoqua (OSEC), Process Solutions Incorporated (Microclor), and De Nora (ClorTec). Recommended materials of construction for tanks, piping, and pumps are as described for bulk hypochlorite equipment. Table 8 below details the equipment requirements.

Table 8: On-Site Generation Equipment Requirements

	KRS-1 WTP	RRS WTP
Brine Saturator		
Recommended 31-day storage, tons[1]	70	55
Number of saturators	1	1
Capacity of saturators, tons	80	72
Number of brine pumps	2 (duty / standby)	2 (duty / standby)
Water Softener		
Number	1	1
Hypochlorite Generator		
Max Demand, lb/day[2]	4,100	4,400
Number of Generators	3	3
Capacity of Generator, lb/day	2,400	2,400
Hypochlorite Storage		
1-Day Storage, gal[2]	62,000	65,000
Number of tanks	3	3
Capacity of tank, gal	20,000	20,000
Total capacity, gal	60,000	60,000
Pumps		
Application Points	Rapid Mix 10 Aldrich Units Pre-Clearwell Chemical Feed Vault, *2 Pipes*	Rapid Mix, *2 Chambers* Filter Inlet Box Filtered Water Control Structure Pre-Clearwell Chemical Feed Vault
Number of metering pumps	14[3]	6[4]

[1]Average flow, average dose

[2]Max flow, max dose

[3]Pump for all application points plus backup for Aldrich Units. KAW will only feed one pipe at a time in chemical feed vault. Second pump for chemical feed vault will act as backup for secondary application points.

[4]Pump for all application points plus one backup for primary application points.

The OSHG process and equipment are different from typical WTP chemical feed systems and have a higher operational complexity. The recommended design provides complete system redundancy. Under average flow and average dose conditions, the hypochlorite tanks will provide 2.7 days and 3.4 days of storage for KRS-1 and RRS, respectively.

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the OSHG alternative. Details of the cost estimate are in Table 9 below.

Table 9: On-Site Generation AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$181,000	$181,000
Architectural / HVAC	$735,000	$735,000
OSHG Package	$2,208,500	$2,191,000
Piping	$90,000	$60,000
Electrical / Instrumentation	$643,000	$634,000
Subtotal Construction	**$3,882,500**	**$3,826,000**
Contingency (30%)	$1,165,000	$1,148,000
Contractor OH&P (15%)	$583,000	$574,000
Total Construction	**$5,630,500**	**$5,548,000**
Engineering (10%)	$564,000	$555,000
Training & Start-Up	$10,000	$10,000
Total Capital Project Cost	**$6,204,500**	**$6,113,000**

The OSHG facilities have many pieces of equipment that will require repairs and replacements during the life cycle. Table 10 below details the items specific to the OSHG system with a total present worth for annual repair / replacement cost (0% Annual Inflation, 1.5% Annual Discount).

Table 10: On-Site Generation Present Worth of Annual Repaid / Replacement Cost

Item	Frequency (years)	KRS-1		RRS	
		Number of Units	*Total Cost*	*Number of Units*	*Total Cost*
Water Softener Media Replacement	5	3	$1,200	3	$1,200
Brine Pump Rebuild[1]	1	2	$2,800	2	$2,800
Brine Pump Replacement[2]	5	2	$9,000	2	$9,000
Valve Replacement[2,3]	3	2	$2,000	2	$2,000
Accessory Replacement[2,4]	5	2[5]	$3,500	2[5]	$3,500
Tank Blower Replacement[2]	10	2	$4,800	2	$4,800
Generator Blower Replacement[2]	10	2	$6,800	2	$6,800
Cell Replacement[2]	7	10	$108,000	10	$108,000

Item	Frequency (years)	KRS-1		RRS	
		Number of Units	*Total Cost*	*Number of Units*	*Total Cost*
Piston Metering Pump Rebuild[1]	1	11	$12,100	0	$0
Piston Metering Pump Replacement[6]	10	11	$88,000	0	$0
Peristaltic Metering Pump Rebuild[1,7]	1	3	$18,000	6	$36,000
Peristaltic Metering Pump Replacement	10	3	$103,500	6	$207,000
Tank Maintenance	10	1	$4,000	1	$4,000
Present Worth of Annual Replacement Cost			**$920,000**		**$1,025,000**

[1]No rebuild during pump replacement
[2]Minimum frequency
[3]Water solenoid valve, brine solenoid valve, brine check valve, hypochlorite check valve
[4]Water rotameter, brine rotameter, cell level switch, cell temperature sensor
[5]Five cell level switches
[6]Pumps for Aldrich Unit application points
[7]Every three months

Bulk salt (sodium chloride) is readily available and supplied in Kentucky or a contiguous state by many manufacturers, including Cargill, Gunther Salt Co, and Nalco Company. Currently, the cost of salt from these suppliers is approximately $180 per ton. Table 10 estimates the annual O&M costs for both WTPs, including chemical costs ($180 per ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), labor ($20 per hour), and costs from Table 9.

Table 10: On-Site Generation System Annual Cost

Item	KRS-1	RRS
Salt[1]	$146,000	$116,000
Power[2]	$69,000	$58,000
Labor	$3,700	$3,700
Equipment Repairs / Replacements[3]	$32,900 - $220,800	$38,800 - $236,300
Annual O&M Costs	**$251,600 - $439,500**	**$216,500 - $414,000**

[1]Average flow, average dose; 3 pounds per pound of chlorine
[2]2 kWh per pound of chlorine, average flow, average dose
[3]Cost of equipment replacements from Table 10, based on frequency

The 20-year life cycle costs for the OSHG facilities are estimated to be $10,880,000 and $10,190,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost includes annual replacement costs as detailed in Table 9.

The following Table 11 summarizes and compares the findings for the hypochlorite alternatives.

Table 11: Bulk Hypochlorite and On-Site Generation Comparison

	Bulk Hypochlorite	On-Site Generation
Chemical Properties	5% sodium hypochlorite solution	0.8% sodium hypochlorite solution
Safety	Corrosive	Mildly corrosive Hydrogen gas explosion hazard

	Bulk Hypochlorite	On-Site Generation
O&M Considerations	Similar to other liquid chemical systems Degradation challenges	More complex, new type of system
Equipment Needs	Bulk and day storage tanks Water softener Pumps	Hypo and brine storage tanks Water softener Hypochlorite generators Pumps
Capital Cost	$4,745,000	$12,317,500
Annual Cost	$800,000 - $1,295,000[1]	$468,100 - $853,500[1]
Life Cycle Cost	$18,900,000	$21,070,000

[1]Range based on frequency of equipment replacements in Table 10

Bulk sodium hypochlorite is more corrosive than hypochlorite produced with an OSHG system due to the difference in solution concentration. However, an OSHG system produces hydrogen gas which can pose an explosion hazard. A bulk hypochlorite storage and feed system is similar to other liquid chemical feed systems and thus will be the most familiar to operators. The OSHG system has additional equipment and is more complex to operate and maintain.

Capital costs for the OSHG systems at KRS-1 and RRS are significantly more than bulk hypochlorite. The estimated annual costs of a bulk hypochlorite system, predominantly the chemical cost, exceeds the annual costs for an on-site generation system. Thus, life cycle costs for the alternatives are similar.

Hazen Memorandum

August 18, 2017

To: Adam Tilley, P.E., Project Engineer, Kentucky American Water (KAW)
Justin Sensabaugh, Operations Manager, KAW
Brent O'Neill, P.E., Director of Engineering, KAW

From: Michael Wang, PhD, P.E., BCEE
Sara Gibson, P.E.
Alana Loughlin, P.E.
David Laliberte
Bret Casey, P.E., BCEE

Re: Evaluation of Liquid Ammonium Hydroxide versus Liquid Ammonium Sulfate

Kentucky American Water (KAW) provides water to over 500,000 customers. Its Lexington service area is serviced by three water treatment plants: Kentucky River Station I (KRS-1), Richmond Road Station (RRS), and Kentucky River Station II (KRS-2). KRS-1 has a rated capacity of 40 million gallons per day (mgd) and has source water from the Kentucky River. RRS has a rated capacity of 25 mgd and can also pull from the Kentucky River or Jacobson Reservoir.

KAW has retained Hazen and Sawyer to evaluate and upgrade identified chemical systems at both KRS-1 and RRS. Currently, KAW utilizes gaseous anhydrous ammonia at both plants but wants to convert to a liquid alternative. Table 1 details the design criteria used for initial equipment sizing.

Table 1: Design Criteria for Ammonia Facilities

	Maximum	Average	Minimum
KRS-1 WTP			
Plant Flow	45	30	15
Dose, mg/L as NH_3[1]	1.6[2]	1.0	0.22
RRS WTP			
Plant Flow[3]	30	15	6.0
Dose, mg/L as NH_3[1]	1.7[3]	1.1	0.31

[1]MORs 2013 - 2017
[2]99th percentile
[3]Plant rated capacity is 25 mgd; chemical design is based on 30 mgd

This memo evaluates both liquid ammonium hydroxide and liquid ammonium sulfate (LAS) with considerations for chemical properties and safety, storage requirements, and availability and cost.

Liquid Ammonium Hydroxide

Chemical Properties and Safety

The chemical properties of liquid ammonium hydroxide, commonly known as aqua ammonia, are detailed in Table 2 below. The high pH indicates a basic solution which can minimize the amount of pH adjustment needed to optimize monochloramine formation. The low boiling point indicates that aqua ammonia is a highly volatile solution and is considered to be instable. As a result, aqua ammonia must be properly stored in order to provide a consistent residual product when forming monochloramines.

Table 2: Liquid Ammonium Hydroxide Chemical Properties

Property	Value
Chemical Formula	$NH_4OH + H_2O$
Concentration	18.5 – 30
Color	Clear
Odor	Strong, pungent ammonia odor
Specific Gravity	0.90 – 0.93
pH	10.6 – 11.7
Boiling Point, °F	82.8

Dosing consideration should include determining the actual concentration of nitrogen for an ammonia solution as only the nitrogen component is involved in the formation of chloramines. For example, a 19% aqua ammonia solution has 14.7% available nitrogen.

Aqua ammonia is considered hazardous and requires special handling and safety procedures. It can cause severe irritation to the lungs if inhaled. Appropriate venting must be implemented to ensure proper safety precautions in the event the chemical is stored indoors. Additionally, skin and eye contact with aqua ammonia may cause severe irritation and burns.

Due to safety concerns, aqua ammonia is subject to strict Occupational Safety and Health Administration (OSHA) regulation and, depending on the quantity stored on site, may require an emergency plan to be filed with the State. Regulations are triggered if storage quantities are greater than 20,000 pounds and at concentrations of 20% or more. As a result, the majority of WTPs that utilize aqua ammonia use a 19% solution.

Equipment Needs

The volatility of aqua ammonia requires it to be contained in pressurized storage tanks. Common tank materials of construction include carbon or stainless steel. American Water Engineering Standard T-2 (*Liquid Chemical Storage, Feed, and Containment*) recommends carbon steel piping for aqua ammonia. Teflon, EPDM, neoprene, and stainless steel may be installed for gaskets, seals, and pumping components.

Table 3 below details the equipment requirements.

Table 3: Aqua Ammonia Equipment Requirements

	KRS-1 WTP	RRS WTP
Bulk Storage		
Recommended 30-day storage, gal[1]	8,000	5,700
Number of tanks	1	1
Capacity of tank, gal[2]	10,000	10,000
Day Tank		
Recommended 24-hour storage, gal[3]	330	190 – 240
Number of tanks	1	1
Capacity of tank, gal	400	300
Pumps		
Number of transfer pumps	2 (duty / standby)	2 (duty / standby)
Application Points	Pre-Clearwell Chemical Feed Vault *2 Pipes*	Pre-Clearwell Chemical Feed Vault
Number of metering pumps	2[4]	2

[1]KRS-1: max flow, average dose; RRS: max flow, average dose
[2]Provides volume for full delivery load of 6,500 gallons
[3]1.25 times max flow, average dose and average flow, max dose
[4]KAW will feed ammonia into one pipe in the chemical feed vault

The recommended design provides system redundancy from the transfer pumps to the application points.

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the aqua ammonia storage and feed alternative. At the conceptual design level, this corresponds to an expected accuracy range of -30% to 50%; as a result, 30% contingency was included in addition to contractor overhead and profit, engineering fees, and training and start-up. Details of the cost estimate are in Table 4 below.

Table 4: Aqua Ammonia AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$30,000	$30,000
Architectural / HVAC	$105,000	$105,000
Bulk Storage	$86,000	$86,000
Transfer Pumps	$19,000	$19,000
Day Tank	$33,000	$33,000
Metering Pumps	$65,000	$65,000

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Item	KRS-1	RRS
Piping	$65,000	$65,000
Electrical / Instrumentation	$54,000	$54,000
Subtotal Construction	**$482,000**	**$482,000**
Contingency (30%)	$145,000	$145,000
Contractor OH&P (15%)	$73,000	$73,000
Total Construction	**$700,000**	**$700,000**
Engineering (10%)	$70,000	$70,000
Training & Start-Up	$3,000	$3,000
Total Capital Project Cost	**$773,000**	**$773,000**

Aqua ammonia is readily available and supplied in Kentucky or a contiguous state, including from Airgas (IL, IN, OH, TN, and VA), Brenntag Mid-South (KY and MO), Tanner Industries (IL), and Univar (OH and VA). The cost of aqua ammonia from these suppliers ranges from $153 to $280 per wet ton, or $0.58 to $0.90 per lb of nitrogen. KAW currently utilizes aqua ammonia at their third WTP and pays $184 per wet ton. Table 5 estimates the annual O&M costs for both WTPs, including chemical costs ($184 per wet ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), and labor ($20 per hour).

Table 5: Aqua Ammonia System Annual Cost

Item	KRS-1	RRS
Aqua Ammonia[1]	$46,000	$25,000
Power	$300	$300
Labor	$4,000	$4,000
Annual O&M Costs	**$50,300**	**$29,300**

[1]Average flow, average dose

The 20-year life cycle costs for the aqua ammonia facilities are estimated to be $1,640,000 and $1,280,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost does not include annual equipment maintenance or repair.

Liquid Ammonium Sulfate

Chemical Properties and Safety

Table 6 below details chemical properties of LAS. The low pH indicates an acidic solution which could require additional pH adjustment to achieve the desired finished water pH for monochloramine formation. However, WTPs that have converted to LAS have indicated that there was not a noticeable change in pH adjustment needed to maintain their pH goals. LAS has a high boiling point which indicates that it is a non-volatile solution but the freezing point can cause design challenges in colder regions. Unlike aqua ammonia which experiences vapor loss, all of the ammonia in LAS remains bound in solution. As a result, the use of LAS to form monochloramine provides a consistent residual product.

Table 6: Liquid Ammonium Sulfate Chemical Properties

Property	Value
Chemical Formula	$(NH_4)_2SO_4 + H_2O$
Concentration	15 – 40
Color	Clear
Odor	Odorless
Specific Gravity	1.11 – 1.28
pH	3.0 – 5.0
Freezing Point, °F	10.4

Dosing consideration should include determining the actual concentration of nitrogen for an ammonia solution as only the nitrogen component is involved in the formation of chloramines. For example, a 40% LAS solution has 8.46% available nitrogen.

LAS may cause eye and skin irritation. Inhalation of LAS mists may also cause irritation to the respiratory tract.

Equipment Needs

The non-volatility of LAS does not require it to be contained in pressurized storage tanks; it can be stored in polyethylene or fiberglass reinforced plastic. LAS is corrosive to stainless steel, copper, cast iron, Tygon, Viton, nylon, brass and alloys. Piping for an LAS system is typically polyethylene or PVC/CPVC. Neoprene, rubber, EPDM, and PVC, may be installed for gaskets, seals, and pumping components.

Table 7 below details the equipment requirements.

Table 7: Liquid Ammonium Sulfate Equipment Requirements

	KRS-1 WTP	RRS WTP
Bulk Storage		
Recommended 30-day storage, gal[1]	11,200	6,200
Number of tanks	1	1
Capacity of tank, gal	12,000	7,000
Day Tank		
Recommended 24-hour storage, gal[2]	460	260 – 340
Number of tanks	1	1
Capacity of tank, gal	500	350
Pumps		
Number of transfer pumps	2 (duty / standby)	2 (duty / standby)
Application Point	Pre-Clearwell Chemical Feed Vault *2 Pipes*	Pre-Clearwell Chemical Feed Vault
Number of metering pumps	2[3]	2

[1]KRS-1: max flow, average dose; RRS: average flow, max dose

[2]1.25 times max flow, average dose and average flow, max dose
[3] KAW will feed ammonia into one pipe in the chemical feed vault

The recommended design provides system redundancy from the transfer pumps to the application points.

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the LAS storage and feed alternative. Details of the cost estimate are in Table 8 below.

Table 8: Liquid Ammonium Sulfate AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$30,000	$30,000
Architectural / HVAC	$105,000	$105,000
Bulk Storage	$39,000	$20,000
Transfer Pumps	$19,000	$19,000
Day Tank	$3,000	$3,000
Metering Pumps	$65,000	$65,000
Piping	$40,000	$40,000
Electrical / Instrumentation	$34,000	$34,000
Subtotal Construction	**$360,000**	**$341,000**
Contingency (30%)	$108,000	$103,000
Contractor OH&P (15%)	$54,000	$52,000
Total Construction	**$522,000**	**$496,000**
Engineering (10%)	$53,000	$50,000
Training & Start-Up	$3,000	$3,000
Total Capital Project Cost	**$578,000**	**$549,000**

LAS can be supplied by Brenntag Mid-South (IN, KY, and MO) and in smaller volumes by Hawkins Incorporated (Illinois) and Water Solutions Unlimited (Indiana). Currently, the cost of LAS from Brenntag ranges from $280 to $420 per wet ton, or $1.66 to $2.48 per lb of nitrogen (Indiana American Water currently receives LAS for $280 per wet ton). Hawkins and Water Solutions Unlimited indicated the ability to deliver larger volumes should they contract with KAW; however, their cost estimate currently ranges from $605 to $739 per wet ton. Table 9 estimates the annual O&M costs for both WTPs, including chemical costs ($280 per wet ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), and labor ($20 per hour).

Table 9: Liquid Ammonium Sulfate System Annual Cost

Item	KRS-1	RRS
Liquid Ammonium Sulfate[1]	$129,000	$70,000

Item	KRS-1	RRS
Power	$300	$300
Labor	$4,000	$4,000
Annual O&M Costs	**$133,300**	**$74,300**

[1]Average flow, average dose

The 20-year life cycle costs for the liquid ammonium sulfate facilities are estimated to be $2,870,000 and $1,830,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost does not include annual equipment maintenance or repair.

Conclusions

The following Table 10 summarizes and compares the findings for the ammonia alternatives.

Table 10: Aqua Ammonia and LAS Comparison

	Aqua Ammonia	LAS
Chemical Properties	18.5 – 30% solution High pH Low boiling point Can form inconsistent residual product	15 – 40% solution Low pH High boiling point Forms consistent residual product
Safety	Hazardous Potential OSHA regulations	Irritant
O&M Considerations	Readily available by numerous suppliers Similar to other liquid chemical systems	Supplier limitations Similar to other liquid chemical systems
Equipment Needs	Pressurized bulk and day tanks Pumps	Non-pressurized bulk and day tanks Pumps
Capital Cost	$1,546,000	$1,127,000
Annual Cost	$79,600	$207,600
Life Cycle Cost	$2,920,000	$4,700,000

In general, aqua ammonia is more hazardous than LAS. While costs for pumps would be similar for both systems, storage costs for aqua ammonia are higher to provide pressurized storage tanks, associated pressure relief equipment, and carbon steel piping. LAS can utilize plastic bulk chemical storage tanks and less expensive materials of construction. Theoretically, based on stoichiometric calculations, aqua ammonia chemical costs are approximately 35 percent of the cost of LAS per pound of available nitrogen in solution. However, this cost difference may be less considering the potential concentration reduction for the aqua ammonia product to off-gas during transport, loading/unloading, and storage activities. Due to aqua ammonia volatilization, KAW may purchase larger quantities than what would be expected based on typical ammonia dose and treatment rates. This may be particularly evident in warmer months when aqua ammonia off-gassing rates would be higher.

Through proper handling, storage, and feed, both chemicals may be used to produce an acceptable finished water monochloramine residual that will meet the needs of KAW. The significant difference in capital and O&M costs for an LAS system should be compared to the KAW safety concerns with an aqua ammonia system.

Hazen Memorandum

August 30, 2017

To: Adam Tilley, P.E., Project Engineer, Kentucky American Water (KAW)
Justin Sensabaugh, Operations Manager, KAW

From: Michael Wang, PhD, P.E., BCEE
Sara Gibson, P.E.
Alana Loughlin, P.E.
David Laliberte
Bret Casey, P.E., BCEE

Re: Evaluation of Sodium Hydroxide versus Liquid Lime

Kentucky American Water (KAW) provides water to over 500,000 customers. Its Lexington service area is serviced by three water treatment plants: Kentucky River Station I (KRS-1), Richmond Road Station (RRS), and Kentucky River Station II (KRS-2). KRS-1 has a rated capacity of 40 million gallons per day (mgd) and has source water from the Kentucky River. RRS has a rated capacity of 25 mgd and can also pull from the Kentucky River or Jacobson Reservoir.

KAW has retained Hazen and Sawyer to evaluate and upgrade identified chemical systems at both KRS-1 and RRS. Currently, KAW utilizes sodium hydroxide at both plants but is considering conversion to liquid lime as it is considered safer, less expensive, and provides more stable pH control. Historical finished water pH at both plants ranges from 6.8 to 7.9 with an average of 7.3. A recent optimization study recommended that KAW target a finished water pH of 7.8. Table 1 details the design criteria used for initial equipment sizing for both chemicals with the new target pH. This is based on experience and theoretical estimations with considerations to historical plant data included pH and alkalinity. It is recommended that bench scale testing be performed to confirm anticipated chemical demands to achieve the finished water pH.

The estimated liquid lime dose was determined using AWWA standard conversion factors from the historical sodium hydroxide doses. Several liquid lime suppliers have the capability to carry out on-site testing to confirm the anticipated liquid lime dose prior to a conversion. If KAW would be interested in refining the dosage rate of liquid lime, the supplier could run tests to refine the dosage rates required for KAW finished water. The client typically pays for chemical costs during the testing period but not for the equipment.

Table 1: Design Criteria for pH Adjustment Chemical Facilities

	Maximum	Average	Minimum
KRS-1 WTP			
Plant Flow	45	30	15
Dose, mg/L as Sodium Hydroxide	54	20	0.40
Dose, mg/L as Liquid Lime[1]	50	19	0.37

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	Maximum	Average	Minimum
RRS WTP			
Plant Flow[2]	30	15	6.0
Dose, mg/L as Sodium Hydroxide	55	10	1.0
Dose, mg/L as Liquid Lime[1]	51	9.3	0.90

[1]Calcium carbonate conversion factors: to sodium hydroxide: 1.25, to liquid lime: 1.35

[2]Plant rated capacity is 25 mgd; chemical design is based on 30 mgd

This memo evaluates maintaining caustic versus converting to liquid lime with considerations for chemical properties and safety, storage requirements, and availability and cost.

Sodium Hydroxide

Chemical Properties and Safety

The chemical properties of sodium hydroxide, commonly known as caustic, are detailed in Table 2 below. The high pH allows it to be used for pH adjustment when the process water pH needs to be increased. The high freezing point temperature of 50% sodium hydroxide can cause challenges for some systems; thus, caustic is also available at lower concentrations or it can be diluted upon delivery.

Table 2: Sodium Hydroxide Chemical Properties

Property	Value
Chemical Formula	$NaOH + H_2O$
Concentration	50%
Color	Clear
Odor	Odorless
Specific Gravity	1.525
pH	14
Freezing Point	54°F

Exposure to sodium hydroxide can cause severe burns to the skin and eyes, necessitating proper protective equipment and emergency shower and eyewash units in the system area. The caustic health hazard classification is corrosive, so a sprinkler system is generally required for indoor storage of more than 500 gallons. Additionally, considerable heat is generated in the dilution process. Thus, any design that involves dilution should include the appropriate materials and methods for this temperature increase.

Equipment Needs

Each sodium hydroxide facility would consist of bulk storage tanks, a day tank, and pumps. Common tank materials of construction for undiluted 50% sodium hydroxide, which is KAW’s preferred concentration for storage and feed, include polyethylene, fiberglass reinforced plastic (FRP), and carbon steel. Piping is typically PVC/CPVC or carbon steel. EPDM, Buna N, Hypalon, Noryl, PVDF, and PVC may be installed for gaskets, seals, and pumping components. Table 3 below details the equipment requirements.

Table 3: Sodium Hydroxide Equipment Requirements

	KRS-1 WTP	RRS WTP
Bulk Storage		
Recommended 30-day storage, gal[1]	35,400	11,800
Number of tanks	2	1
Capacity of tank, gal	18,000	12,000
Total capacity, gal	36,000	12,000
Day Tank		
Recommended 24-hour storage, gal[2]	1,500 – 2,700	500 – 1,400
Number of tanks	1	1
Capacity of tank, gal	2,000	1,200
Pumps		
Number of transfer pumps	2 (duty / standby)	2 (duty / standby)
Application Points	Pre-Rapid Mix Pre-Clearwell Chemical Feed Vault, *2 Pipes*	Rapid Mix, *2 Chambers* Pre-Clearwell Chemical Feed Vault
Number of metering pumps	3[3]	4[4]

[1]Max flow, average dose

[2]1.25 times max flow, average dose and average flow, max dose

[3]KAW will only feed one pipe at a time in chemical feed vault. Second pump for chemical feed vault will act as backup for all application points.

[4]Pump for each application point plus a backup.

The recommended design provides complete system redundancy for both plants (downstream of the bulk tank for RRS). The existing bulk and day tank storage volumes at the KRS-1 WTP are 12,000 and 300 gallons, respectively. Although a new caustic system for KRS-1 is not part of this project scope, the existing system does not meet the storage recommendations in Table 3.

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the caustic storage and feed alternative. At the conceptual design level, this corresponds to an expected accuracy range of -30% to 50%; as a result, 30% contingency was included in addition to contractor overhead and profit, engineering fees, and training and start-up. Details of the cost estimate are in Table 4 below.

Table 4: Sodium Hydroxide AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$62,000	$30,000

Item	KRS-1	RRS
Architectural / HVAC	$237,000	$105,000
Bulk Storage	$120,000	$39,000
Transfer Pumps	$32,000	$32,000
Day Tank	$8,000	$6,000
Metering Pumps	$182,000	$182,000
Piping	$50,000	$50,000
Electrical / Instrumentation	$79,000	$62,000
Subtotal Construction	**$795,000**	**$531,000**
Contingency (30%)	$239,000	$160,000
Contractor OH&P (15%)	$120,000	$80,000
Total Construction	**$1,154,000**	**$771,000**
Engineering (10%)	$116,000	$78,000
Training & Start-Up	$3,000	$3,000
Total Capital Project Cost	**$1,273,000**	**$852,000**

Sodium hydroxide is currently provided at KRS-1 for KAW at a cost of $260 per wet ton; it is readily available by numerous vendors in the region. Table 5 estimates the annual O&M costs for both WTPs, including chemical costs ($260 per wet ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), and labor ($20 per hour).

Table 5: Sodium Hydroxide System Annual Cost

Item	KRS-1	RRS
Sodium Hydroxide[1]	$475,000	$119,000
Power	$300	$300
Labor	$4,000	$4,000
Annual O&M Costs	**$479,300**	**$123,300**

[1]Average flow, average dose

The 20-year life cycle costs for the sodium hydroxide facilities are estimated to be $9,510,000 and $2,970,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost does not include annual equipment maintenance or repair.

Liquid Lime

Chemical Properties and Safety

Liquid lime is lime that has been slaked in a highly controlled, industrial setting to ensure lime milk of the highest quality and is very stable. Due to its formation in a controlled environment, liquid lime is most often produced off site and must be transported via truck or rail to the site. Table 6 below details the chemical properties of liquid lime, or calcium hydroxide. This form of lime is extremely stable and provides a very accurate means of pH control.

Table 6: Liquid Lime Chemical Properties

Property	Value
Chemical Formula	$Ca(OH)_2 + H_2O$
Concentration	30 - 35
Color	White
Odor	Odorless
Specific Gravity	1.20 – 1.24
pH	12.44
Freezing Point, °F	32

Liquid lime can cause skin irritation, respiratory irritation, and serious eye damage if exposure occurs. The liquid lime health hazard classification is corrosive, so a sprinkler system is generally required for indoor storage of more than 500 gallons. It is considered to be less hazardous than 50% sodium hydroxide.

Equipment Needs

The liquid lime system would consist of bulk storage tanks equipped with mixers, transfer pumps, a day tank equipped with a mixer, and metering pumps. Packaged feed systems can be provided by liquid lime suppliers such as Burnett, Inc, and these systems typically do not include a day tank. Conversely, individual components of the system can be purchased and installed similar to a typical liquid chemical storage and feed system. Common tank materials of construction for liquid lime include polyethylene and FRP. Piping is typically PVC. Buna N, Nylon, PTFE, PVDF, PVC, and Viton may be installed for gaskets, seals, and pumping components. Table 7 below details the equipment requirements.

Table 7: Liquid Lime Equipment Requirements

	KRS-1 WTP	RRS WTP
Bulk Storage		
Recommended 30-day storage, gal[1]	69,400	23,200
Number of tanks	4	2
Capacity of tank, gal	17,500	12,000
Total capacity, gal	70,000	24,000
Day Tank		
Recommended 24-hour storage, gal[2]	2,900 – 5,200	960 – 2,700
Number of tanks	1	1
Capacity of tank, gal	3,500	1,500
Pumps		
Number of transfer pumps	2 (duty / standby)	2 (duty / standby)
Application Points	Pre-Rapid Mix	Rapid Mix,

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	KRS-1 WTP	RRS WTP
	Pre-Clearwell Chemical Feed Vault, *2 Pipes*	*2 Chambers* Pre-Clearwell Chemical Feed Vault
Number of metering pumps	3[3]	4[4]

[1]Max flow, average dose

[2]1.25 times max flow, average dose and average flow, max dose

[3]Pump for each application point plus a backup. KAW will only feed one pipe at a time in chemical feed vault. Second pump for chemical feed vault will act as backup for secondary application points.

[4]Pump for each application point plus a backup.

The recommended design provides complete system redundancy.

Capital and O&M Costs

An AACE Class 4 cost estimate was prepared for the liquid lime storage and feed alternative. Details of the cost estimate for a component system, not a packaged system, are in Table 8 below.

Table 8: Liquid Lime AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$106,000	$62,000
Architectural / HVAC	$420,000	$237,000
Bulk Storage Tanks	$240,000	$97,000
Transfer Pumps	$32,000	$32,000
Mixers	$260,000	$260,000
Day Tank	$9,000	$8,000
Metering Pumps	$234,000	$234,000
Piping	$50,000	$50,000
Electrical / Instrumentation	$165,000	$137,000
Subtotal Construction	**$1,541,000**	**$1,142,000**
Contingency (30%)	$463,000	$343,000
Contractor OH&P (15%)	$232,000	$172,000
Total Construction	**$2,236,000**	**$1,657,000**
Engineering (10%)	$224,000	$166,000
Training & Start-Up	$5,000	$5,000
Total Capital Project Cost	**$2,465,000**	**$1,828,000**

Liquid lime is readily available and supplied by Chemtrade Solutions (Burnett), Polytec Inc., and others. Currently, the cost of liquid lime from these suppliers ranges is approximately $140 per wet ton for a 30% slurry. Table 9 estimates the annual O&M costs for both WTPs, including chemical costs ($140 per wet ton), power ($0.064 per kWh for KRS-1; $0.067 per kWh for RRS), and labor ($20 per hour).

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Table 9: Liquid Lime System Annual Cost

Item	KRS-1	RRS
Liquid Lime[1]	$395,000	$99,000
Power	$26,200	$14,300
Labor	$4,000	$4,000
Annual O&M Costs	**$421,200**	**$113,300**

[1]Average flow, average dose

The 20-year life cycle costs for the liquid lime facilities are estimated to be $9,770,000 and $3,850,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost does not include annual equipment maintenance or repair.

Conclusions

The following Table 5 summarizes and compares the findings for the pH adjustment chemical alternatives.

Table 5: Sodium Hydroxide and Liquid Lime Comparison

	Sodium Hydroxide	Liquid Lime
Chemical Properties	50% solution High pH High freezing point	30 - 35% solution High pH Extremely stable
Safety	Corrosive	Corrosive
O&M Considerations	KAW familiarity with system	Extremely stable Requires mixers
Equipment Needs	Bulk and Day storage tanks Pumps	Bulk and Day storage tanks Pumps Mixers Vendor package system available
Capital Cost	$2,125,000	$4,293,000
Annual Cost	$602,600	$534,500
Life Cycle Cost	$12,480,000	$13,620,000

Sodium hydroxide, particularly at a 50% solution, is considered more corrosive than liquid lime slurry. Safety considerations in design and operation are more numerous for 50% caustic compared to a liquid lime system. The main challenge for caustic storage and feed is the high freezing point at 50%, necessitating heat tracing or carrying water for any portions of the system that are outside and in unheated spaces. Liquid lime requires mixers to maintain the slurry in suspension and thus has a higher electrical cost. However, liquid lime is considered to be more stable and provides a very accurate means of pH control.

Liquid lime has a higher capital cost than caustic due to the additional equipment needs and the lower solution percentage, necessitating additional storage. However, the overall annual cost is slightly more for sodium hydroxide based on historical dosages. The estimated annual cost for liquid lime may change as dosages are verified through pilot testing.

Addendum 1 details conceptual level information for a quicklime alternative at both plants.

Hazen

Addendum 1: Quicklime Alternative

Table A-1 details the design criteria used for initial equipment sizing for quicklime systems.

Table A-1: Design Criteria for Quicklime Facilities

	Maximum	Average	Minimum
KRS-1 WTP			
Plant Flow	45	30	15
Dose, mg/L as Quicklime[1]	38	14	0.28
RRS WTP			
Plant Flow[2]	30	15	6.0
Dose, mg/L as Quicklime[1]	39	7.0	0.70

[1]Calcium carbonate conversion factor to quicklime: 1.79
[2]Plant rated capacity is 25 mgd; chemical design is based on 30 mgd

Each packaged quicklime facility would consist of lime silos, slakers, slurry aging tanks, slurry loop pumps, a dosing assembly, and instrumentation. Quicklime system manufacturers include Chemco, Merrick, and RDP Technologies. The recommended design provides complete system redundancy.

An AACE Class 4 cost estimate was prepared for the quicklime storage and feed alternative. Details of the cost estimate for a packaged system, are in Table A-2 below. This is an outdoor silo system with all equipment housed within and underneath the silo. A costlier alternative would be a system housed within a building.

Table A-2: Quicklime AACE Class 4 Capital Project Cost

Item	KRS-1	RRS
Earthwork / Grading	$25,000	$25,000
Structural	$43,000	$43,000
Packaged System	$1,395,000	$1,375,000
Piping	$50,000	$50,000
Electrical / Instrumentation	$289,000	$285,000
Subtotal Construction	**$1,802,000**	**$1,778,000**
Contingency (30%)	$541,000	$534,000
Contractor OH&P (15%)	$271,000	$267,000
Total Construction	**$2,614,000**	**$2,579,000**
Engineering (10%)	$262,000	$258,000
Training & Start-Up	$3,000	$3,000
Total Capital Project Cost	**$2,879,000**	**$2,840,000**

Quicklime is readily available and supplied by Mississippi Lime Company, Carmeuse Lime, and others. Currently, the cost of quicklime from these suppliers is approximately $170 per ton. Table A-3 estimates the annual O&M costs for both WTPs, including chemical costs ($170 per wet ton), power, and labor ($20 per hour). The power costs are assumed to be the same as liquid lime although they will likely be higher due to temperature demands of the system.

Table A-3: Quicklime System Annual Cost

Item	KRS-1	RRS
Quicklime[1]	$109,000	$28,000
Power	$26,200	$14,300
Labor	$4,000	$4,000
Annual O&M Costs	**$139,200**	**$46,300**

[1]Average flow, average dose

The 20-year life cycle costs for the quicklime facilities are estimated to be $11,110,000 and $4,960,000 for KRS-1 WTP and RRS WTP, respectively (0% Annual Inflation, 1.5% Annual Discount). This life cycle cost does not include annual equipment maintenance or repair.

Kentucky River Station 1
Tram Inspection and Replacement Conceptual Design Study

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Sign-off Sheet

This document entitled Kentucky River Station 1 Tram Inspection and Replacement Conceptual Design Study was prepared by Stantec Consulting Services Inc. for the account of Kentucky American Water Company (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

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Reviewed by ______________________
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1.0 INTRODUCTION

1.1 BACKGROUND

Kentucky River Station 1 (KRS 1) is a water treatment plant operated by Kentucky American Water Company (KAWC). The plant is located at 6300 Cedarcreek Lane, in Lexington Kentucky adjacent to the Kentucky River. The facility consists of an upper main treatment area and a lower water intake station (refer to Drawings 1 and 2 for, respectively, an aerial view and a contour site plan of the plant). Currently, the only permanent access between the upper and lower areas is provided by a tram, constructed in 1957, and a 2 foot 9 inch wide steel stair system. The tram and stairs have exceeded their design lives and are a safety concern for people using them and therefore it is recommended the tram and stairs be replaced. The current tram only has the capacity for four people or about 1,200 pounds. In order to get large equipment to the lower intake area, KAWC must rent a barge and crane to transport the materials to the intake station. While this process has been successfully completed multiple times, there are concerns about the future cost and availability of continuing this operation.

1.2 SCOPE OF WORK

This tram replacement conceptual design study assesses and compares various options to replace the current dated and low capacity tram. Alternatives must provide access for personnel, tools, and large equipment to the intake area from the upper plant. The options were evaluated for functional feasibility, constructability, and initial and reoccurring (O&M) costs. The three most feasible and cost effective alternatives, of an original seven, were refined to provide conceptual designs and life cycle cost analysis.

1.3 DESIGN CONSTRAINTS

The design requirements for the tram replacement are as follows:

- Alternatives must be able to regularly transport at least four people and small tools/equipment. A small tool/equipment is defined as those able to be handed by one to two people.
- Alternatives must have the capacity to transport large equipment, defined as weighing up to 15 tons with a maximum size of 15x10x10 feet.
- Alternatives are restricted to the property boundaries of KRS 1.

1.4 SITE CONDITIONS

For conceptual design, topographic site conditions were based on Kentucky Aerial Photography and Elevation Data (KY APED) 2010. The location and sizes of the KRS 1 structures and utilities were determined from aerial views and historical construction plans. Information from the 2011 Kentucky River Navigational Charts, USGS Kentucky River levels at Lock 9, and FEMA Floodplain mapping indicate the Kentucky River normal pool elevation is 548.60 feet and the maximum high water elevation is 585.40 feet at the lower intake structure.

Based on available published literature and subsurface information from Lock and Dam 8, the general soil and rock conditions in the region consist of a thin veneer of soil materials overlying limestone bedrock referred to as the Lexington Formation. The members of this formation at the site consist of the Grier, Tyrone, and Camp Nelson limestones. These units are fossiliferous, mostly good to excellent quality limestones containing thin interbedded shale layers, with average unconfined compressive strengths of 9,000 psi. No information on groundwater is available at this time; however, minimal groundwater is expected to be encountered.

1.5 STUDY MILESTONES

At the request of Kentucky American Water Company, Stantec Consulting Services (Stantec) provided a scope of work "Tram Inspection and Replacement Conceptual Design Study" on April 15, 2016.

Stantec completed the structural component inspection of the tram and stairs on June 24, 2016. Staggs and Fisher Consulting Engineer, Inc. completed the inspection of the tram's mechanical and electrical components on July 20, 2016. The field investigation findings and recommendations of these inspections can be found in the "Tram and Stair System Inspection Report" in Appendix A.

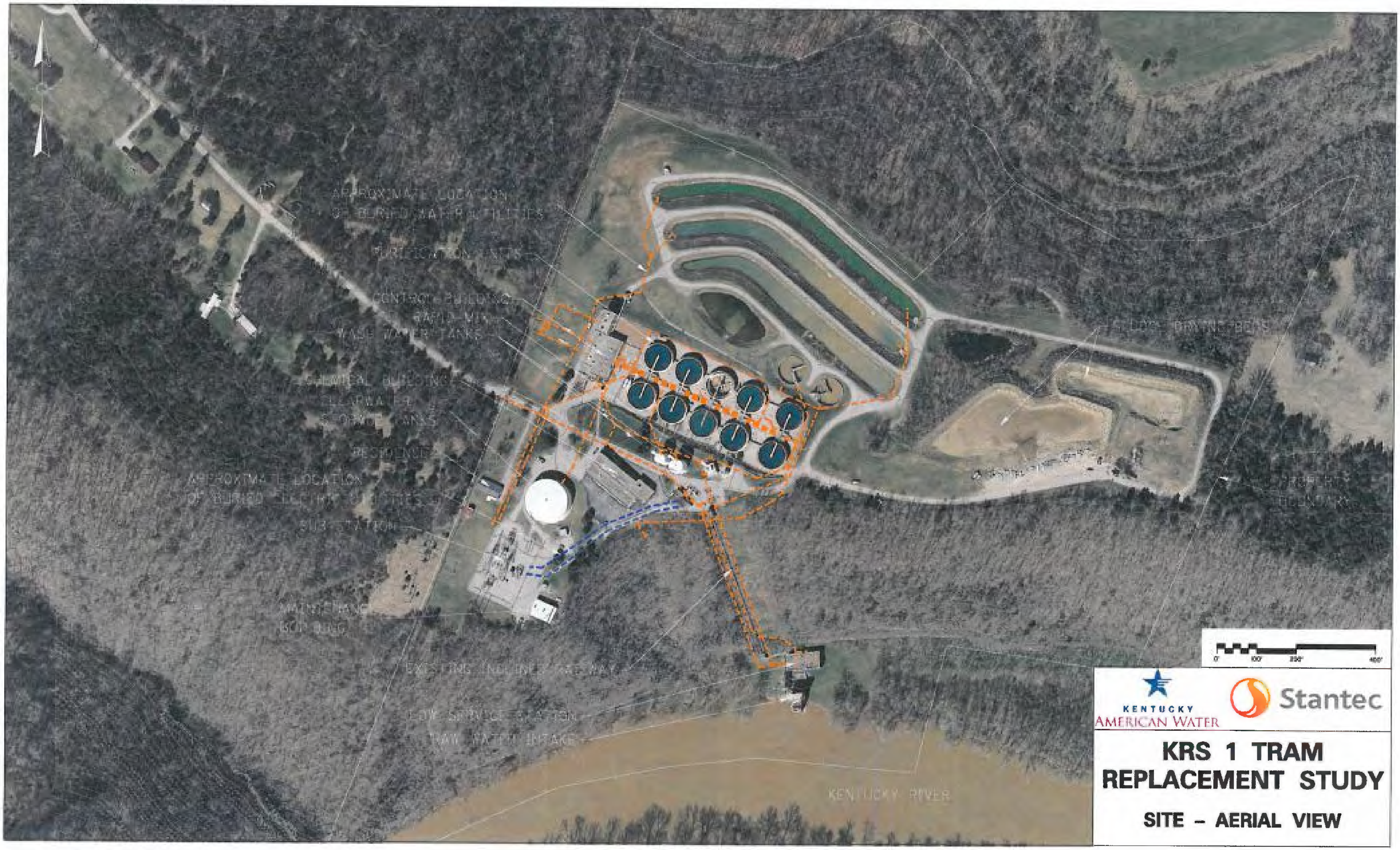
Stantec held a tram replacement brainstorming meeting with KAWC stakeholders, operators, and contractors on July 27, 2016. During the meeting, the following seven preliminary alternatives were presented and discussed:

- Renting or buying a barge and installing a replacement personnel tram
- Renting a heavy-lift helicopter and installing a replacement personnel tram
- Installing an industrial gondola
- Installing a large capacity inclinator
- Constructing a roadway
- Constructing a shaft and adit
- Constructing a roadway tunnel

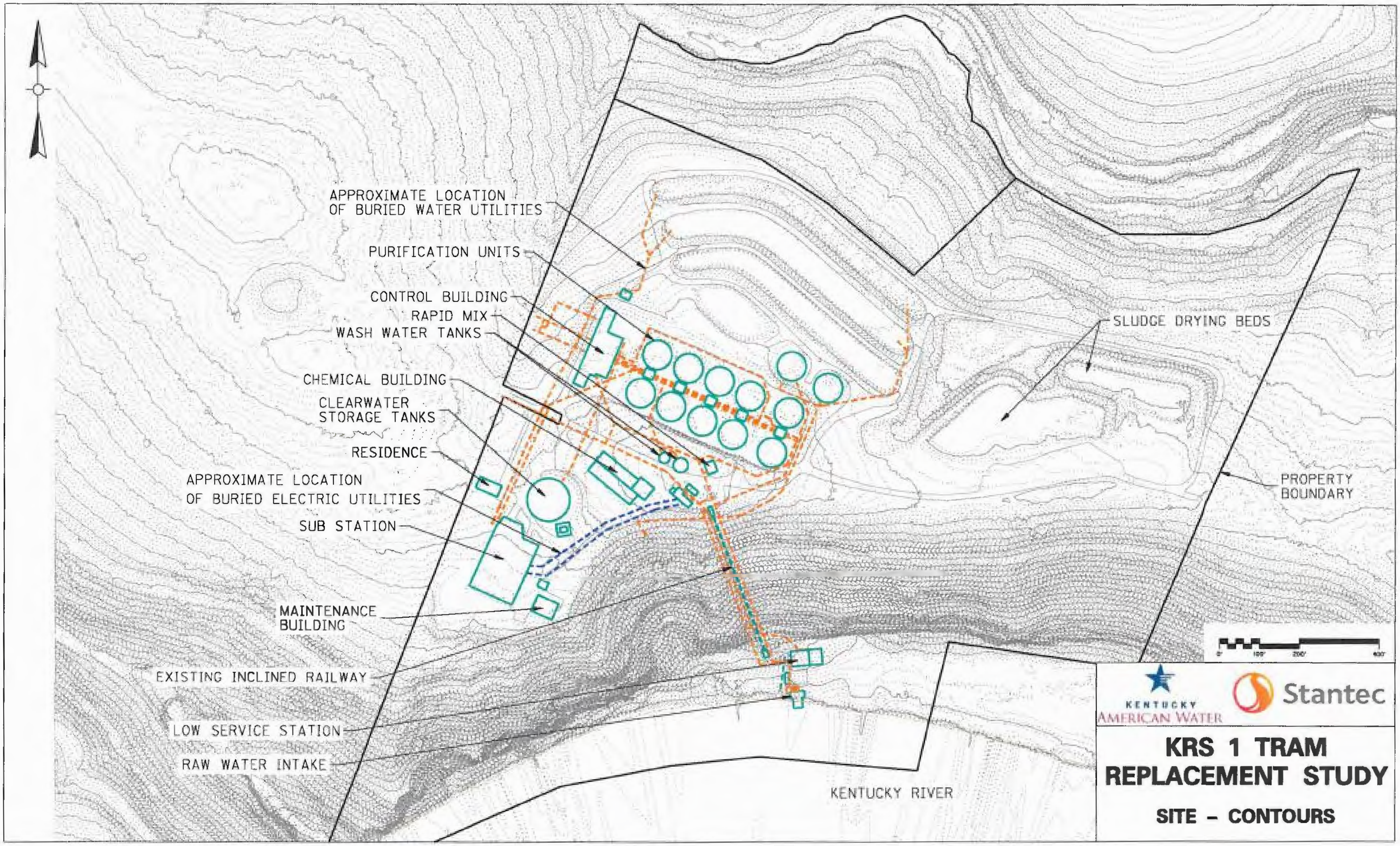
After evaluating the different aspects and feasibility of the preliminary alternatives, it was decided the large capacity inclinator, roadway, and shaft and adit alternatives warranted further study and conceptual designs. The brainstorming meeting presentation and discussion results can be found in Appendix B.

This report concludes the scope of work and provides the evaluation of the preliminary alternatives and the conceptual design and cost analysis for the three final alternatives.

DRAWING 1: SITE - AERIAL VIEW



DRAWING 2: SITE - CONTOURS



2.0 PRELIMINARY ALTERNATIVES

The following alternatives were considered and evaluated during the preliminary stages of the study, but refined designs were not pursued after further research and discussion with KAWC personnel.

2.1 BARGE

Currently, heavy equipment is barged to the lower intake structure. The process involves renting a barge and crane. The barge is put in the Kentucky River two miles upstream from the raw water intake at the Clay's Ferry Boat Dock and Ramp (refer to Figure 1 for the Kentucky River navigation chart at the lower intake area). A barge mounted crane is used to load equipment from the dock to the barge and unload equipment to the intake structure (refer to Figure 2 for an image of the unloading process). This process requires a minimum two week lead time for organization and mobilization. The current operation cost $240,000 per month long rental of the barge and crane.

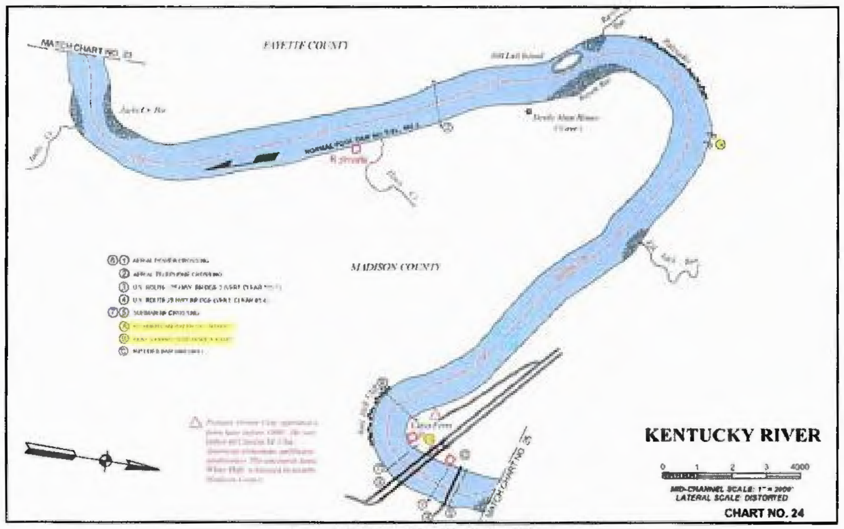


Figure 1: Kentucky River Navigation Chart

Figure 2: Barge Unloading at Raw Water Intake Structure

While renting a barge results in minimal infrastructure to maintain, there are significant issues regarding future river access at Clay's Ferry. Since Clay's Ferry Boat Ramp is the only pool access between dams 9 and 10, there are concerns current and/or future management of the ramp may increase ramp access fees or completely prevent access to the ramp. Therefore, this is not considered a viable long term solution.

A barge and crane could be purchased to eliminate any future reliance on access at the Clay's Ferry Boat Ramp. However, purchasing a barge and crane presents new issues such as the logistics of loading equipment onto the barge, maintenance of the barge and crane, and docking/storage of the barge. For these reasons, purchasing a barge and crane does not appear to be a viable option.

2.1.1 Replacement Personnel Lift

Using a barge to transport heavy equipment would require a personnel lift for daily access to the lower service station and raw water intake structure. The current personnel lift has exceeded its design life and should be replaced (see Appendix A for the tram and stair system inspection report). The proposed replacement lift would have the capacity for 6 people or 1,500 lbs. The upper terminal of the lift would be located east of the rapid mix station and south of the access road. The lower lift terminal would be located east of the lower service station. The tram would traverse a distance of approximately 500 feet at a constant 40° angle.

The personnel lift would cost approximately $350,000 for its structural components and electro/mechanical equipment. The estimated civil works and construction cost is an additional $650,000. Therefore, the total installation cost of the personnel lift is about $1,000,000. Material delivery will take about six months and construction will take approximately three to four months. The personnel lift would have additional costs for operation, inspections, and maintenance. A stair system would be installed adjacent to the new personnel lift for access in the event of power failure or personnel lift malfunction. The installation cost of the stairs is approximately $225,000.

2.2 HELICOPTER

Helicopters are commonly used to deliver construction materials and large equipment to remote and difficult access areas. For application at the KRS 1, trucks would be used to drop off equipment at the plant. A helicopter would then pick up the equipment from a staging area located east of the lagoons and drop the equipment off at a lower staging area east of the lower service station. A monorail crane system would be used to move the equipment to its necessary location.

Helicopters with a lifting capacity of 4,500 pounds are readily available from companies such as Aircrane and Midwest Helicopter Airways. Chi aviation provides 8,500 pound capacity helicopters. For helicopters with a capacity of 8,500 pounds or less, there is a $20,000 mobilization fee and $1,000 charge per lift. The required minimum of 10 lifts per mobilization results in a total cost of approximately $30,000.

Erickson Inc. provides helicopters with lifting capacity of up to 20,000 pounds (refer to Figure 3 for a picture of one of Erickson's large capacity lift helicopters). These helicopters have a $65,000 mobilization fee and daily cost of $25,000, which includes 10 lifts; each additional lift cost $2,500. Therefore, the total cost of a helicopter lift with 20,000 pounds or less capacity is roughly $90,000.

Figure 3: Erickson S-64 20,000 lb. Capacity Helicopter

While using helicopters to transport large equipment is a relatively inexpensive alternative, there are several problems relating to availability and coordination. The minimum lead time for the smaller capacity helicopters is two weeks and for the large capacity Erickson helicopters the minimum lead time is a month. The lead time accounts for helicopter availability, FAA permitting, and mobilization. For this alternative to be viable, extensive planning and coordination would be required to successfully stage and transport the equipment. Inclement weather and high winds could prevent helicopter access to the lower service station. A detailed site analysis of wind currents and uplift would also be required to certify helicopters are capable of safely accessing the lower staging area. Additionally, the maximum lift capacity of 20,000 pounds is less than the client specified 30,000 pound lift requirement.

2.2.1 Replacement Personnel Lift

A personnel lift will be required in conjunction with heavy-lift helicopters for daily access to the lower intake area. The current personnel lift has exceeded its design life and should be replaced (see Appendix A for the tram and stair system inspection report). For details regarding the replacement personnel lift, refer to Section 2.1.1.

2.3 GONDOLA

Gondolas are typically used in the ski industry, but they are also used to transport large material up steep terrain. The proposed gondola would consist of two spans. The first span would extend from an upper terminal located south of the sludge drying beds and access road to a tower located on the hill. The second span would extend from the support tower to a lower terminal located east of the lower service station. The upper terminal would be a multipurpose structure as it would also be used for storage. The gondola would transport personnel in an enclosed cabin while large equipment would be suspended below attached via cables or in a steel container (see Figures 4 and 5 for images of the various gondola transportation methods).

Figure 4: Gondola Transporting Material Suspended by Cables

Figure 5: Gondola Transporting Equipment in a Steel Container

The gondola would cost approximately $5,000,000 for its structural components and the electro/mechanical equipment. The estimated civil works and construction cost is an additional $1,000,000. Therefore, the total initial cost of the gondola is approximately $6,000,000. Material delivery will take about twelve months and construction will take approximately three to four months. The gondola would have additional annual costs for operation, maintenance, and inspection. A stair system would be installed below the gondola. Installation cost of a stair system is about $225,000.

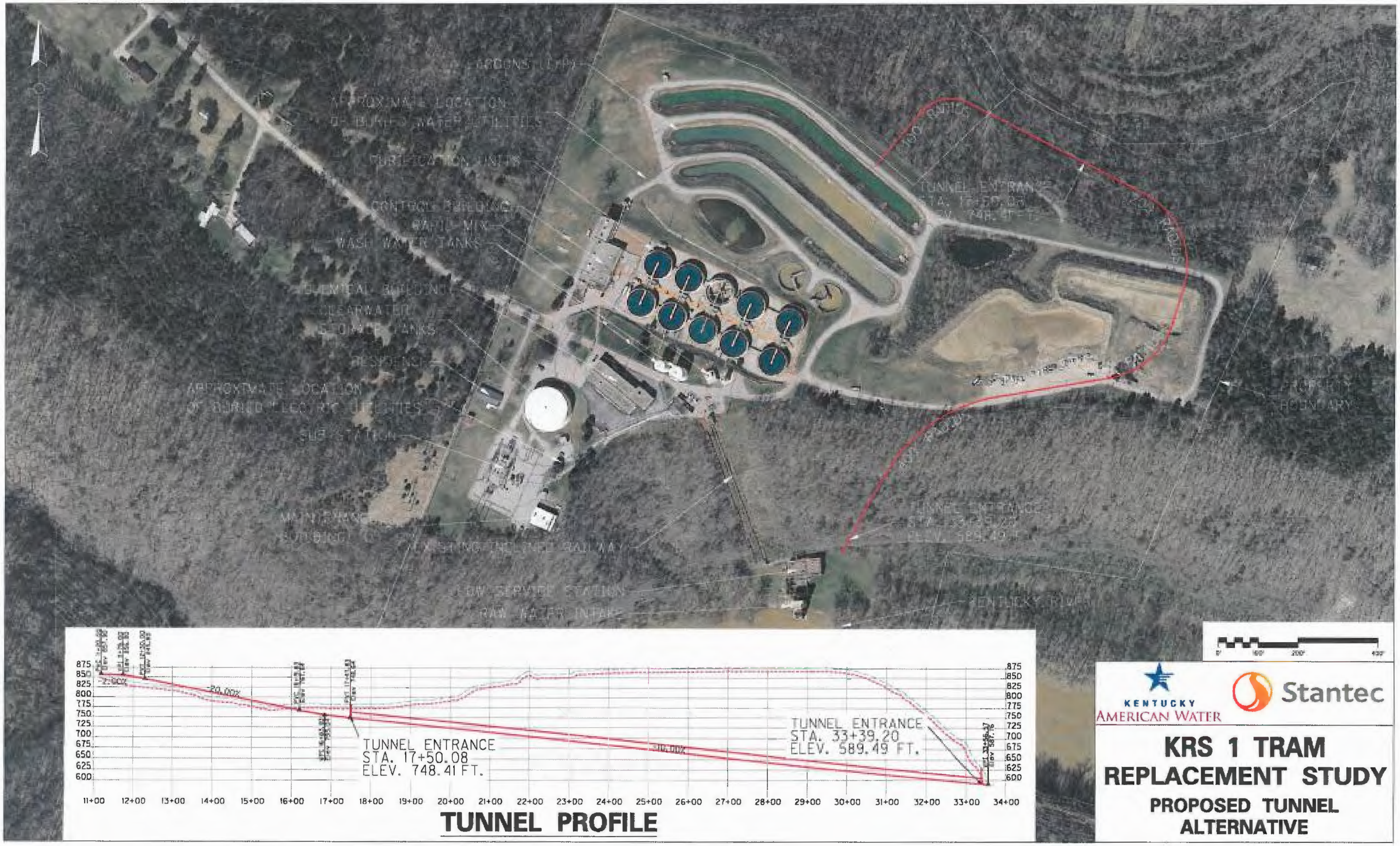
The gondola was deemed a non-feasible alternative due to concerns over user comfort, difficulty loading and unloading equipment, and high maintenance and inspection cost due to the uniqueness of the system for this location. Additionally, access to the lower station could be limited due to adverse weather and high winds.

2.4 TUNNEL

The proposed tunnel alternative consist of 650 feet of roadway beginning north of the lagoons and traversing downhill at an incline of 20% to the tunnel entrance. The tunnel would extend about 1,600 feet at a 10% grade and exit to the east of the lower service station (refer to Drawing 3 for the plan and profile of the tunnel alternative). The tunnel cross-section would consist of a 17 foot wide roadway and 3½ foot wide walkway with a finished height of 15 feet. The tunnel would also include a 6½ foot wide by 8 foot tall emergency corridor. The tunnel would enable people to access the lower station in a standard vehicle or small all-terrain utility vehicle. Large equipment would be transported on a trailer or truck and offloaded with a monorail crane system.

The proposed tunnel would cost approximately $20,000,000 and require about twelve to sixteen months for construction. While a tunnel would provide easy access and be relatively maintenance free, the cost is significantly higher than the other options and exceeds the replacement budget.

DRAWING 3: PROPOSED TUNNEL ALTERNATIVE



3.0 FINAL ALTERNATIVES

Conceptual designs and cost estimates were completed for the following feasible options:

1. Large Capacity Inclinator
2. Roadway
3. Shaft and Adit

Costs presented in this section follow the parameters indicated in the Scope of Work and are conceptual in nature. As such, the opinion of probable construction cost will need to be updated as the design is advanced. These costs estimates are in 2016 dollars and, should construction begin in 2017 or later, cost escalation will need to be added to the midpoint of the construction schedule. Note, prime contractor markup has not been included and the site is assumed to be free of environmental contamination. The 25 year reoccurring operation and maintenance (O&M) costs are present costs assuming a 4% annual interest rate. As these costs are for comparison purposes only, other variables over time were not included.

3.1 LARGE CAPACITY INCLINATOR

3.1.1 Conceptual Design

The large capacity inclinator would be capable of transporting personnel and small tools daily and large equipment as necessary. The proposed concept design is an inclinator with a 12x17 foot platform and a capacity of 15 tons. The inclinator will travel on two rails at a single gradient, supported by concrete foundations with a 115 feet steel frame support structure at the low end of the slope (a constant gradient provides a level surface during transportation). The proposed inclinator will travel 500 feet at a slope of 39°. A stair system, required in the event of power failure or inclinator malfunction, would be installed adjacent to the inclinator. (Refer to Drawing 4 for the layout and Drawing 5 for the profile of the large capacity inclinator)

An upper terminal for the large capacity inclinator would be located East of the rapid mix station and Southwest of the sludge drying beds. A walkway ramp will provide personnel and small tools access to the inclinator. A 40x100 foot pre-engineered metal building (PEMB) would be constructed adjacent to the terminal for storage and maintenance. A monorail crane will be used to lift large equipment off of trucks or trailers and load it directly onto the inclinator or transport it into the storage building. A bridge crane system will be used to maneuver the large equipment within the building and place it for storage. Small tools and equipment can also be stored in the storage building with easy access to the inclinator. (Refer to Drawing 6 for details of the inclinator upper terminal)

The lower terminal for the inclinator would be located 20 feet East of the lower service station and centered on the exiting crane system in the lower service station. Access doors would be installed on the East face of the lower service station and the existing monorail crane would be extended out of the structurally reconfigured East elevation of the raw water intake structure. A monorail crane system would lift the large equipment off of the inclinator and transport it inside the lower service station or to the crane extension at the intake structure. The existing monorail system would be used to move the equipment into the lower intake structure and to the intake valve vault building. Personnel with small tools will have access to the lower service station on an elevated walkway. (Refer to Drawing 7 for details of the inclinator lower terminal)

3.1.2 Cost

Based on the proposed conceptual design of the large capacity inclinator, an opinion of probable construction, operation, and maintenance cost has been prepared.

The total probable construction cost, not including O&M cost, for the inclinator is presented in Table 1. The delivered inclinator cost includes the inclinator platform and the structural, electrical, and mechanical components of the system. The inclinator construction and installation cost includes rock excavation, substructure members and foundations, a 115 foot elevated frame support structure at the lower end, and the inclinator installation and testing. The upper terminal cost includes the monorail system, a PEMB storage and maintenance building, and bridge crane. The lower terminal cost includes the monorail system, the structural reconfiguration and crane extension at the lower intake structure, and the platform and access to the lower service station.

Table 1: Total Estimated Conceptual Level Construction Costs – Inclinator

Item	Cost	
Inclinator, delivered	$	4,520,000.00
Inclinator Construction and Installation	$	1,590,000.00
Upper Terminal Cost	$	310,000.00
Lower Terminal Cost	$	150,000.00
Large Capacity Inclinator Direct Construction Cost	**$**	**6,470,000.00**
Demolition Existing Stairs	$	15,000.00
Stairway Construction and Installation	$	225,000.00
Stairway Direct Construction Cost	**$**	**240,000.00**
Rounded Total, Construction Costs - Inclinator Option	**$**	**6,710,000.00**

Material delivery will take about twelve months and construction will take approximately six to eight months. The assumed design life of the large capacity inclinator is thirty to fifty years, assuming regular inspection and maintenance. Estimated annual O&M cost for the large capacity inclinator is shown in Table 2. The inclinator O&M cost includes annual inspection of the inclinator's structural, electrical, and mechanical systems and repair or replacement of secondary components as necessary. The stair system O&M cost include inspection and minor repairs of the system. For comparison, Table 2 also presents the conceptual level O&M costs for the large capacity inclinator projected over twenty five years.

Table 2: Conceptual Level O&M Cost Opinion – Inclinator

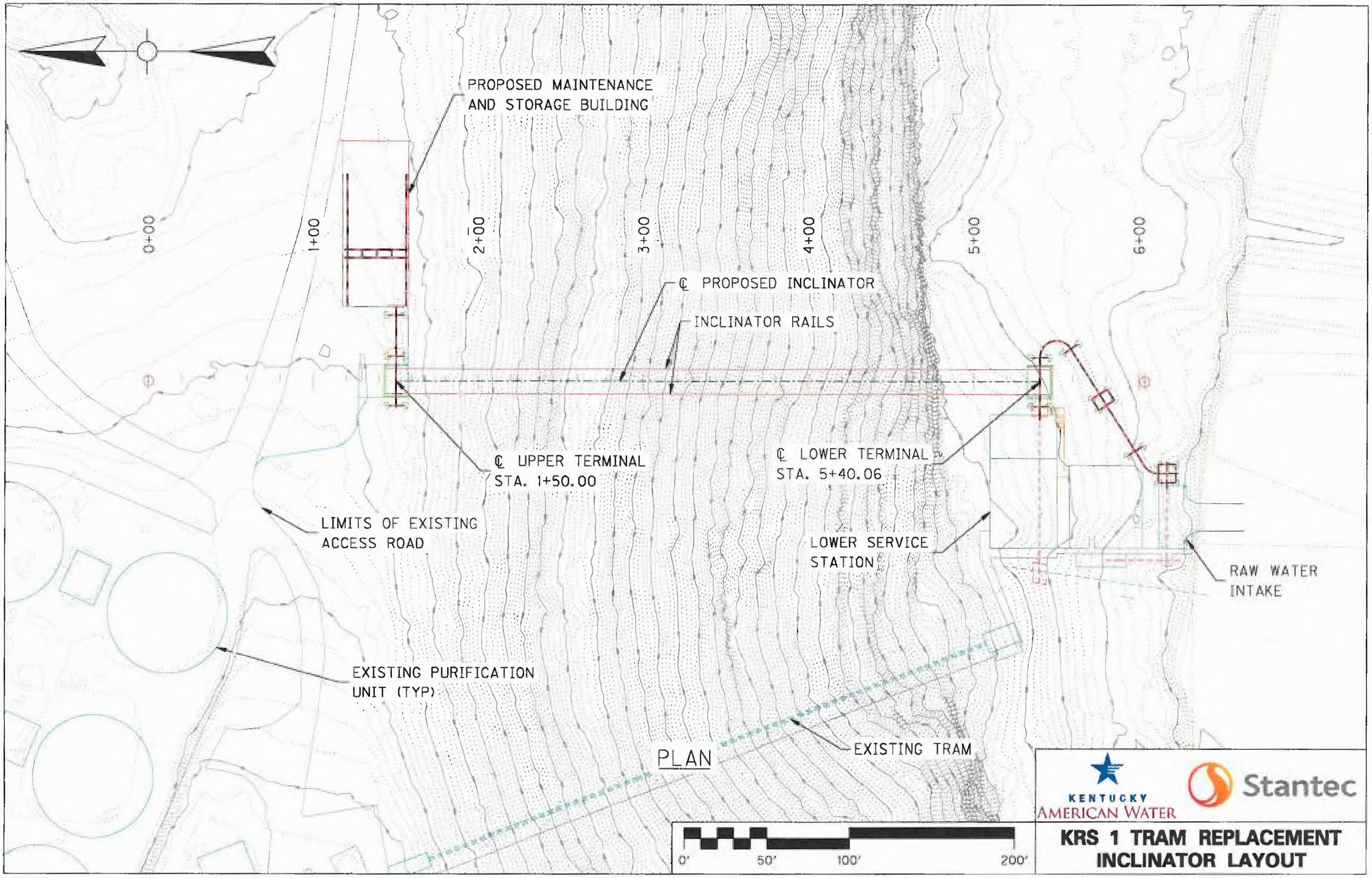
Task		Annual O&M		25-yr O&M
Inclinator	$	40,000.00	$	625,000.00
Upper and Lower Terminals	$	20,000.00	$	310,000.00
Stair System	$	2,000.00	$	30,000.00
Total 25-YR O&M Present Cost – Inclinator Option			**$**	**965,000.00**

3.1.3 Risk

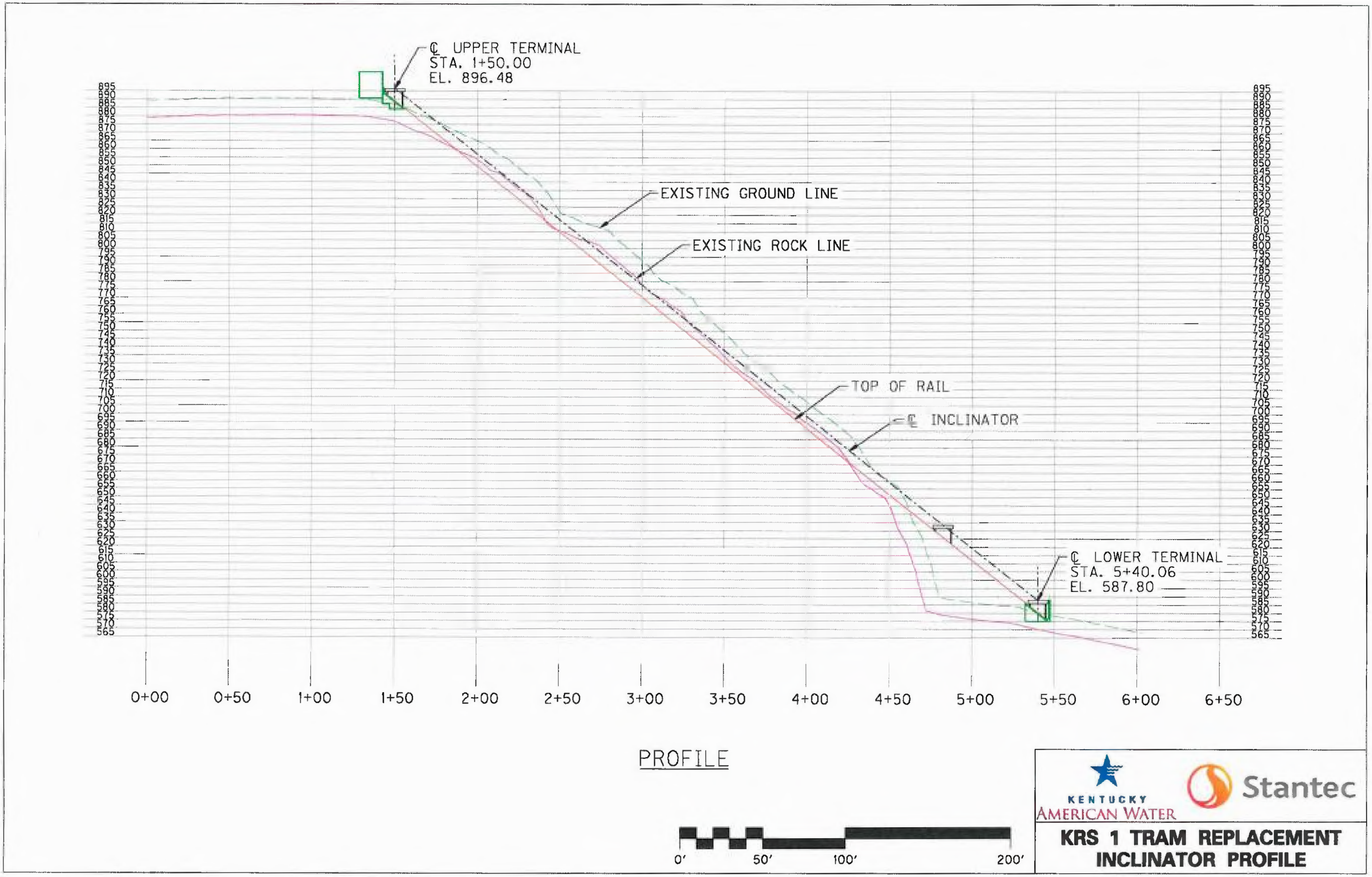
Without a subsurface investigation, the existing rock line is not precisely known. If there is less overburden and the rock line is closer to ground level, the amount of rock excavation for the substructure of the inclinator would increase significantly. This would increase installation cost of the inclinator; however, the layout of the inclinator and/or elevation of the lower terminal could be altered by design to decrease the necessary excavation. A change in the design would marginally increase the cost of the foundations and civil work, but it would be less than the cost of extensive rock excavation.

Conceptual operational risks include instances when inclinator access to the lower station is prevented due to power outages, mechanical/electrical malfunctions, inclement weather, etc. However, these issues rarely arise and if they do, the stair system will provide limited access to the lower intake area. Flooding could be another issue, but based on current information, the lower terminal is designed so as to not be rendered inaccessible by high water levels.

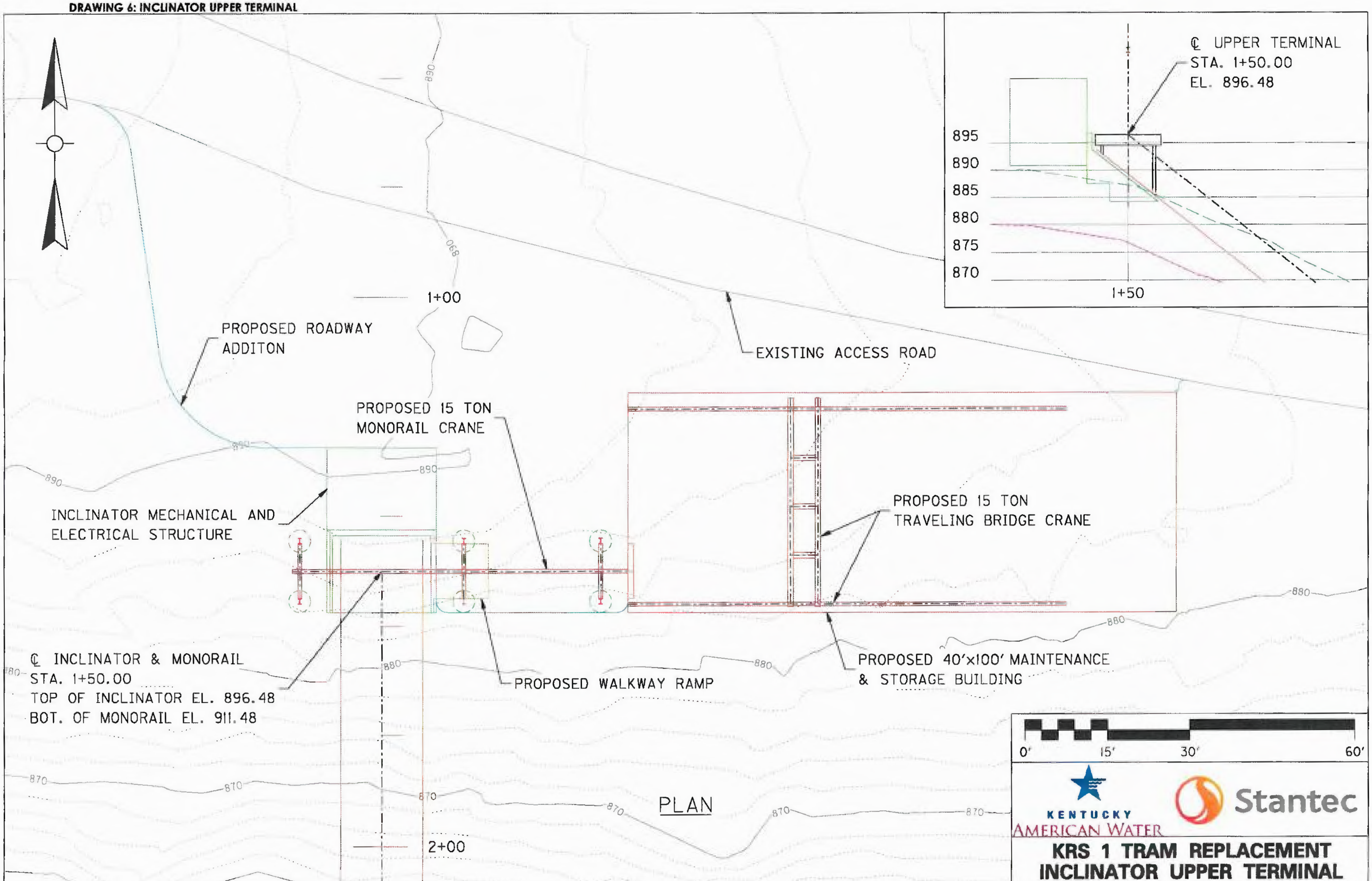
DRAWING 4: INCLINATOR LAYOUT



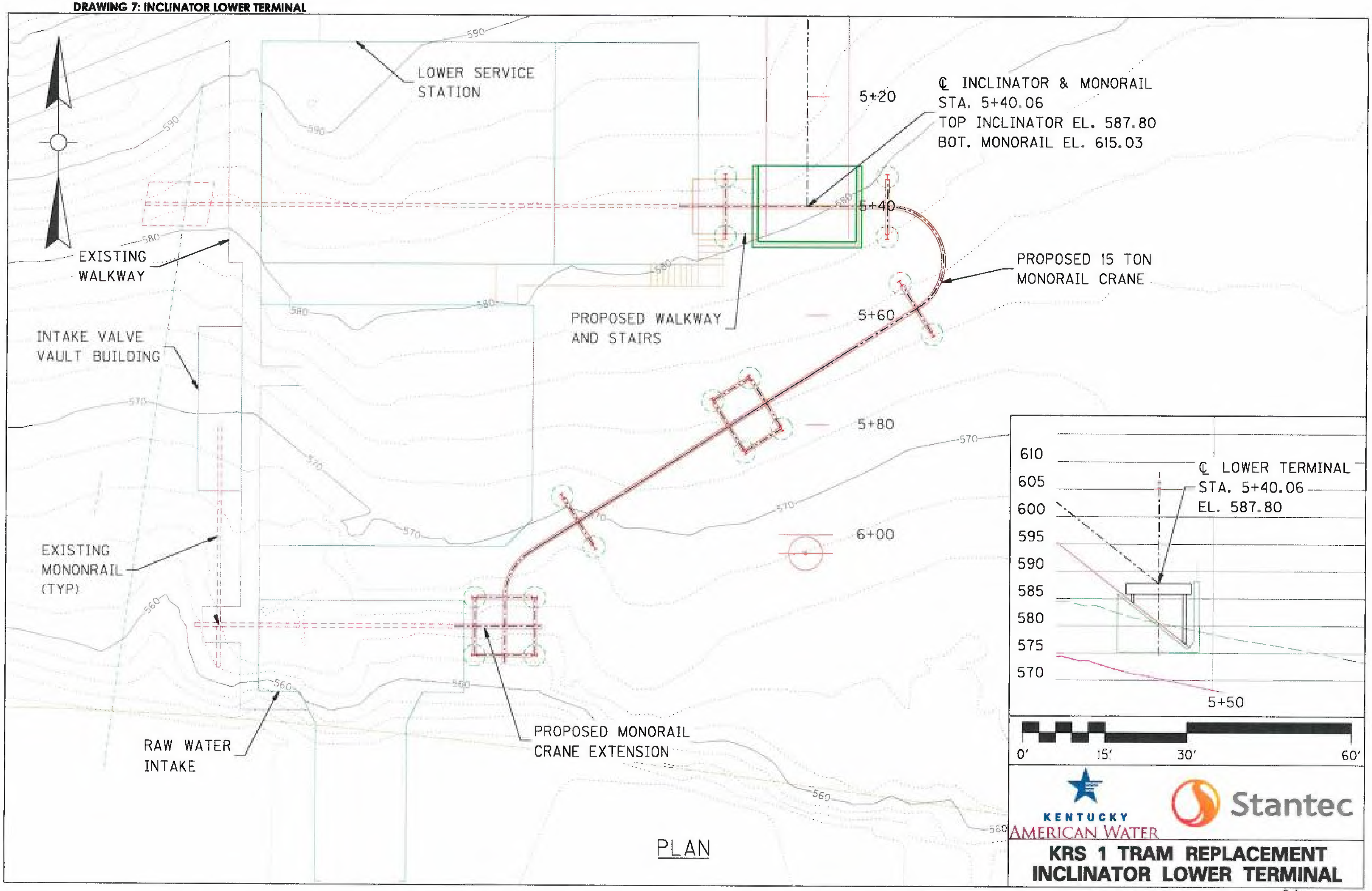
DRAWING 5: INCLINATOR PROFILE



DRAWING 6: INCLINATOR UPPER TERMINAL



DRAWING 7: INCLINATOR LOWER TERMINAL



KRS 1 TRAM REPLACEMENT
INCLINATOR LOWER TERMINAL

3.2 ROADWAY

3.2.1 Conceptual Design

The roadway alternate was initiated to determine the feasibility of accessing the lower facility with standard wheeled vehicles. The existing steep hillside, approximately 1:1 slope, and substantial 320 feet elevation differential, make the roadway alternate a challenging undertaking. A 20 foot wide roadway notched into the existing rock is being proposed. The horizontal geometry utilizes a 75 foot minimum radius that will accommodate a standard AASHTO single unit truck (20 foot wheelbase, 30 feet overall length). After discussions at the brainstorming meeting mentioned in Section 1.5, minimal ditches were added and the maximum grade utilized for the roadway alternate was reduced to 16 percent. From further investigation after the brainstorming meeting, it was determined intermediate benches would be needed for this design which significantly increases the amount of required excavation. Since geotechnical investigation and design was not included in the project scope, 1:4 rock cut slopes, with intermediate benches at each 30 feet of elevation change, were assumed for this conceptual design. (Refer to Drawing 8 for the roadway layout and profile)

Due to the vehicle constraints of the roadway geometry, a truck and trailer dedicated to delivering the heavy loads is proposed. An upper loading terminal for the roadway would be located East of the rapid mix station and Southwest of the sludge drying beds. A 40x100 foot pre-engineered metal building (PEMB) would also be constructed adjacent to the terminal for storage and maintenance. A monorail crane will be used to lift large equipment off of the delivery trucks and load it directly onto the designated truck and trailer or transport it into the storage building. A bridge crane system will be used to maneuver the large equipment within the building and place it for storage. The loaded truck will start to traverse down the hillside at the roadway entrance located East of the substation and North of the existing maintenance building. (Refer to Drawings 9 and 10 for the proposed roadway entrance and upper loading terminal)

At the lower intake area, a monorail crane system will be used to unload the truck and trailer. The large equipment will then be transferred into the lower service station by the monorail crane through proposed access doors or moved to the raw water intake structure. A proposed monorail crane extension would move the equipment into the intake structure and the existing monorail will transport the equipment to the intake valve vault building. A walkway and exterior elevator will provide people and small tools access to the lower service station. (Refer to Drawing 11 for details of the roadway lower terminal)

3.2.2 Cost

The opinion of probable construction cost for the Roadway Alternate is based on the geometry noted in section 3.2.1, and includes guardrail at select locations. The pavement structure includes 4 inches of aggregate base and 5.25 inches of asphalt material. Table 3 presents the total construction cost for the proposed roadway alternative.

Table 3: Total Estimated Conceptual Level Construction Costs – Roadway

Item	Cost	
Rock Excavation	$	5,400,000.00
Pavement and Guardrail	$	500,000.00
Pipe Bridge Structure	$	225,000.00
Truck and Trailer	$	100,000.00
Upper Terminal Cost	$	300,000.00
Lower Terminal Cost	$	150,000.00
Rounded Total, Construction Costs - Roadway Option	**$**	**6,675,000.00**

The assumed design life of the roadway is fifty years, assuming regular maintenance. Estimated annual O&M cost for the roadway is shown in Table 4. The roadway O&M cost includes the cost of debris, rock, and snow removal as necessary. Roadway O&M costs also account for a probable future resurfacing. Table 4 also presents the conceptual level O&M costs for the roadway projected over twenty five years.

Table 4: Conceptual Level O&M Cost Opinion – Roadway

Task	Annual O&M		25-yr O&M	
Roadway	$	5,000.00	$	80,000.00
Upper and Lower Terminals	$	20,000.00	$	310,000.00
Total 25-YR O&M Present Cost – Roadway Option			**$**	**390,000.00**

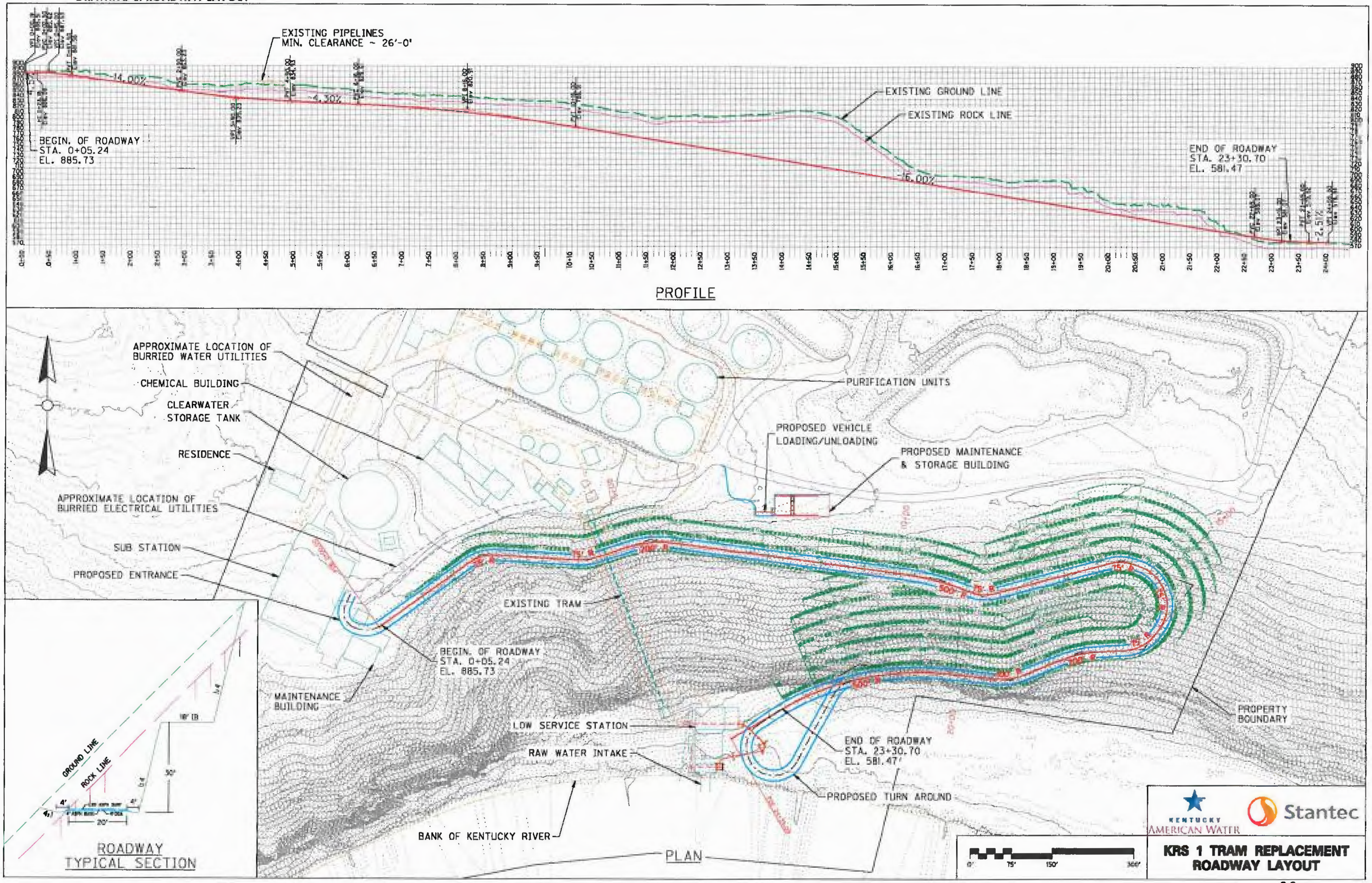
3.2.3 Risk

The lack of geotechnical investigation results in significant risk associated with the roadway alternate. Criteria used for the cut slope design is based on experience for rock cuts encountered on other projects and the published information from Lock and Dam 8 noted in Section 1.4 of this report. The feasibility of this alternate could be called into question if a geotechnical investigation reveals the cut slopes must be reduced.

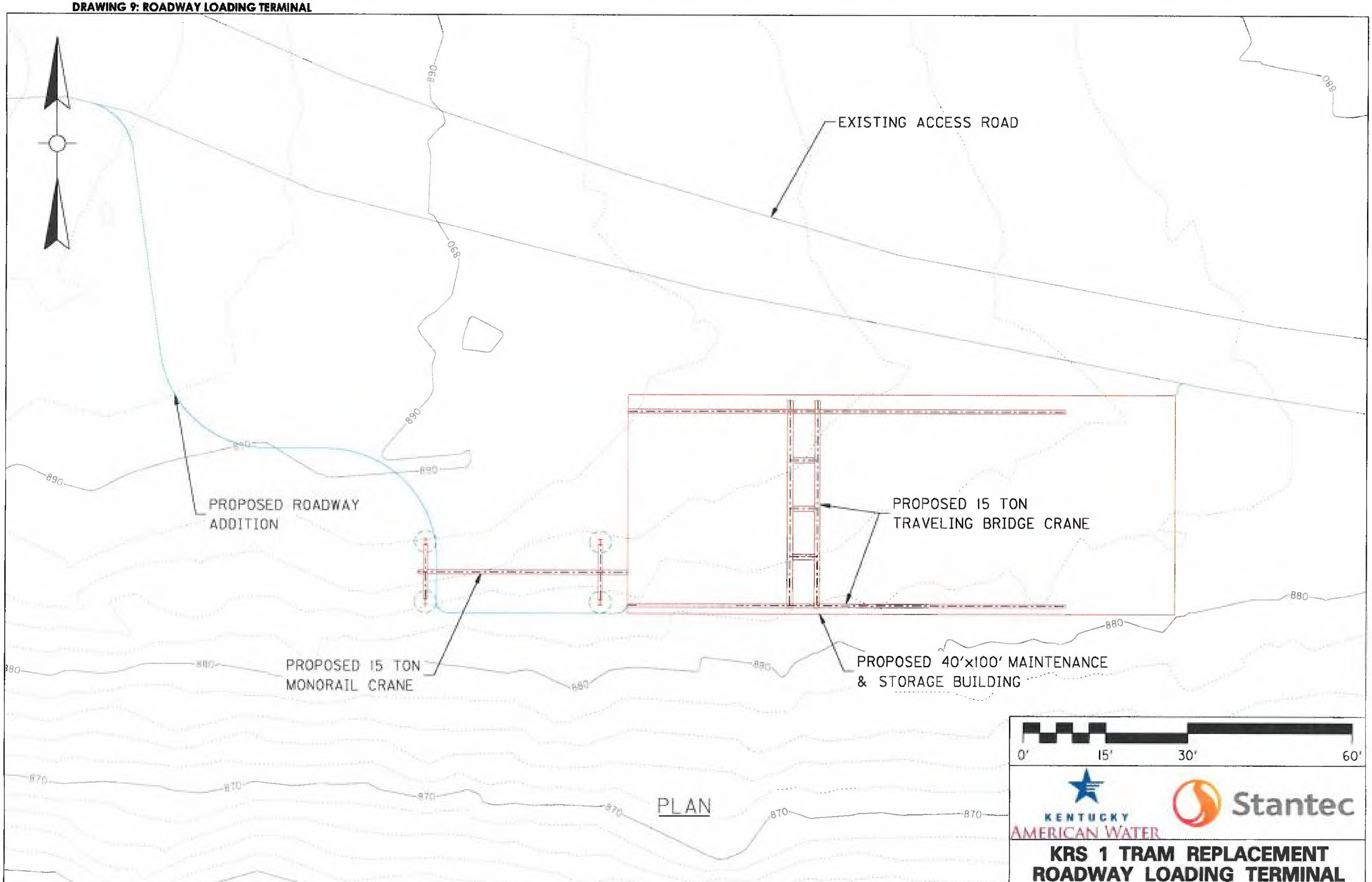
The largest and most expensive component of the anticipated roadway cost is the rock excavation. Limited access to the excavation site and lack of a convenient location to dispose of the excavated material, combine to increase the excavation cost. We attempted to reflect these factors in the opinion of probable cost, however, there is still financial risk associated with this alternate.

The Roadway Alternate will impact a much greater area than the other conceptual alternates and will require a more extensive environmental investigation. Upon completion of the investigation, any required permitting must be coordinated with the reviewing agencies and may require monitoring during the construction process.

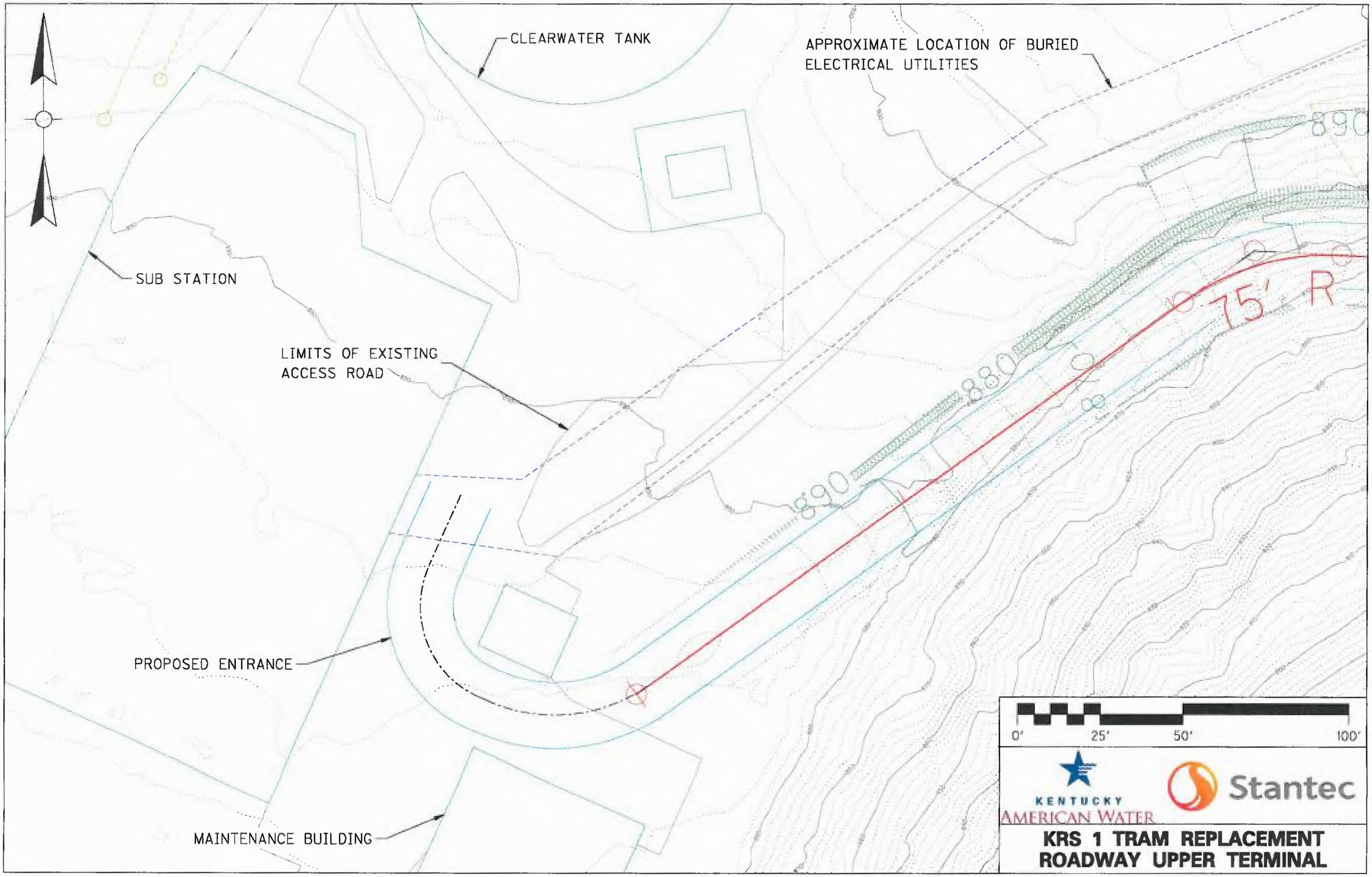
DRAWING 8: ROADWAY LAYOUT



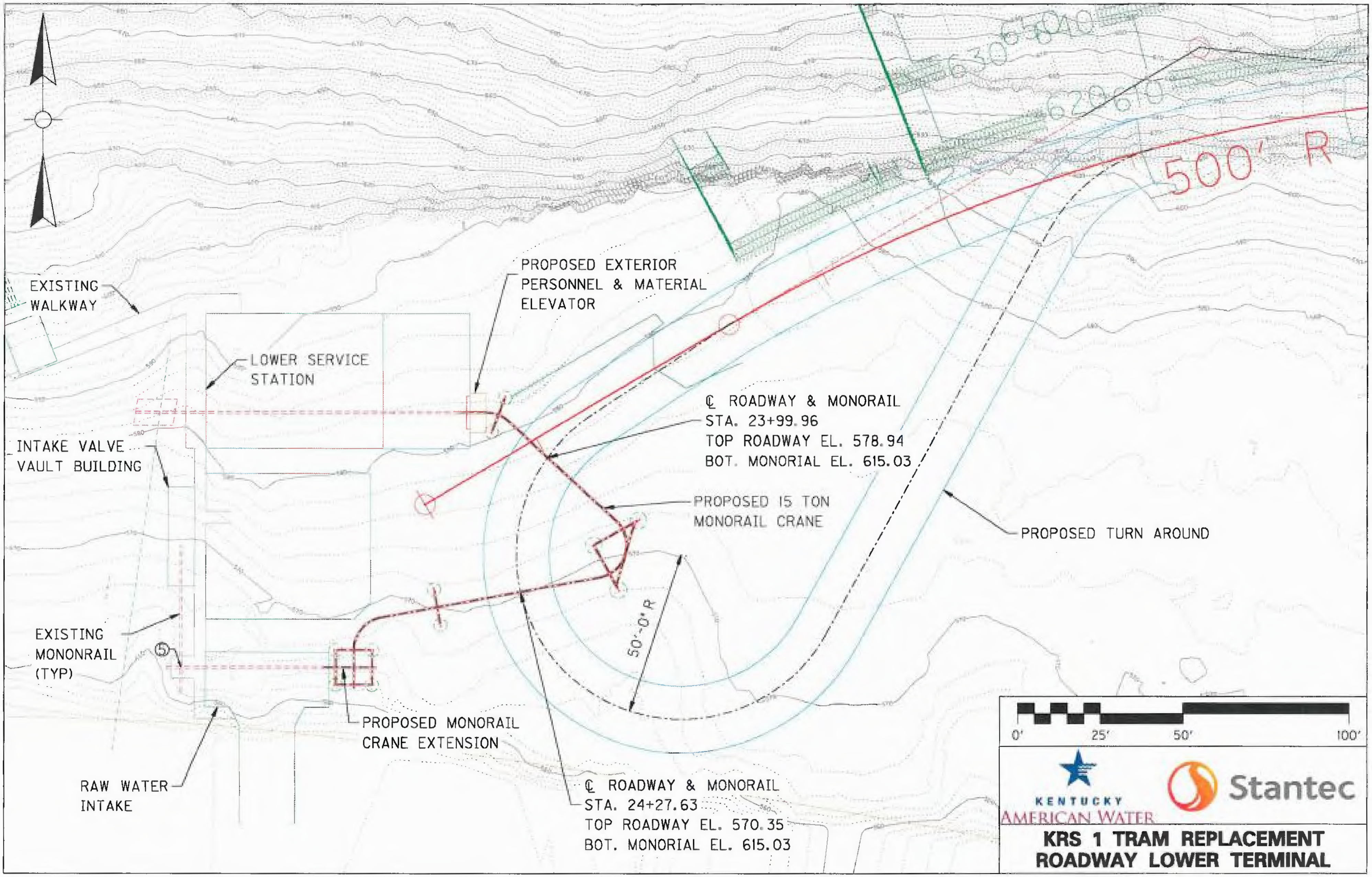
DRAWING 9: ROADWAY LOADING TERMINAL



DRAWING 10: ROADWAY UPPER TERMINAL



DRAWING 11: ROADWAY LOWER TERMINAL



3.3 VERTICAL SHAFT AND ADIT

3.3.1 Conceptual Design

A review of the requirements for the long term maintenance of the intake structure facility necessitate an 18 feet diameter shotcrete lined, rock bolt reinforced vertical shaft, connected to an approximately 385 feet long tunnel adit to the existing intake structure area. (Refer to Drawing 12 for the location plan of the proposed features and Drawing 13 for the profile of the shaft and adit)

The shaft will be designed with a 5x7 foot, recessed, rack and pinion elevator, with a 3,500 pound capacity for transporting personnel and some equipment. A manual ladder with a safety cage will also be provided and installed within the shaft. A small vent and auxiliary generator, and elevator entrance building will be required at the top of the shaft. A 30-ton capacity telescoping crane will be located near the shaft area for moving large equipment through the shaft. (Refer to Drawing 14 for a plan of the shaft upper terminal and shaft cross section)

The adit will be equipped with an electronically operated 13x17 foot flatbed rail system for personnel and heavy equipment transport through the adit to the intake structure. The adit is assumed to be 17 feet diameter, shotcrete lined with rock bolt reinforced above the springline, and includes a personnel walkway, and an independent emergency fireproof walkway designed in accordance with National Fire Protection (NFPA) standards. A monorail crane system will be used at the lower intake area to lift equipment off the flatbed and transport it inside the lower service station or to the raw water intake structure and intake valve vault building. A walkway to an exterior elevator will provide personnel and small tools access to the lower service station. (Refer to Drawing 15 for a plan of the shaft lower terminal and shaft cross section)

The shaft, adit, and emergency fireproof walkway will require permanent ventilation, lighting, and drainage. The structures will be designed in accordance with National Fire Protection Agency (NFPA) 2015 standards and in accordance with standard underground design practices.

3.3.2 Cost

A conceptual level opinion of probable construction, operation, and maintenance cost for the vertical shaft and adit option has been prepared for the KAWC Tram Alternative study. Dimensions of the shaft and adit section, as well as systems are in accordance with updated NFPA 2015 standards.

Excavation of the shaft, elevator section, and adit will be performed by drilling and blasting, and rock support and shoring within the shaft and adit will be by rock bolting and shotcrete, as indicated in Section 3.3.1. Costs for excavation and shoring are derived from the proposed shaft and adit dimensions, as portrayed on the attached drawings, and summarized below in Table 5.

Table 5: Summary of Dimensions in the Current Concept – Shaft and Adit

Item	Unit	Quantity
Shaft Diameter	FT	18
Shaft Depth	FT	278
Shaft Surface Area	SF	12408
Shaft Volume	CY	2615
Elevator Section Depth	FT	300
Elevator Section Surface Area*	SF	9900
Elevator Section Volume*	CY	1188
Adit and Emergency Corridor Length	FT	385
Adit and Emergency Corridor, Wall Surface Area	SF	22493
Adit and Emergency Corridor Volume	CY	5003

*Does not include section where elevator footprint overlaps with shaft

Work productivity for drilling, blasting and shoring is derived from previous experience and conservative assumptions for drilling and blasting advancement rates, based on a twelve hour workday. The total estimated duration for drilling, blasting and shoring the shaft, elevator, and adit sections is one hundred eighty workdays, thus the total construction time is roughly twelve months. Productivity and labor rates for systems and finishes installation are inherently assumed in the cost.

The total conceptual level opinion of probable construction cost, not including O&M, is included in Table 6. The shaft and adit systems and finishes cost includes the cost of the utility building, elevator, flatbed rail system, lighting, ventilation, and drainage. The lower terminal cost includes the proposed monorail crane system, crane extension, access to the lower services station, and additional walkway and stairs.

Table 6: Total Estimated Conceptual Level Construction Costs – Shaft and Adit

Item		Cost
Mobilization, Surveying, and Site Preparation	$	325,000.00
Shaft & Adit Excavation	$	970,000.00
Elevator Excavation, Support, Lining and Finishes	$	875,000.00
Shaft & Adit Support and Lining	$	613,000.00
Shaft & Adit Systems and Finishes	$	4,916,000.00
30-ton Capacity Telescoping Crane	$	400,000.00
Lower Terminal Cost	$	150,000.00
Rounded Total, Construction Costs – Shaft & Adit Option	**$**	**8,249,000.00**

The estimated design life for the shaft and adit section is one hundred years. The estimated design life for the elevator is twenty five years, assuming monthly elevator inspection. Certain mechanical equipment will have estimated design life of twenty five to fifty years, assuming routine maintenance. Estimated annual operating and maintenance O&M costs for the shaft, elevator, adit, and railway are provided in Table 7. Estimated annual O&M costs for the elevator include monthly inspection of the elevator, elevator rack, and pinion. Estimated annual O&M costs for the flatbed railway include yearly flatbed, rail, and mechanical/electrical component inspection. For the shaft and adit sections, conceptual level estimated annual O&M costs include inspection and testing of the lighting, electrical, fire suppression systems, ventilation, and sump pumps. The annual O&M cost for the 30-ton capacity crane assumes 400 hours per year at an $80 per hour equipment operation cost.

Certain mechanical and electrical components of the shaft and adit section have an estimated design life of less than one hundred years, as discussed above. Therefore, Table 7 also presents estimated conceptual level O&M costs for the shaft, adit, elevator, and railway projected over twenty five years.

Table 7: Conceptual Level O&M Cost Opinion – Shaft and Adit

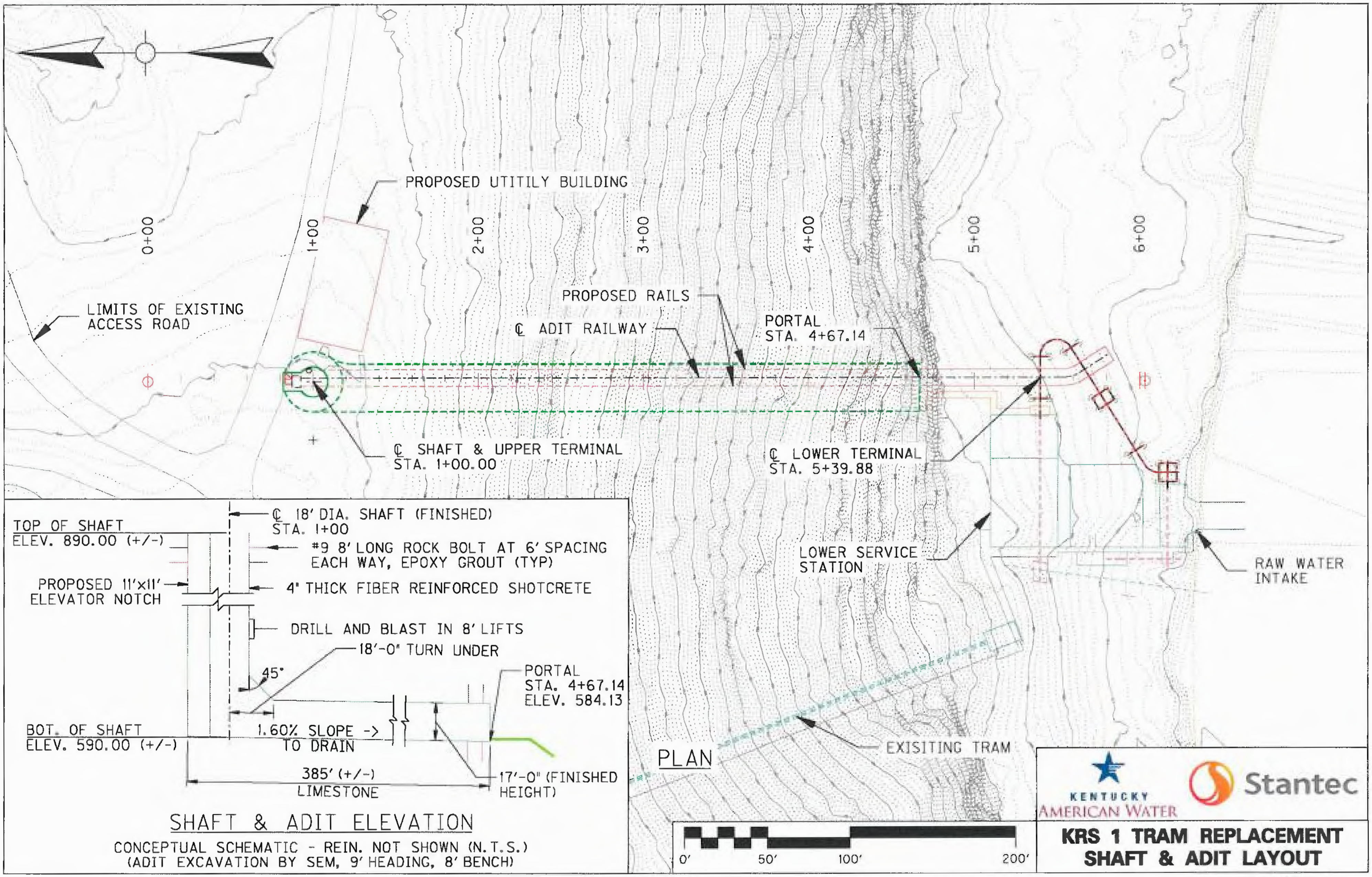
Task	Annual O&M	25-yr O&M
Elevator	$ 5,400.00	$ 85,000.00
Flatbed Railway	$ 5,000.00	$ 78,000.00
Shaft, Adit, and Sump	$ 20,000.00	$ 310,000.00
30-ton Capacity Telescoping Crane	$ 32,000.00	$ 500,000.00
Lower Terminal	$ 10,000.00	$ 156,000.00
Total 25-YR O&M Present Cost – Shaft & Adit Option		**$ 1,129,000.00**

3.3.3 Risk

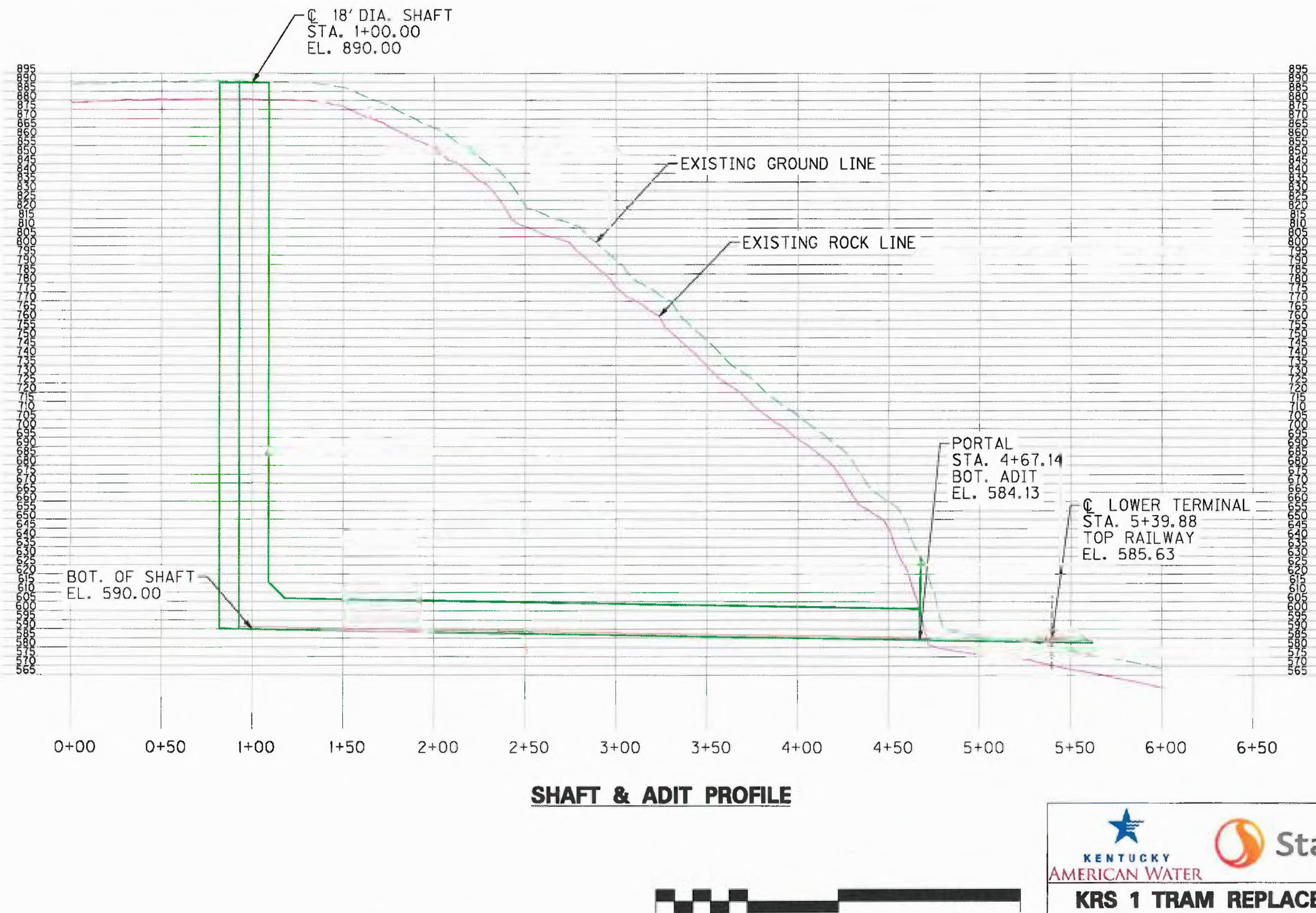
At a conceptual level, the geotechnical risks during construction include unanticipated poor rock conditions encountered during the drill and blast and excavation operations, and excessive groundwater inflows into the shaft or adit. These conditions are commonly avoided with prior subsurface investigations and in-situ permeability testing and laboratory testing. Groundwater mitigation, where necessary, is commonly handled with a grouting program to seal the shaft and adit prior to construction. Poor ground conditions are also stabilized with grout, rock bolts, and/or poly-fiber reinforced shotcrete.

The post construction operational risks conceptually include fire and safety risks that are part of any underground project. The shaft and adit have been designed with redundancy to mitigate major risks during plant operations. This includes construction of a separate egress pathway separated from the adit, inclusion of ventilation, and two forms of egress from the shaft. As design proceeds, a risk identification and mitigation process should be initiated and carried through construction and operation of the facility. This includes preparation and maintenance of a project risk register.

DRAWING 12: SHAFT AND ADIT LAYOUT



DRAWING 13: SHAFT AND ADIT PROFILE

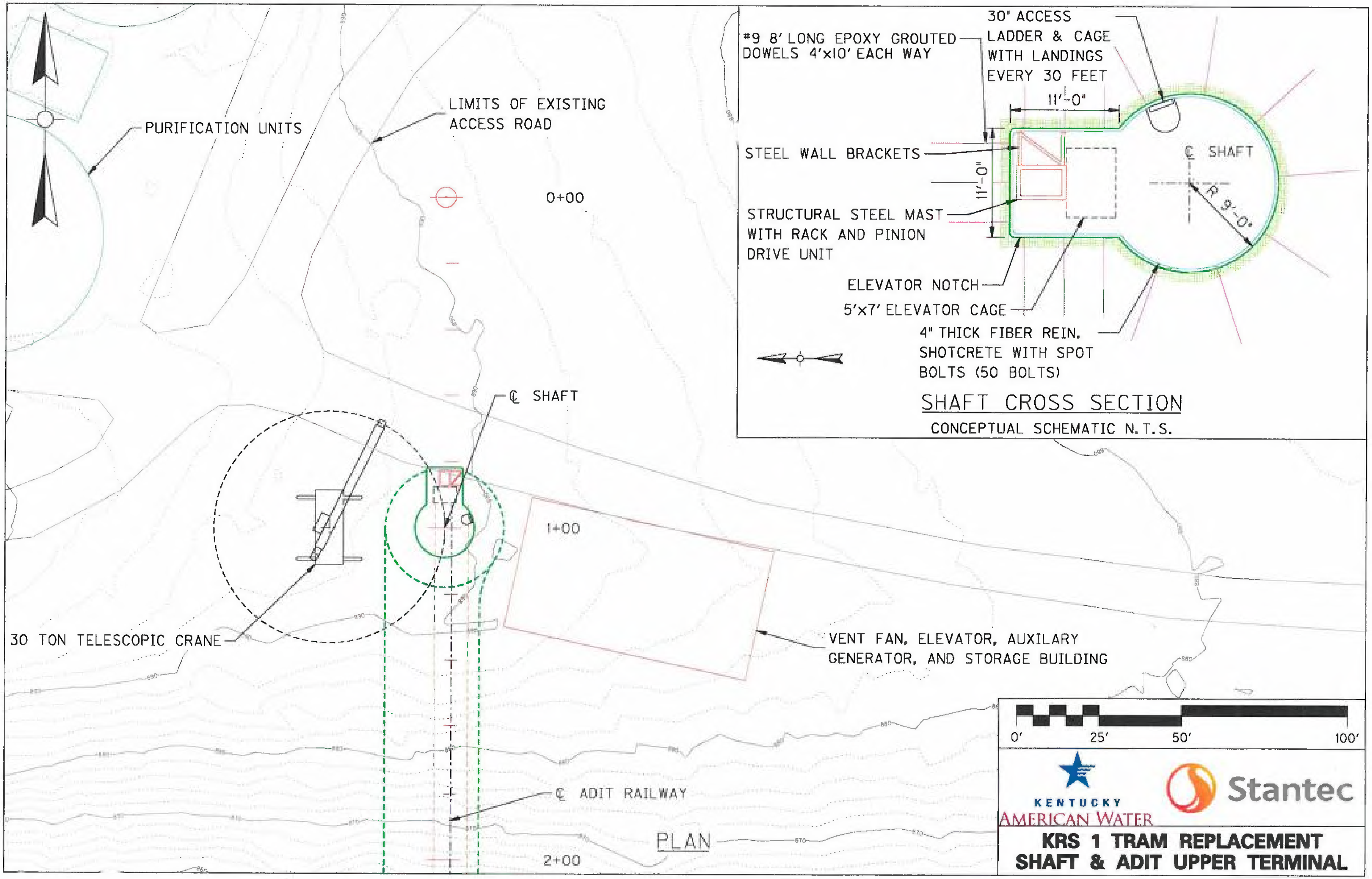


KENTUCKY AMERICAN WATER

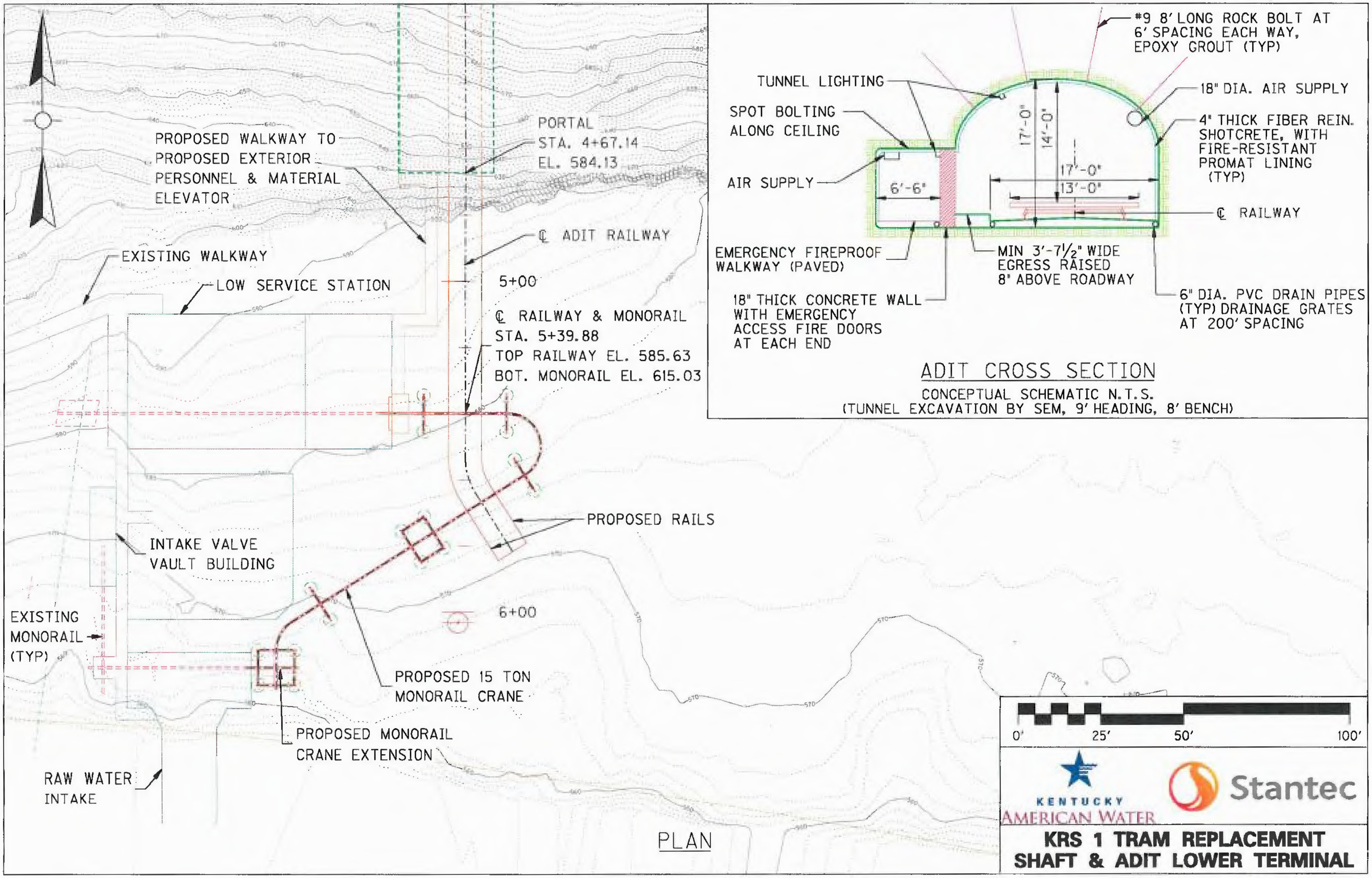
Stantec

KRS 1 TRAM REPLACEMENT
SHAFT & ADIT PROFILE

DRAWING 14: SHAFT AND ADIT UPPER TERMINAL



DRAWING 15: SHAFT AND ADIT LOWER TERMINAL



4.0 CONCLUSION

4.1 SYNOPSES OF REPORT

The following alternatives were evaluated to replace the dated tram system and provide access for personnel, tools, and large equipment to the intake area from the upper plant at Kentucky River Station 1:

- Renting or buying a barge and installing a replacement personnel tram
- Renting a heavy-lift helicopter and installing a replacement personnel tram
- Installing an industrial gondola
- Installing a large capacity inclinator
- Constructing a roadway
- Constructing a shaft and adit
- Constructing a roadway tunnel

From preliminary research and discussions with Kentucky American Water personnel, it was determined the large capacity inclinator, roadway, and shaft and adit were the most feasible alternatives and therefore warranted further study and conceptual design efforts. Conceptual designs and costs analyses have been completed for these three alternatives. A 25 year cost analysis, including initial construction costs and reoccurring O&M costs, for the three main options is presented in Table 8. After 25 years, major maintenance and upgrades to the electrical and mechanical components of all alternatives should be expected.

Table 8: Alternatives Conceptual Design 25 Year Present Cost Comparison

Alternative	Total Installation	25-YR O&M	Total 25-YR Cost
Large Capacity Inclinator	$ 6,710,000.00	$ 965,000.00	$ 7,675,000.00
Roadway	$ 6,675,000.00	$ 390,000.00	$ 7,065,000.00
Shaft & Adit	$ 8,249,000.00	$ 1,129,000.00	$ 9,378,000.00

Based on the conceptual design, the large capacity inclinator provides access to the lower intake area for any sized equipment and people using only one system. The proposed upper terminal for the inclinator provides storage that is easily accessible and integrated into the transportation system. The inclinator is also very versatile and requires minimal lead time for moving large equipment to the lower intake area. However, a large capacity inclinator is specialized equipment that will require regular inspection and maintenance to ensure its continued safe operation. Compared to the other alternatives, the inclinator has a shorter design life thus a complete replacement of the system will be required within 50 years.

The roadway alternative provides immediate, versatile, and easy access to the lower intake area. The roadway requires the least amount of maintenance and the maintenance is traditional relative to the other alternatives. Due to the site conditions, the roadway has the highest environmental impact and creates multiple geotechnical concerns such as possible erosion and rock slides. The proposed design also limits the vehicle size that can use the road and has a considerably steep grade of 16%.

The proposed shaft and adit results in the least environmental impact and has the fewest conditions that could limit access to the lower intake area. Relative to the other alternatives, the shaft and adit provides the longest design life. However, the shaft and adit utilizes multiple systems, such as an elevator, electric rail system, telescoping crane, ventilation system, and lighting that must be maintained and inspected by specialists for the particular system to operate properly.

The major risk of these alternatives is derived from the lack of a geotechnical investigation. For the conceptual designs, geotechnical assumptions were made based on experience from previous projects and published information. If a geotechnical investigation reveals the site has minimal overburden, poor rock conditions, or excessive groundwater, the cost of the alternatives could increase significantly and some of the alternatives may no longer be feasible.

4.2 RECOMMENDED NEXT STEPS

The recommended next step for this project is to initiate preliminary design to further refine the feasibility and opinion of probable costs for one or two of the tram replacement alternatives. Initiating preliminary design will be based upon the desired future method in which water intake will be accomplished. Presently, the options under consideration are 1) the existing method of pumping water from the Kentucky River via the existing intake pumping system, 2) pumping water from the river via a system located at the upper treatment level or, 3) pumping water from the aquifer via vertical shaft pumps located at the upper treatment level.

If Option 1 is selected, construction of one of the three tram replacement alternatives presented in this report would be required. Therefore, the recommended next steps for preliminary design would be to initiate field investigations that would include a geotechnical investigation, detailed site survey to refine mapping, and initiating key environmental baseline studies. The field investigations will either refine the design and cost estimates from this study level investigation, or determine constraints that would eliminate one of the alternates. A preliminary 30% level technical design would be completed for the preferred tram replacement alternatives. The estimated fee for Preliminary design, including the scope items above, is $298,000, and could be completed in 6-8 months.

APPENDIX A: TRAM AND STAIR SYSTEM INSPECTION REPORT

Stantec Consulting Services Inc.
400East Vine Street Suite 300, Lexington KY 40507-1532

August 5, 2016

Attention: Adam Tilley, PE
Kentucky American Water Company
2300 Richmond Road
Lexington, KY 40502

Reference: Results of Investigation – Tram Inspection

Dear Mr. Tilley,

As requested, Stantec Consulting Services Inc. (Stantec) has completed the structural component inspection of the incline tram and adjacent stairs on June 24, 2016. Staggs and Fisher Consulting Engineers, Inc. (Staggs and Fisher) has completed the inspection of the tram's mechanical and electrical components on July 20, 2016. This letter provides the results of the investigation and offers repair/replacement recommendations.

BACKGROUND & SCOPE OF SERVICES

The scope of services included:

- A visually inspect of the tram structural components at arm's length including the concrete pad foundation, ties, rail supports, rails, cross struts, trolley and stair structural components, and terminal wall, column, and roof members. (Stantec)
- A visually inspect including as necessary operation, calibration, and testing of the mechanical and electrical tram components. (Staggs and Fisher)
- A list of the field investigation findings with photos showing the existing state of the tram and stairs.
- A list of recommendations to improve the mechanical operations of the tram and overall structural stability of the tram and stairs.

SUMMARY OF FINDINGS

The following list summarizes the field investigation findings:

A. Tram – Structural:

The funicular manufactured by Philadelphia Toboggan in 1957 spans 510 feet on a slope with an average incline of 43°. The 1,200 lb. capacity car is propelled by a chain lift and counter weight system. The car and counter weight travel on channels supported by wood ties spaced at 5 feet. The ties are attached to 2 longitudinal track sills. For 445 feet, the sills are attached to a 4" x 3'-6" concrete pad; for 22 feet, they are supported by 2 wide flanged 8x17; and for 43 feet, they are connected to 2 wide flanged 16x36. The upper chain trough is attached to spreader bars spaced at 10 feet and the lower chain trough is attached to the wood ties. For further details, refer to Diagram 1.

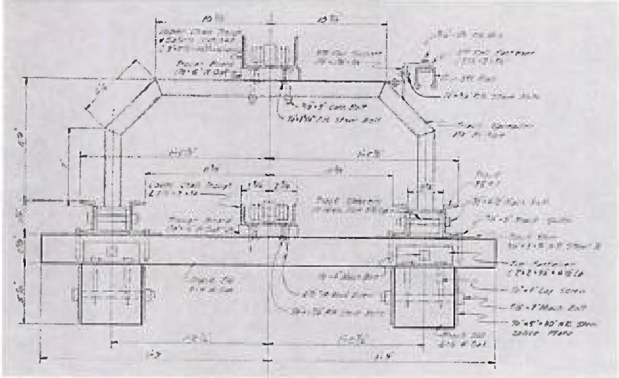


Diagram 1: Typical Tram Cross Section

General areas of damage and/or deterioration are as follows **(Sketches 1 and 2)**:

- Structure
  1) Typical vegetation growth around structure with minor vegetation growth on structure **(Photo 1)**.
  2) Typical loss of protective steel coating and formation of rust **(Photo 2)**.
- Substructure
  1) Typical minor spalls and cracks throughout the foundation.
  2) Fractured concrete pad (foundation) with a 10" gap with exposed earth at spreader bar (SB) 22 **(Photo 3)**.
  3) 3' x 2' spall in concrete pad at SB 37 **(Photo 4)**.
  4) Longitudinal crack in concrete pad between SB 37 and 38 **(Photo 5)**.
  5) Poor compaction in the foundation and loose nut at south anchor at SB 47 **(Photo 6)**.
  6) I-beams are not connected to foundation at STA. 00+54 **(Photo 7)**.
- Superstructure
  1) Cross ties starting to deteriorate with typically longitudinal splitting **(Photo 8)**.
  2) Typical cracks in welds between ends of car and counter weight channel beams **(Photo 9)**.
  3) 0.125" deep chip in east track counterweight rail at SB 3 **(Photo 10)**.

4) 0.25" to 0.50" longitudinal gap between end of east car rails at SB 15 **(Photo 11)**.
5) 0.50" section of bent west rail between SB 39 and 40 **(Photo 12)**.
6) Typical loose tie fasteners due to tie splitting and/or deterioration **(Photo 13)**.
7) There is impact damage to SB 36 and 40 **(Photo 14)**.
8) Lower chain trough at SB 15 is not connected resulted in a 0.625" longitudinal gap and 0.25" shift left **(Photo 15)**.
9) Upper trough board is deteriorating between SB 49 and 50 **(Photo 16)**.
10) Typical laminate sheared around screws and worn from chain movement in upper and lower chain trough **(Photo 17)**.

B. Tram – Mechanical and Electrical:

The tram's electrical components were also installed in 1957 and consist of a chain driven motor using counter weights. The motor, the motor starters and controls, and associated electrical equipment are located in the upper terminal building. The railway starters and controls are fed with a 100 amp feed from a 480 Volt, 100 amp Russelectric Automatic Transfer Switch. The normal power feed to the incline lift motor is a 100 amp feeder from Panel Substation E. The emergency power feed to the incline lift motor is a 100 amp feeder from Distribution Panel EDPB. For a schematic of the tram's electrical components, refer to Diagram 2.

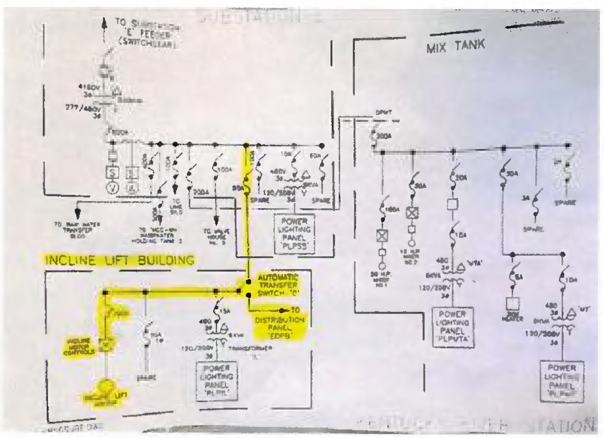


Diagram 2: Tram Electrical Schematic

C. Stairs:

The service stairs are comprised of MC10x8.4 stringers with 9½" x 2" steel treads, 1½" diameter pipe rail posts with $1^5/_8$" diameter rails **(Sketch 3)**. The stairs are founded on thrust blocks **(Sketch 4)** and the body of an abandoned 24" diameter steel pipe running from the main plant area to the intake area. The stairs are located 10 feet West of the tram, **(Sketches 5 – 7 and Photo 18)** and they generally exhibit moderate deterioration with numerous areas of severe deterioration.

General areas of damage or deterioration are as follows:

1) Paint system has failed on the stair treads **(Photo 19)** and over 10% of the remaining structure.
2) There are numerous areas of corrosion at the pipe rail weld connections to the top flange of the MC10 stringer **(Photo 20)**.
3) Numerous locations of advanced corrosion of the channel members at the connection of the stringers to the thrust block **(Photo 21)**.
4) Several of the concrete thrust blocks exhibit cracking and/or spalling **(Photos 22 and 23)**.

Specific areas of damage or deterioration are described below and keyed to the stair drawing Sections:

1) Stringer channel to support channel separated at first thrust block, west side **(Sketch 5)**.
2) 1^{st} post past thrust block at 24 feet – both posts disconnected at channel top due to corrosion and expansion-contraction constraint due to location of expansion joint **(Sketch 5)**.
3) Welds broken at stair system connection to waterline pipe **(Sketch 7)**.

CONCLUSION & RECOMMENDATIONS

A. Tram – Structural

Due to the age and frequent use of the tram, structural components are damaged and deteriorating. If the tram is not replaced, the following repairs are recommended to ensure the tram remains in safe working condition:

1) Clear vegetation away from tram area
2) Reapply protective steel coating
3) Replace decaying or split ties
4) Tighten loose nut at spreader bar 47 and any loose tie fasteners
5) Prep, re-weld, and grind smooth ends of car and counter weight tracks
6) Replace damaged spreader bars
7) Replace deteriorated upper trough board between spreader bars 49 and 50
8) Replace sheared and damaged laminate in upper and lower chain trough

9) Realign and attached lower chain trough at spreader bar 15
10) Monitor concrete foundation for growing cracks and spalls

B. Tram – Mechanical and Electrical:

The system is inspected periodically with the last inspection performed on June 21, 2016. The last inspection stated that the railway is acceptable for use. During a site visit, the railway was operated and was in working condition. The incline railway and all the electrical systems appear to be well maintained. However, the transfer switch, motor starters and controls have all exceeded their useful life and it is recommended that they be replaced.

C. Stairs

The stair system has reached the end of its design life and should be programed for replacement. If the stairs are not replaced in the next five years, the following maintenance is recommended:

1) All of the corroded areas throughout the entire system should be prepared for painting or replaced as necessary and the system painted.
2) The cracks and spalls in the concrete thrust blocks should be prepped and repaired.
3) As necessary, tighten or replace bolts connecting the stair support channels to the thrust blocks or pipe body.
4) Reattach the stringer channel to the support channel separated at the first thrust block, west side **(Sketch 3)**.
5) Repair broken welds at stair system connection to the waterline pipe **(Sketch 5)**.

The tram system and stairs have outlasted their design life and should be replaced; if they aren't replaced, extensive and regular maintenance as well as in-depth inspections are advised to ensure proper operation and safety.

We appreciate the opportunity to provide these services. If you have any questions or need additional information, please call.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Tony Hunley, PhD, PE, SE
Principal

Michael A. Lawler, PE
Senior Project Manager, Structures

Enclosures

Photo 1

Photo 2

Photo 3

Photo 4

KRS 1 TRAM SYSTEM INSPECTION
FAYETTE COUNTY, KY


Photo 5


Photo 6


Photo 7


Photo 8


Photo 9


Photo 10


Photo 11


Photo 12


Photo 13


Photo 14


Photo 15


Photo 16

KRS 1 TRAM SYSTEM INSPECTION
FAYETTE COUNTY, KY


Photo 17


Photo 18

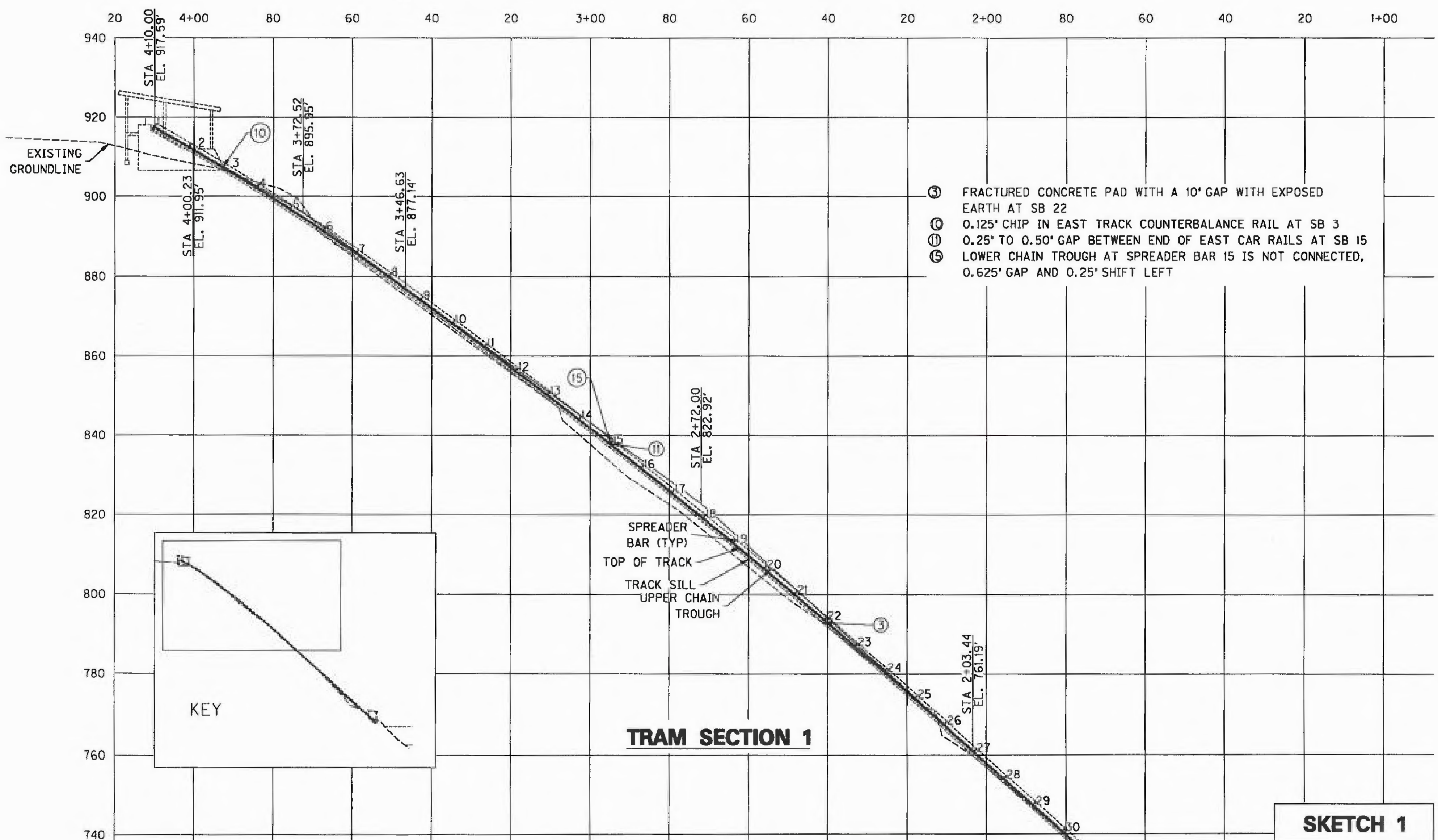

Photo 19


Photo 20


Photo 21


Photo 22

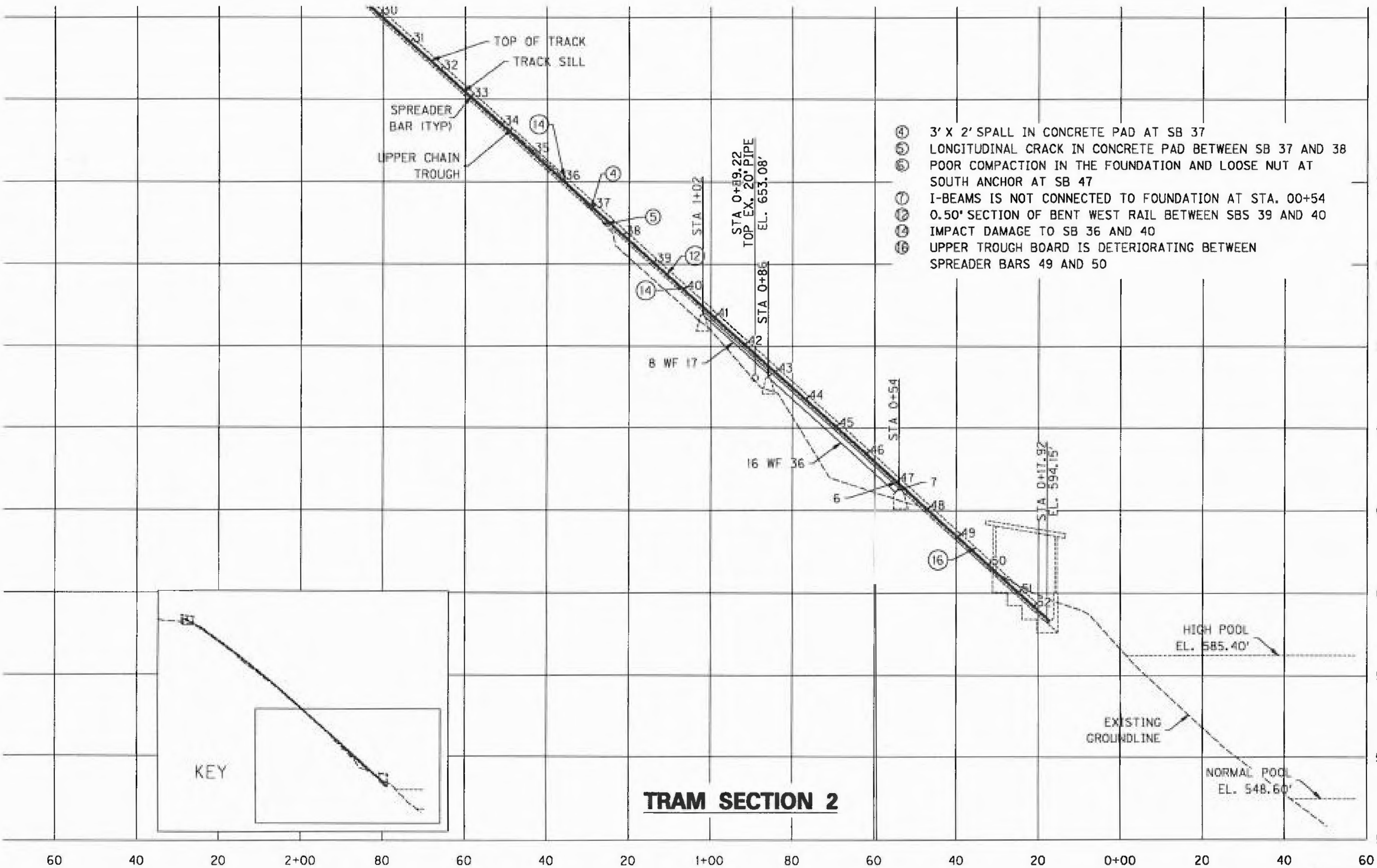

Photo 23



TRAM SECTION 1

SKETCH 1

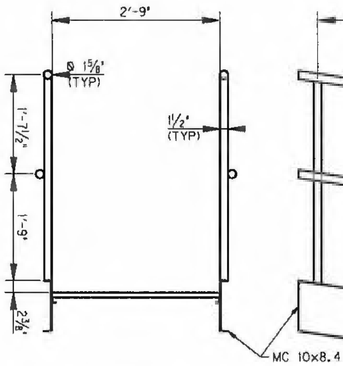
A.7



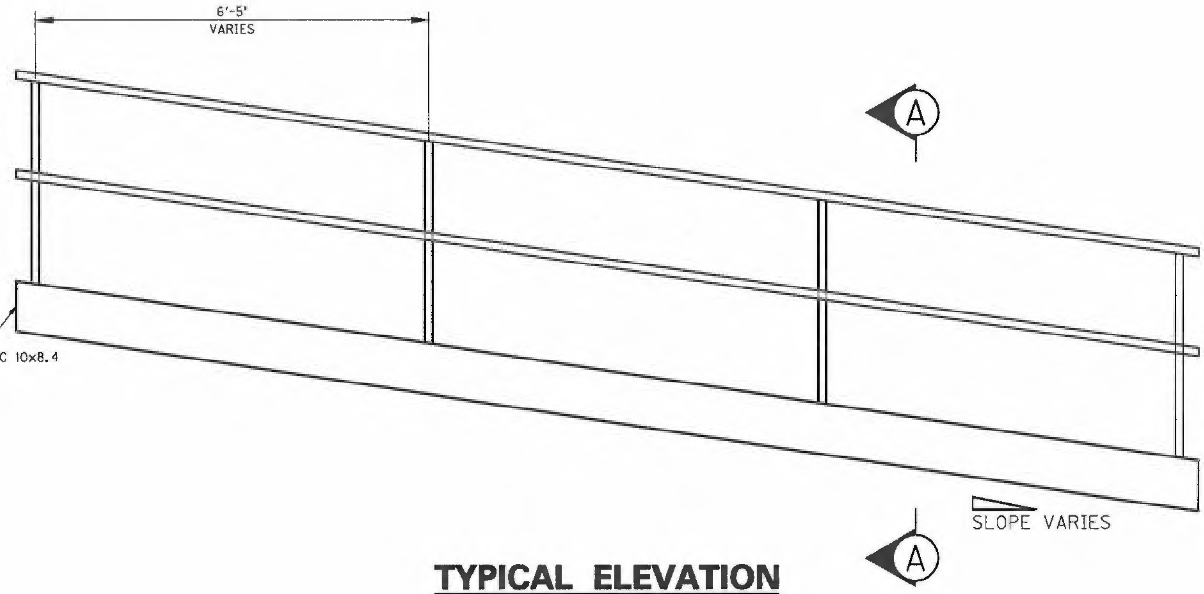
TRAM SECTION 2

SKETCH 2

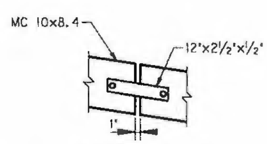
A.8



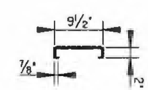
A SECTION
N.T.S.



TYPICAL ELEVATION

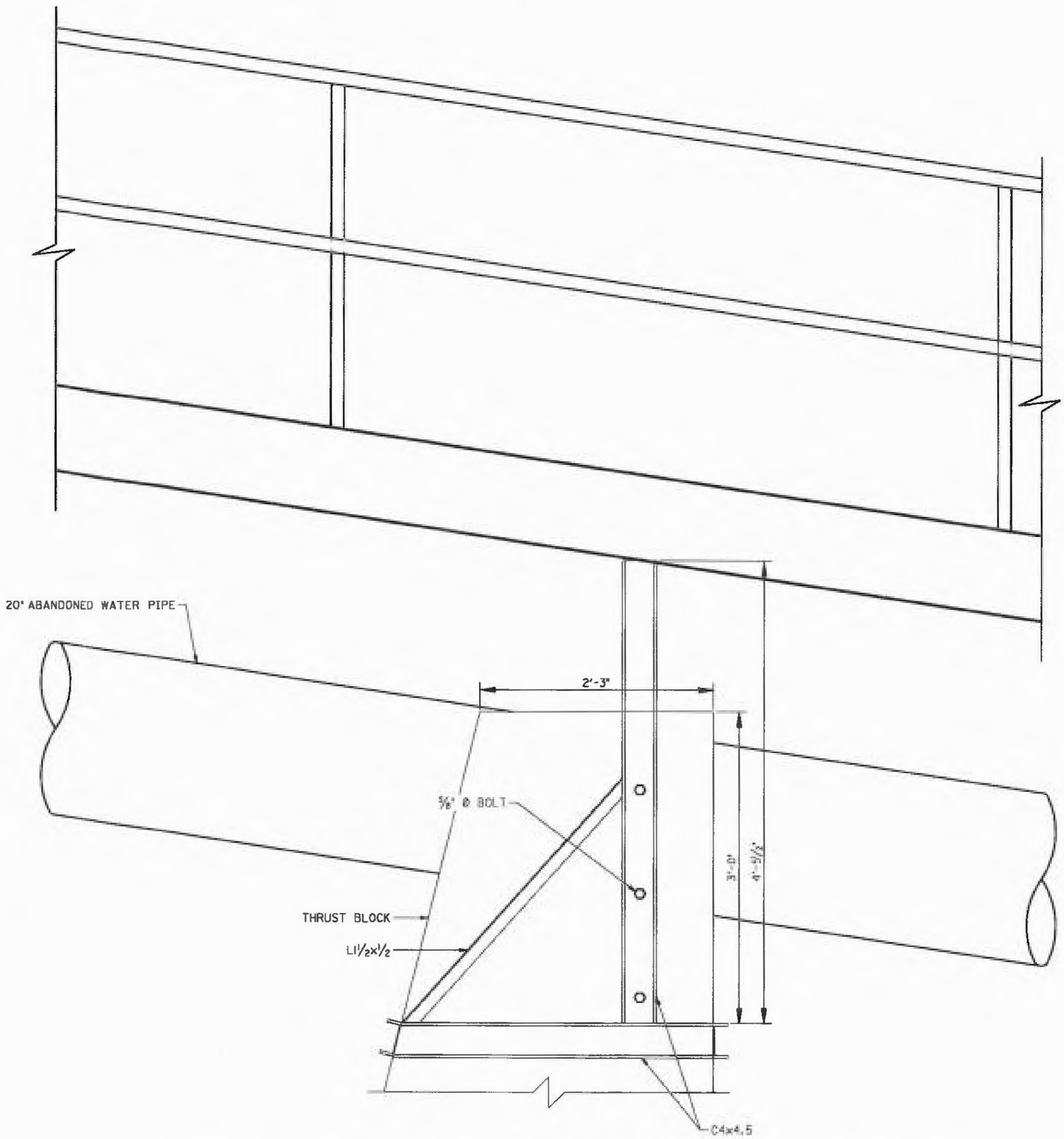


DETAIL 1
EXPANSION JOINT (TYP)



DETAIL 2
STAIR TREAD (TYP)

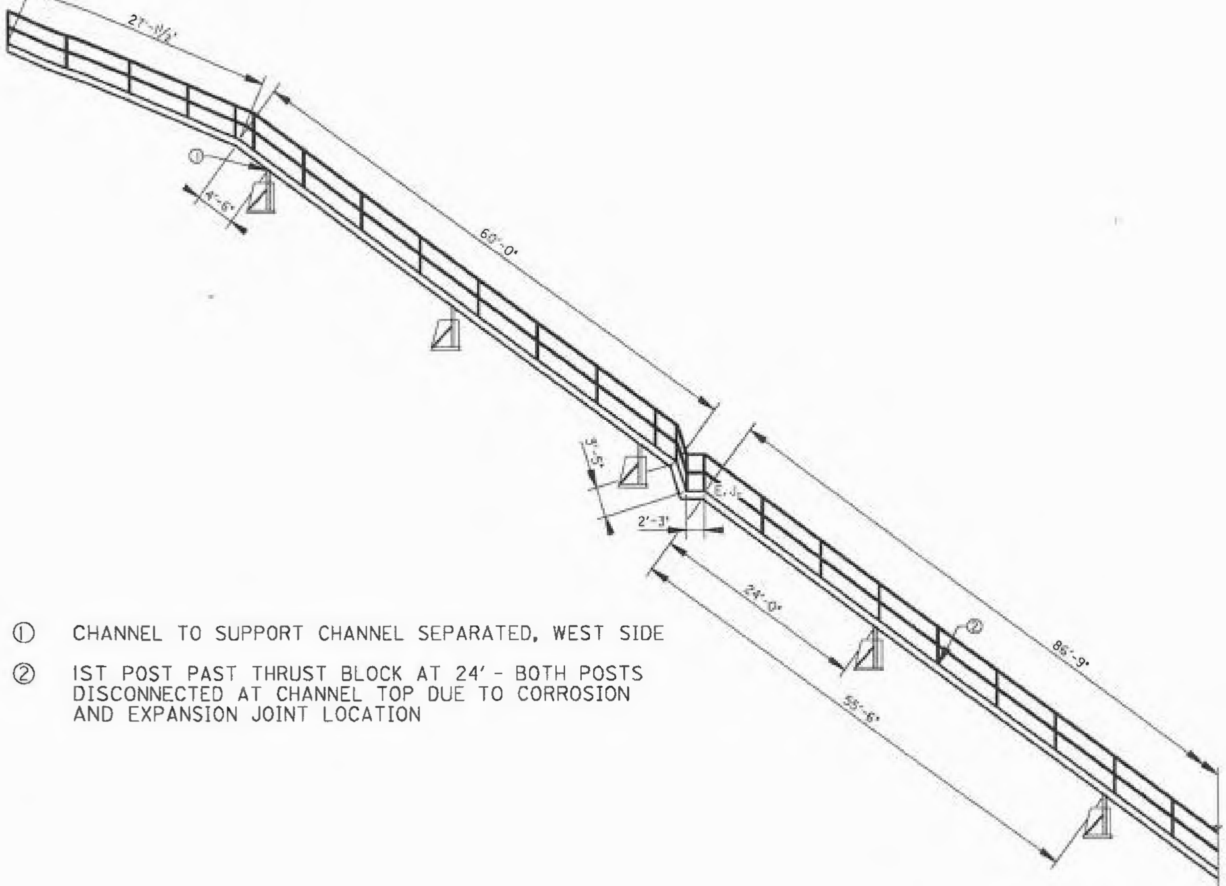
SKETCH 3



TYPICAL CONNECTION AT PIPE THRUST BLOCK

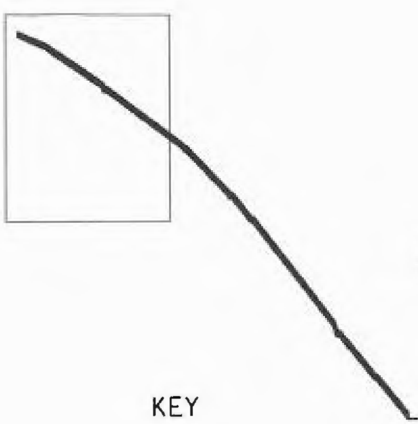
NOTE: SKETCH SHOWS ONE OF A NUMBER OF VARIATIONS OF CHANNEL SUPPORT FRAMING AT THE THRUST BLOCKS.

SKETCH 4



① CHANNEL TO SUPPORT CHANNEL SEPARATED, WEST SIDE

② IST POST PAST THRUST BLOCK AT 24' - BOTH POSTS DISCONNECTED AT CHANNEL TOP DUE TO CORROSION AND EXPANSION JOINT LOCATION



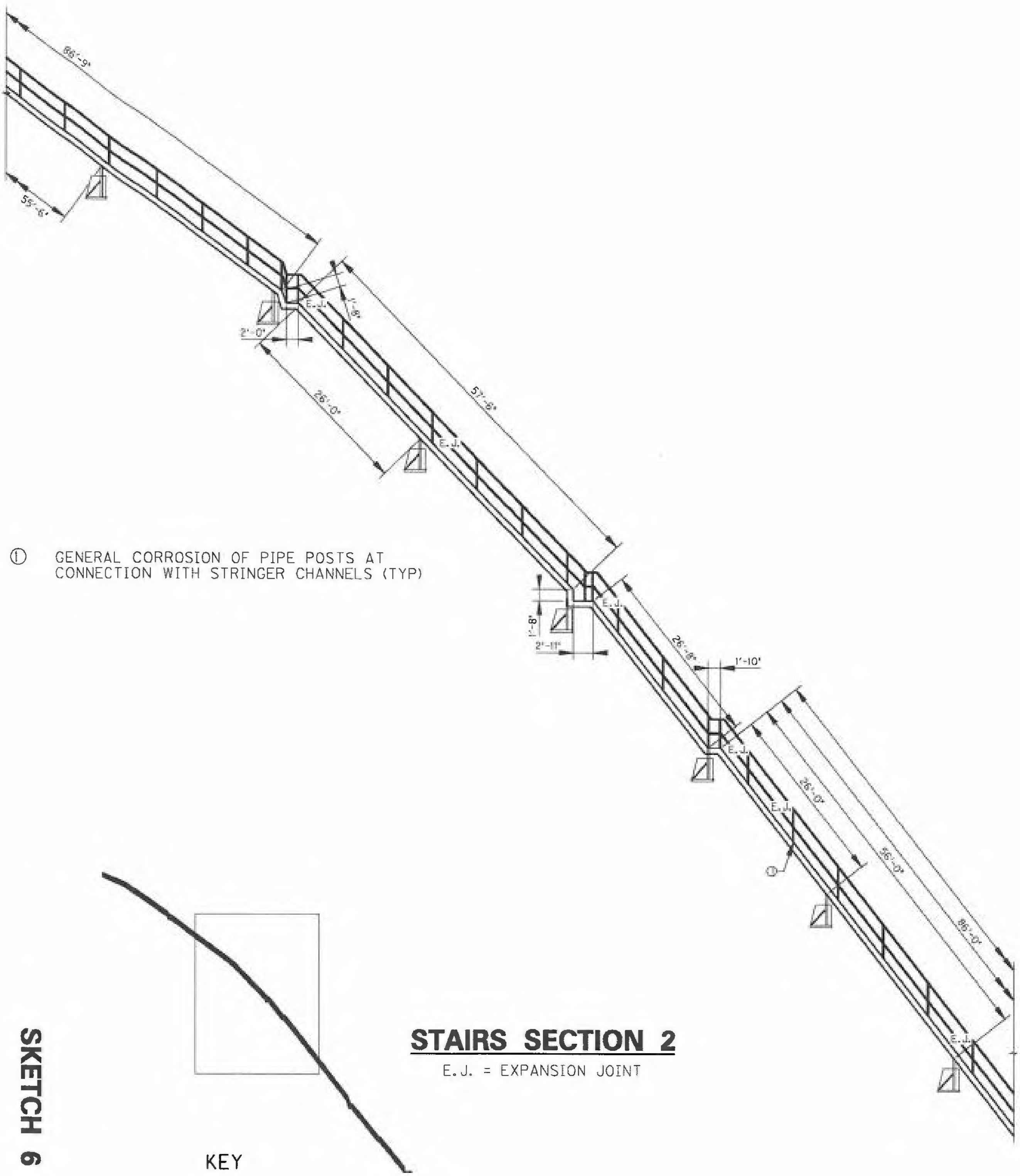
KEY

STAIRS SECTION 1

E.J. = EXPANSION JOINT

SKETCH 5

A.11



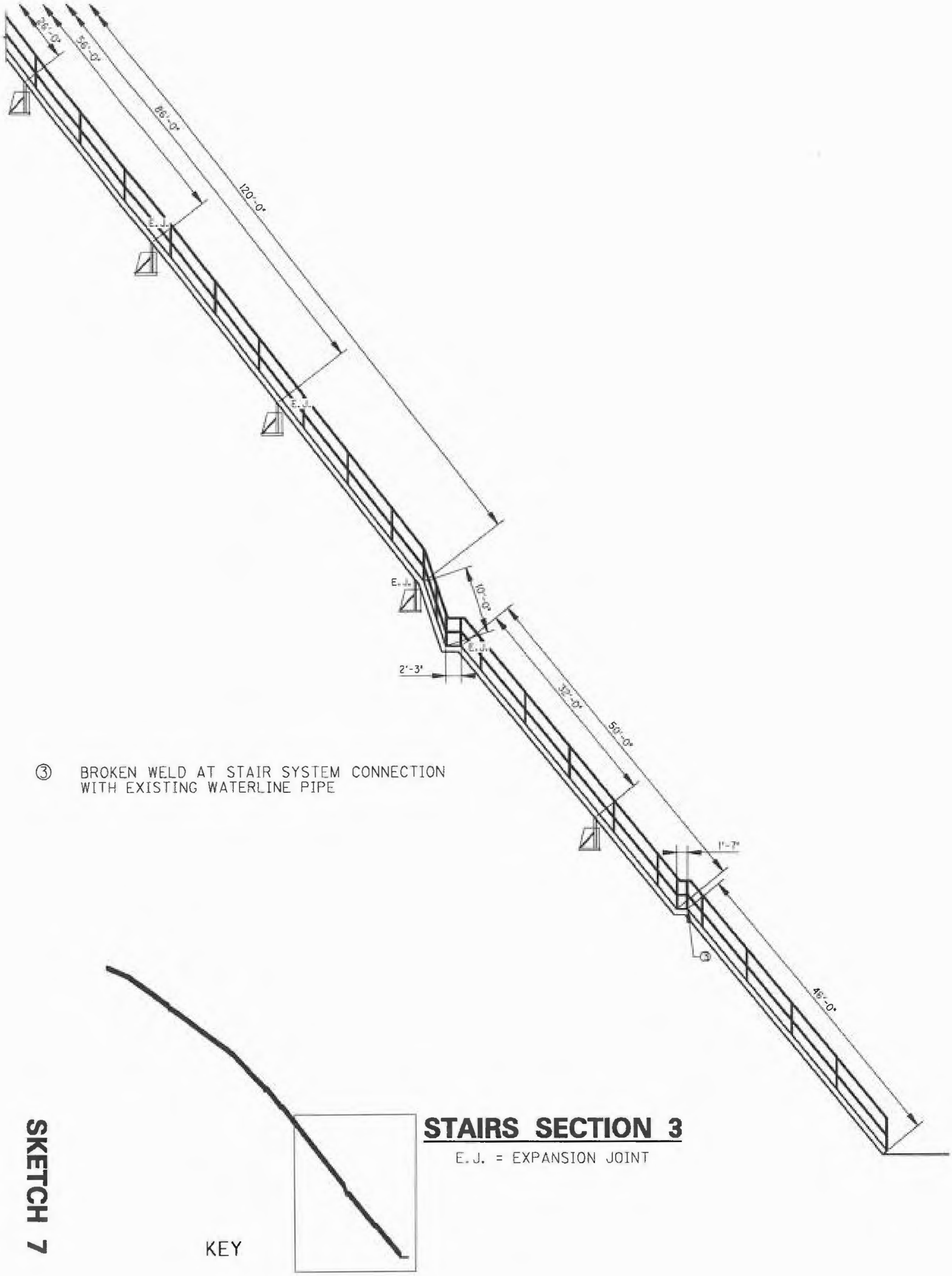
① GENERAL CORROSION OF PIPE POSTS AT CONNECTION WITH STRINGER CHANNELS (TYP)

STAIRS SECTION 2

E.J. = EXPANSION JOINT

SKETCH 6

A.12



③ BROKEN WELD AT STAIR SYSTEM CONNECTION WITH EXISTING WATERLINE PIPE

KEY

STAIRS SECTION 3

E.J. = EXPANSION JOINT

SKETCH 7

A.13

APPENDIX B: TRAM REPLACEMENT BRAINSTORMING MEETING

KENTUCKY AMERICAN WATER

KRS 1 Tram Replacement Brainstorming Session

July 27, 2016

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Agenda

KRS 1 Tram Replacement Study

July 27, 2016

1. Study Overview
2. Project Background
3. Replacement Alternatives
   - Barge & Replace Tram
   - Helicopter & Replace Tram
   - Large Capacity Inclinator
   - Gondola
   - Roadway
   - Tunnel
   - Vertical Shaft & Adit
4. Project Site Tour
5. Small Group Breakout
   - Pros / Cons
   - Questions?
6. Large Group Discussion
7. Next Steps

Design with community in mind

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Agenda

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B.3

KRS 1 TRAM TIMELINE

1950

1957 — Existing Personnel Tram Built

2000

2009 — Carrick Engineering Corp. Tram Replacement Feasibility Study

2016 — Stantec Tram Inspection and Replacement Conceptual Design Study

B.4

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Agenda

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July 27, 2016

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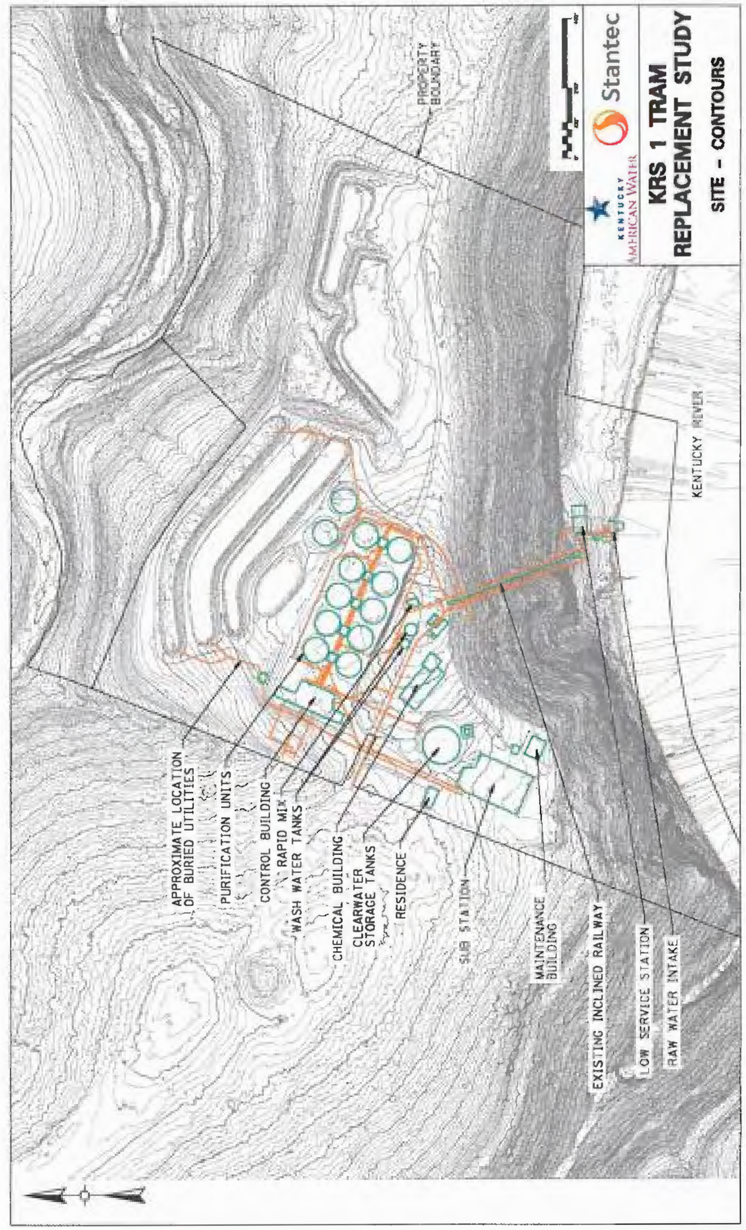

B.5

REPLACEMENT
INCLINATOR

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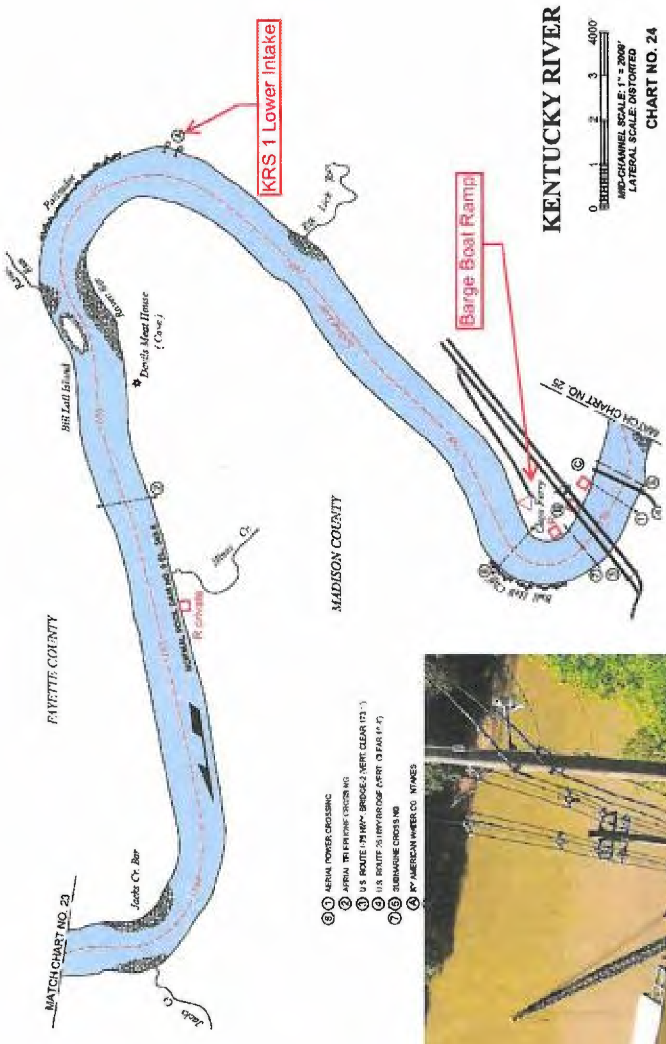
Design with community in mind



BARGE

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Design with community in mind

HELICOPTER


Stantec
KENTUCKY AMERICAN WATER
KRS 1 TRAM REPLACEMENT STUDY
PROPOSED LIMITS OF MECHANICAL LIFT

Stantec **Agenda**

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July 27, 2016

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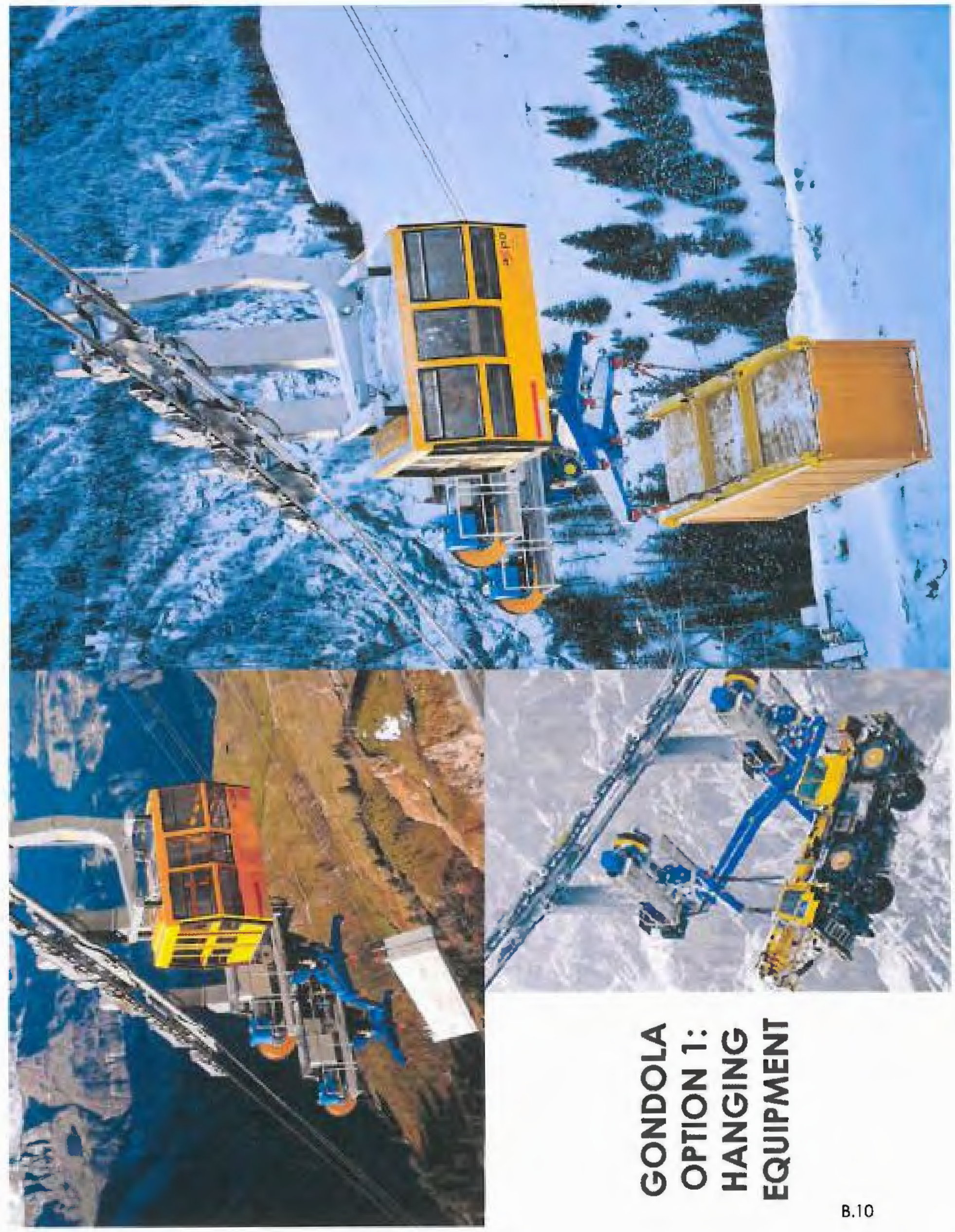

GONDOLA OPTION 1: HANGING EQUIPMENT

GONDOLA OPTION 2: PLATFORM

GONDOLA or INCLINATOR: TERMINAL & STORAGE

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Agenda

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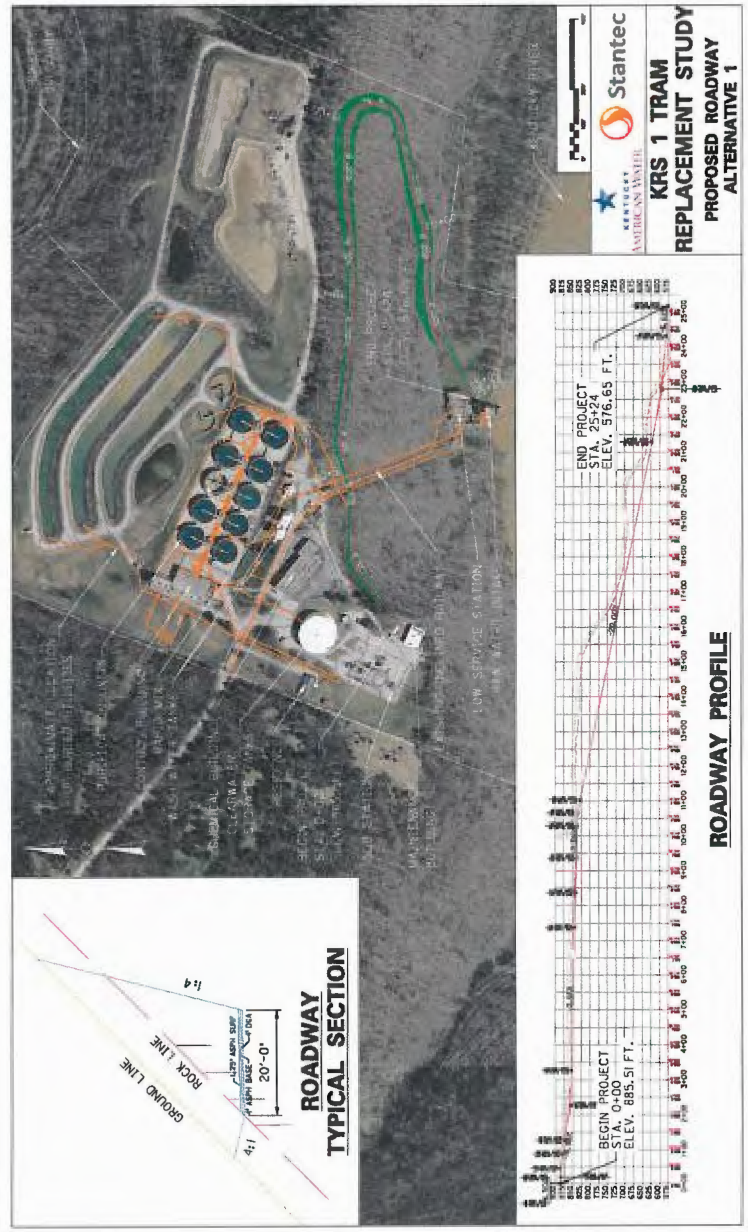

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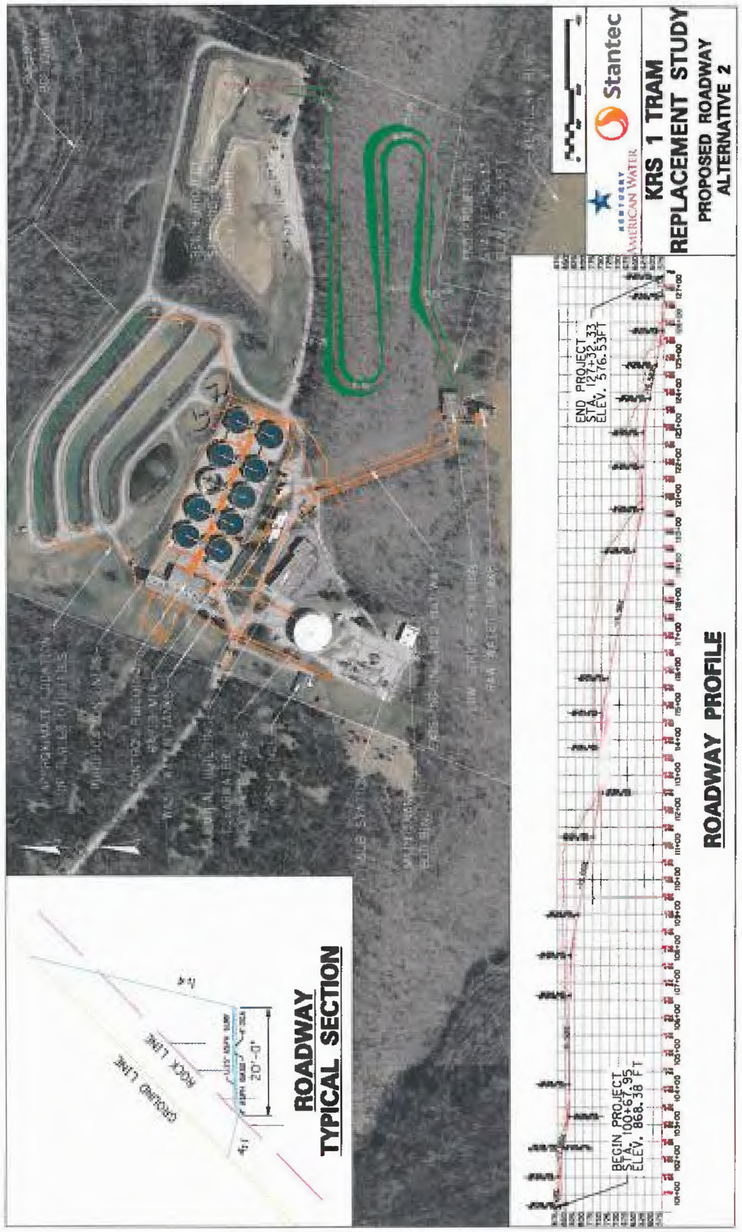

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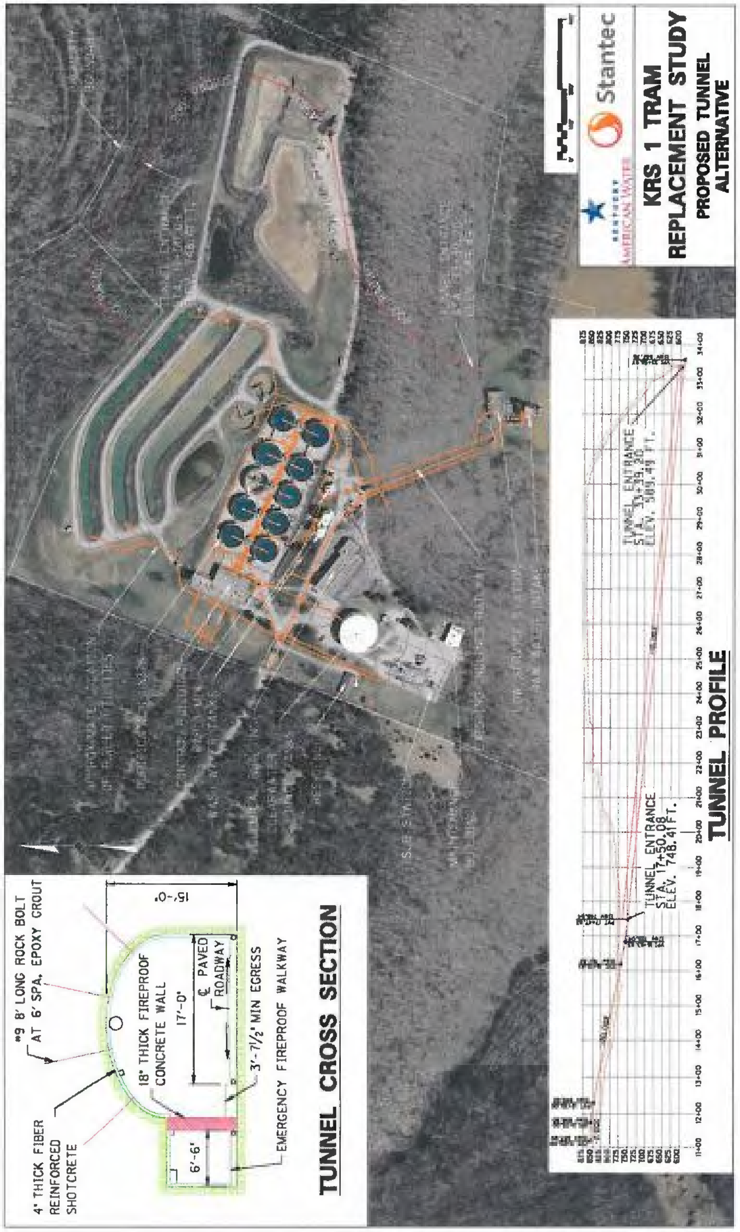

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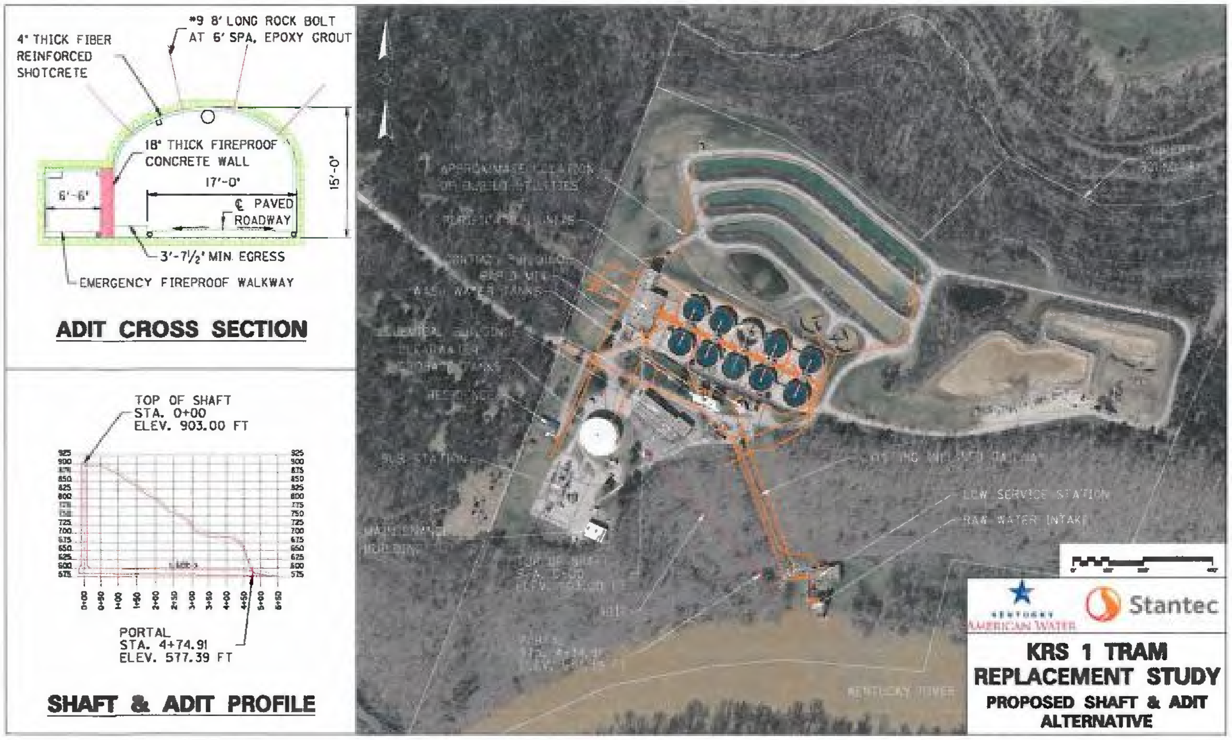
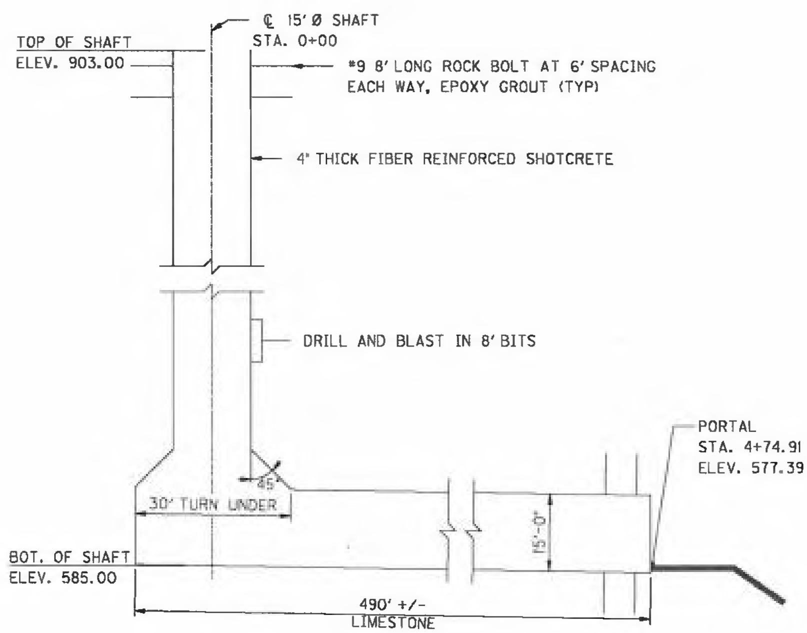
7. Next Steps

Design with community in mind





SHAFT & ADIT ELEVATION

(ADIT EXCAVATION BY SEM, 8' TOP BENCH, 7' BOTTOM BENCH)

Stantec

KRS 1 Tram Replacement Study

KENTUCKY AMERICAN WATER

BRAINSTORMING MEETING

July 27, 2016

PERSONAL IDENTIFIERS REDACTED

NAME	ORGANIZATION	PHONE NUMBER	E-MAIL ADDRESS
Tony Hunley	Stantec	[redacted]	[redacted]
Greg Sharp	Stantec	[redacted]	[redacted]
Sheila Foy	Stantec	[redacted]	[redacted]
Bret Lavey	Stantec	[redacted]	[redacted]
Mitzi Combs	KAW	[redacted]	[redacted]
Edwin Sturgis	KAW	[redacted]	[redacted]
Rick Ponti	Stantec	[redacted]	[redacted]
Paul Thaman	Glenwood Elect.	[redacted]	[redacted]
Erik Hall	KAWC	[redacted]	[redacted]

Stantec

KRS 1 Tram Replacement Study

KENTUCKY AMERICAN WATER

BRAINSTORMING MEETING

July 27, 2016

PERSONAL IDENTIFIERS REDACTED

NAME	ORGANIZATION	PHONE NUMBER	E-MAIL ADDRESS
Adam Tilley	KAW	[redacted]	[redacted]
Connor Ellison	Stantec	[redacted]	[redacted]
Bob Tucker	Stantec	[redacted]	[redacted]
Mike Maggard	KAW	[redacted]	[redacted]
Kenny Buehler	KAW	[redacted]	[redacted]

Stantec

KRS 1 Tram Replacement Study

KENTUCKY AMERICAN WATER

BRAINSTORMING MEETING

July 27, 2016

NAME	ORGANIZATION	PHONE NUMBER	E-MAIL ADDRESS
Chuck Fischer	Ky Service Co.	[redacted] PERSONAL IDENTIFIERS REDACTED	

Stantec

KRS 1 Tram Replacement Study
July 27, 2016

Comment on Alternatives

Comments on all:

- Crane or loading/unloading system at top and bottom
- Environmental and Permitting
- Flooding

1. Barge & Replace Tram
   - Pros
     - o Minimal environmental impact
     - o Minimal Infrastructure to maintain
   - Cons
     - o Access to Boat Ramp – rental fee, change in ownership
     - o No other river access in pool
     - o 2 weeks lead time – slow accessibility
     - o Infrastructure at river
   - Comments
     - o 3 major moves every 2 years

2. Helicopter & Replace Tram
   - Pros
     - o Less expensive than barge
   - Cons
     - o Access to lower intake – updraft
     - o Weather
     - o Availability
     - o 2 weeks to 1 month lead time (x2)
     - o Coordination of staging and equipment moving
   - Comments
     - o Time to hold load?

3. Large Capacity Inclinator
   - Pros
     - o Accomidate all equipment and people
     - o Terminal at top for storage
     - o One system to maintain
     - o Minimal environmental impact
     - o Most Versatile
     - o Close to the ground (less fear than gondola)
     - o Weather less of an issue
   - Cons
     - o Inspection
     - o Specialized equipment
     - o Safety
     - o Maintenance & conditioning worsening over time
     - o More power cost

4. Gondola
   - Pros
     - o Terminal at top for storage
     - o Least footprint
   - Cons
     - o Cost
     - o User comfort
     - o Higher maintenance and inspection cost
     - o Functionality in adverse weather
   - Comments
     - o Life span of cables

5. Roadway (Alternate 1)
    - Pros
        - No mechanical equipment
        - Cost
        - Traditional maintenance
        - Immediate access
        - Versatility
    - Cons
        - Slope – Geotech, Erosion, Rock Slides
        - Winter maintenance
        - Vehicle size limited
        - Cost risk
        - Top side termination/alignment & access
        - Overhead pipe breaks & clearance
        - 20% grade
        - Barrier cost
    - Comments
        - Would stairs be necessary?
        - Barriers

6. Tunnel
    - Cons
        - Way too expensive

7. Vertical Shaft & Tunnel
    - Pros
        - Weather independent
    - Cons
        - Cost
        - Maintenance & inspection
        - Ventilation system
        - Monitoring system
    - Comments
        - Load terminal under roof
        - Buggy/cart system in adit
        - Increase shaft size to 18 ft?
        - Ensure plenty of vertical clearance in adit

Technical Memorandum

Date:	Friday, July 29, 2016
Project:	KAW Hydraulic Efficiency Study – Treatment Plant High Service and Finished Water Transfer Facilities
To:	Adam Tilley Kentucky American Water 2300 Richmond Road Lexington, KY 40502
From:	Brent Tippey, P.E.
Subject:	Technical Memorandum

This Technical Report is prepared in accordance with HDR's proposal for engineering services dated December 9, 2014 for this referenced project.

The intent of the project is to evaluate the current high service pumping operations and provide recommendations for improved efficiency with efficiency recommendations including both short term and future optimization. The evaluation procedures included site inspections, review of record drawings/ pump curves and hydraulic modeling.

KAWC facilities included in this evaluation are:

- Kentucky River Station No. 1 (KRS1)
- Kentucky River Station No. 2 (KRS2)
- Woodlake Transfer Station
- Richmond Road Station (RRS)
- Jacobson Reservoir Station (JRS)

Current rated production and delivery capacity for these facilities are approximately:

Water Treatment Plants

- KRS 1 45 MGD
- KRS 2 20 MGD
- RRS 25 MGD

Total 90 MGD

Pumping Facilities

- Woodlake Road 20 MGD
- Jacobson Reservoir 25 MGD

Total 45 MGD

KAW Plant Production Background

For the purposes of comparison, Figure 1 illustrates the total cumulative daily production rates for all KAW treatment plants for the period between January 14, 2014 and August 15, 2015. As shown, the most common production is between 32 MGD (22,250 GPM) and 45 MGD (31,275 GPM) with maximum day values approaching 57 MGD (39,615 GPM). The average daily production during the time period was 38 MGD (26,410 GPM).

Individual Plant Production and Transmission

The daily production can be further detailed through a review of the individual trends at each of the treatment facilities. This review will help us to understand the most likely range of current operation and whether any clear gaps in production and transmission capability exist.

During interviews with KAW staff, it has become apparent that gaps exist at facilities in terms of their ability to deliver a specific throughput. Operators currently manage this though a time of operations approach. This means that the operators have a traditional range of production and vary the total daily output based on the operating time of the plant.

A major driver for the rate of production and cost related to finished water pumping at both KRS1 and RRS is the amount of raw water flow that is diverted from KRS1 (through the raw water transfer station) and sent to the Richmond Road Station (RRS) or Jacobson Reservoir. As the raw water pumps and transfer station pumps are constant speed, the flow produced and diverted has a narrow range which requires operators to treat water based on the pumping limitations more than on the most optimal treatment ranges.

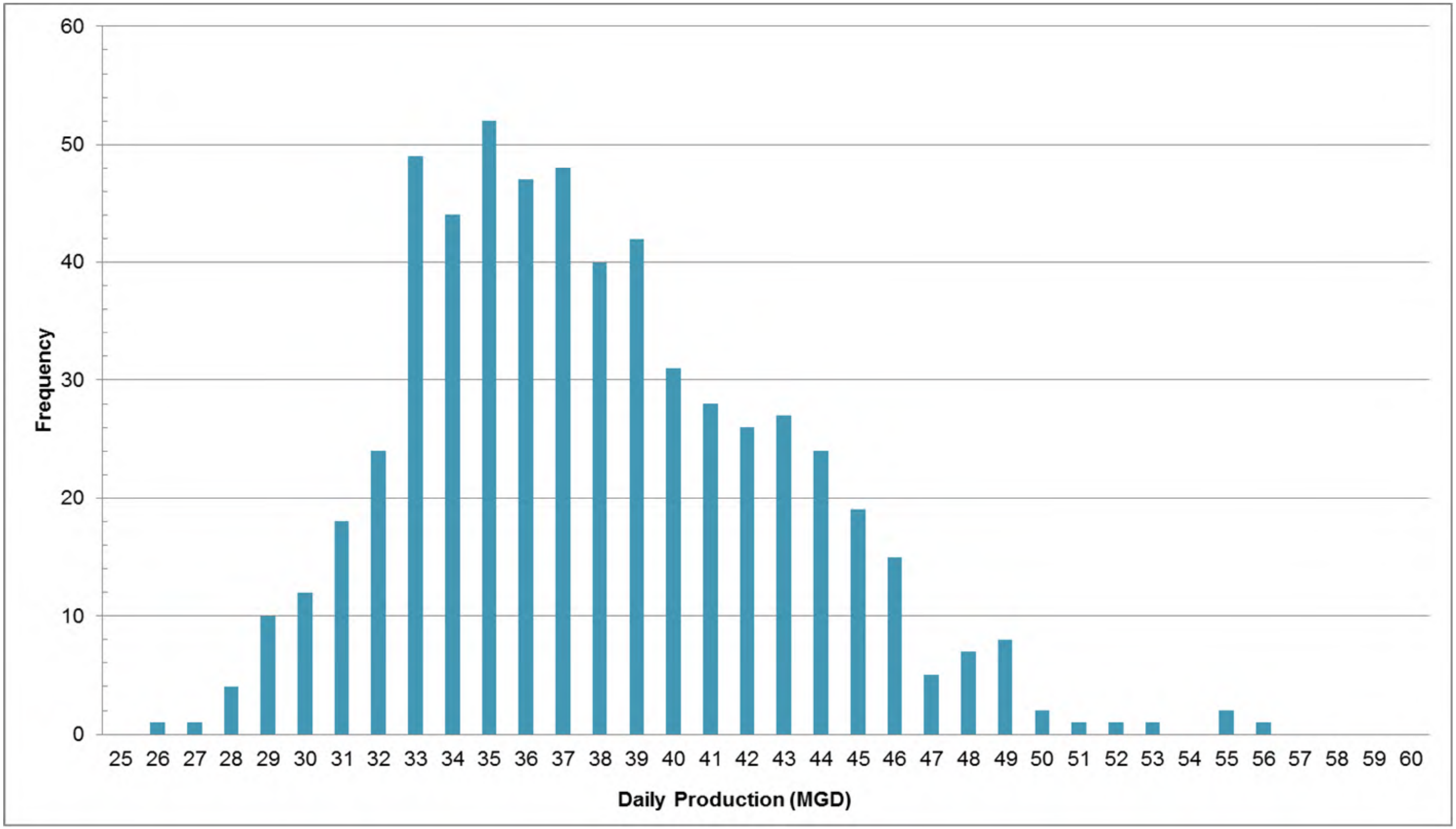
As far as total cost of production, it is noteworthy that RRS is perceived to be the most economical treatment facility and KAW has sought to maximize its use. A major component of the total cost of production is electrical rates. Table 1 (below) shows the average electrical cost per kW-hr based upon the total usage at each of KAW's facilities.

TABLE 1
KENTUCKY AMERICAN WATER
TOTAL ELECTRICAL COST (Per KW-HR used)

FACILITY	2013	2014	2015	AVERAGE
Kentucky River Station No.1	$ 0.060	$ 0.065	$ 0.067	$ 0.064
Kentucky River Station No.2	$ 0.085	$ 0.085	$ 0.084	$ 0.085
Woodlake Transfer	$ 0.068	$ 0.063	$ 0.075	$ 0.069
Richmond Road Station	$ 0.069	$ 0.065	$ 0.068	$ 0.067
Jacobson Reservoir	$ 0.082	$ 0.074	$ 0.079	$ 0.078

1) Average cost per kW-hr based on electrical usage and billing total for each station provided by KAW.

FIGURE 1
KENTUCKY AMERICAN WATER
CUMULATIVE PLANT PRODUCTION
JANUARY 2014 – AUGUST 2015



Additionally, KAW's estimated production costs for 2015 (provided by KAW) are summarized in Table 2 to give a more complete view of the issue.

TABLE 2
KENTUCKY AMERICAN WATER
ESTIMATED PLANT PRODUCTION COSTS

FACILITY	CHEMICAL COST / MG	FUEL - POWER / MG	OTHER COSTS / MG	TOTAL COST / MG
Richmond Road Station	$ 140	$ 159	$ 27	$ 326
Kentucky River Station No. 1	$ 102	$ 244	$ 17	$ 363
Kentucky River Station No. 2	$ 105	$ 341	$ 6	$ 452

1) Production cost estimates provided by KAW for 2015.

As shown above, the RRS total costs are positively impacted by having the lowest fuel and power costs. One key aspect of this is the cost-effectiveness of using Jacobsen Reservoir as a partial supply to the plant. Absent this, RRS fuel and power consumption would increase due to the usage of KRS 1 raw water pumping and KRS 1 transfer to RRS which is estimated to be 36.9% of the total raw water flow based on recent data.

Recent Changes in System Performance

For background purposes, it should be noted that several recent changes in operations or in equipment have occurred that will impact the results of this study.

- In recent years, the discharge pressures from KRS1 and RRS have been reduced through system improvements and load shifting to KRS2. These changes are estimated as follows:
  - KRS1 – Reduction in average discharge pressures from 160 psi to 120 psi
  - RRS – Reduction in average discharge pressures from 90 psi to 70 psi
- Pump 15 at KRS1 has been removed and replaced with a 900 Hp, VFD-driven model that will improve the flexibility of operations.
- Pump 12 at KRS 1 has been selected for replacement with the purchase and replacement expected in late 2016.
- JRES pumps have been replaced with two VFD-driven models & one constant speed model. Their performance is not a part of this study.

Scope of Investigation

HDR will utilize available information from operator interviews, field observation, historical information and the updated KAW hydraulic model in order to assess the effectiveness of the current pumping facilities in the following manner:

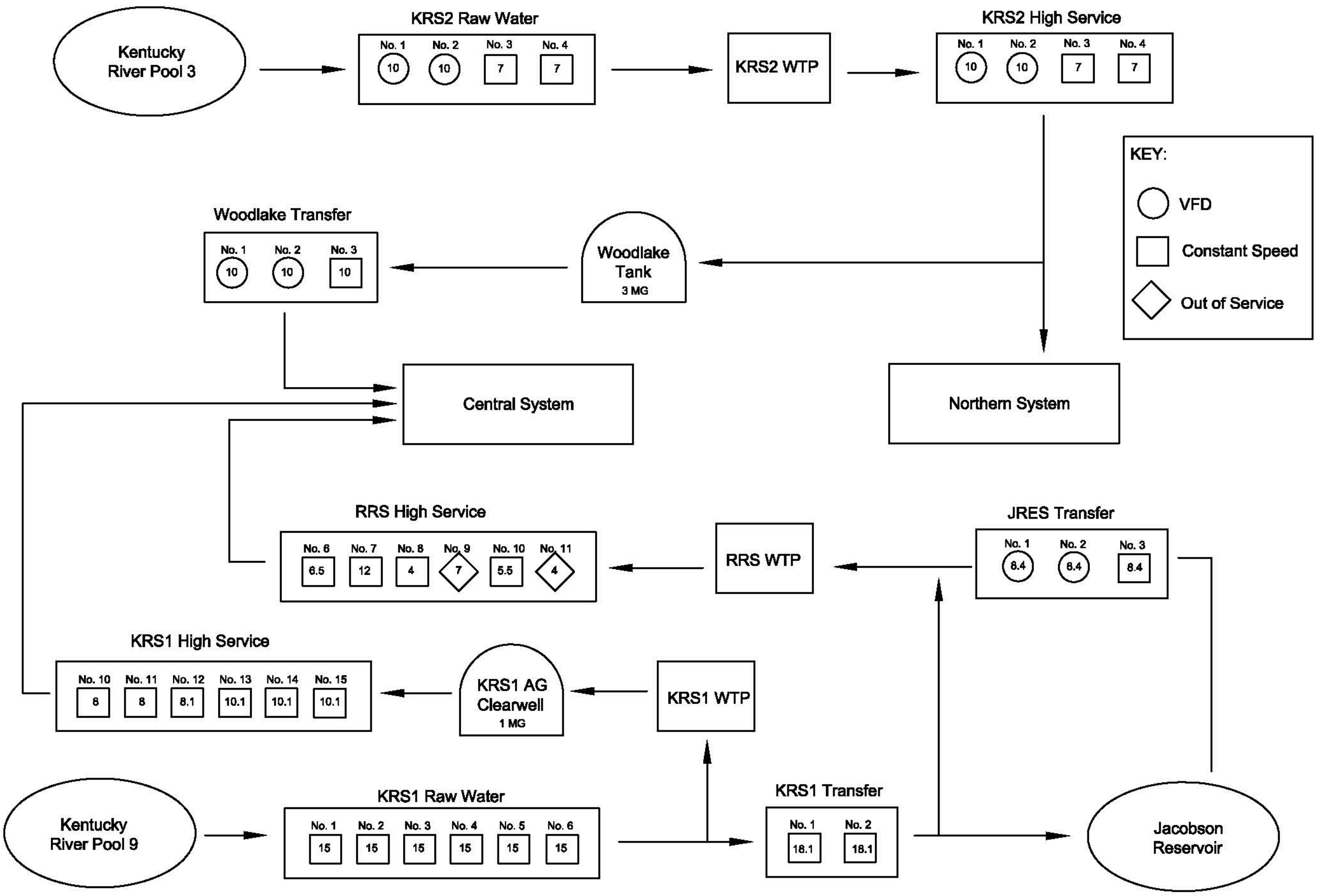
- Understand the operating ranges for each active pump at the facility.
- Determine operator preferences through the plant flow ranges and identify any gaps.
- Evaluate benefits to operations if variable frequency drives were incorporated.
- Review economics of pumping at each facility (including production costs).

- Optimize pumping at each facility across the typical range of production.
- Develop a list of priorities for pump replacement.

KAW Pumping Processes Background

As noted previously, five key pump facilities comprise the supply sources for the KAW distribution network. However, the operation of these five facilities is complex and dependent on the throughput from the three water plants that supply them. Often, the limitation of raw or high service pumping requires less than optimal operations to meet the water supply needs of KAW's customers.

To better understand the capabilities and relationships of all the current pumping facilities, we have constructed a schematic that reflects our understanding of the major components.



From the information presented in the schematic, a summary of the limitations for each facility is provided in Table 3.

TABLE 3
KETUCKY AMERICAN WATER
PUMPING FACILITY LIMITATIONS - OBSERVED

FACILITY	PUMPING UNIT	LIMITATION OBSERVED
KRS1	Raw Water	No VFDs on the 6 raw water pumps limit the flow ranges that may be supplied to KRS1 and the KRS1 Transfer Pumps.
	Transfer Station	No VFDs limit flow range conveyed to RRS/Jacobsen to approximately 18 MGD. This affects RRS or requires water to be diverted to reservoir.
	High Service	VFD addition to HSP 12 and 15 will remove many gaps in high service flows and capabilities.
JRES	Raw/Transfer	None noted.
RRS	High Service	High Service pumps all constant speed with two out of service. Plant throughput is range-limited based on need to match up with the supply from KRS1 transfer pumps with RRS discharge capabilities.
KRS2	Raw Water	Current practice is the rotation of 2 pumps with VFDs while 2 smaller constant speed pumps are rarely used.
	High Service	Current practice is the rotation of 2 pumps with VFDs while 2 smaller constant speed pumps are rarely used.
Woodlake	Booster	Central Division system delivery preformed by 2 pumps with VFDs and a constant speed pump.

A more detailed review of each facility is provided in the following sections.

Kentucky River Station No. 1

Pumping Facility Description

As noted previously, the replacement of High Service Pump 15 has improved the range of discharge flows that can be conveyed from the plant but there are still a number of limitations and blind spots in the operating ranges. In addition, no VFD-driven backup currently exists for HSP 15, so the flexibility is lost if it is out of service or undergoing maintenance.

Until recently, Kentucky River Station No. 1 (KRS1) utilized six (6) constant speed high service pumps, identified as pumps 10 through 15. Four (4) of the pumps are vertical turbine type and two (2) are horizontal split case. Details of each of the pumps are provided below in Table 4. It should be noted that Pump 12 is also currently in a replacement cycle and VFDs will be included in the new pumping approach. For pump 15, a 900 horsepower pump rated for 10.1 MGD with variable speed was installed which will improve the flexibility for the operators in delivering a wider range of flows. Pump 12 is proposed to be an 800 horsepower pump rated for 8.1 MGD with variable speed.

TABLE 4
KENTUCKY RIVER STATION NO. 1
SUMMARY OF HIGH SERVICE PUMPS

PUMP NO.	PUMP TYPE	DRIVE	DESIGN FLOW (MGD)	DESIGN HEAD (TDH)	MOTOR SIZE (HP)	% TOTAL TIME PUMP IS IN OPERATION [2]	WIRE/ WATER EFF[1,3]
10	VT	Constant Speed	8.0	380	700	44%	60%
11	VT	Constant Speed	8.0	380	700	64%	61%
12 (Future)	VT	Variable Speed	8.1	-	-	-	80%
13	HSC	Constant Speed	10.1	380	800	30%	73%
14	VT	Constant Speed	10.1	380	800	67%	75%
15 (Future)	VT	Variable Speed	10.1	410	900	-	80%

1) Wire to Water Efficiency is a combined efficiency reflection of the hydraulic efficiency of the pump impeller and the electrical efficiency of the motor at the design operating point. Provided on existing pumps from 2012 KAW memo.
2) Pump usage from Nov. 29, 2012 to Oct. 29, 2013.
3) Wire to Water Efficiency for Pumps 12 & 15 based on typical values for new vertical turbines with VFDs at 60hz, reductions in efficiency occurs when operating are reduced hz.

High Service Pump Operation

KAW has already initiated replacement of pumps in order to upgrade reliability and optimize pump operating ranges so that a wider incremental flow may be discharged from the plant to the system. Pump 15 and Pump 12 are currently in different forms of replacement and will narrow the operation gap shown in Figure 3 while providing an improved efficiency when operating within the standard design ranges.

Per the SCADA data provided by KAW and found in Appendix A, it is understood that the high service pumps currently are operated in accordance with several preferred plant production rates. The typical plant production rates / required high service pumping rates and their percent of total time at each rate are provide in Table 5.

TABLE 5
KENTUCKY RIVER STATION NO. 1
PRODUCTION RATES

FLOW RANGE (MGD)	FLOW RANGE (GPM)	FLOW PRECENTAGE
Less than 15.0	0 – 10,425	16.1%
15.0 – 17.0	10,425 – 11,800	0.0%
17.0- 18.0	11,800 – 12,500	21.8%
18.0 – 20.0	12,500 – 13,900	14.8%
20.0 – 26.0	13,900 – 18,000	5.2%
26.0- 28.0	18,000 – 19,500	27.4%
28.0- 30.0	19,500 – 20.850	7.8%
Above 30.0	20,850 +	6.4%

1) Pump usage from Nov. 29, 2012 to Oct. 29, 2013.

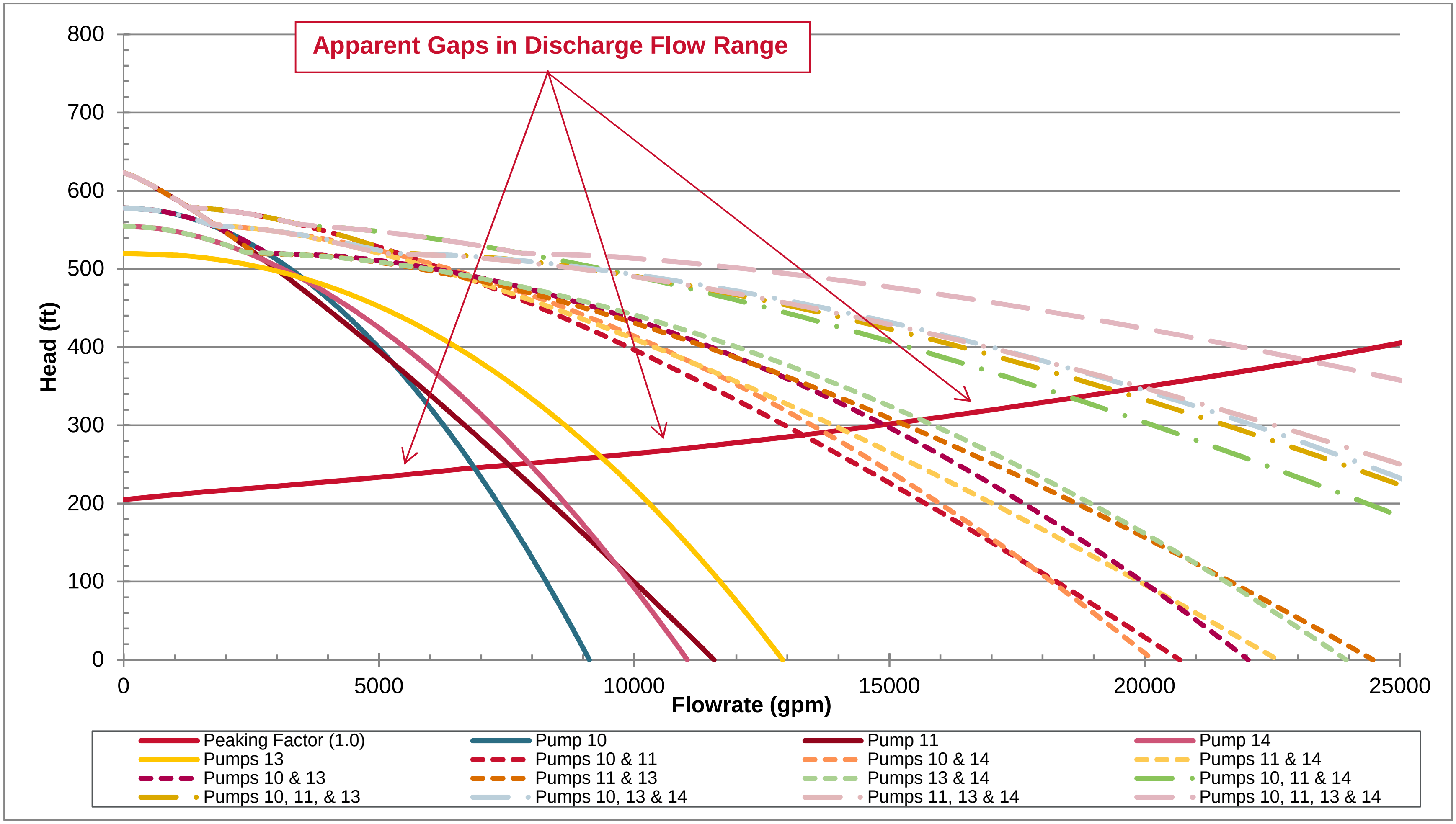
As can be seen from the information above **71.8% of the time** the station is being operated between 17.0 – 20.0 MGD (11,815 – 13,900 GPM) and 26.0 – 30.0 MGD (18,070 – 20,850). Another 16.1% of the time the station is operating below 15.0 MGD (10,425 GPM).

As evidenced from the findings of the hydraulic model and the production rates, it is clear that several gaps currently exist where the production rates, raw water supply pumps and finished water transmission pumps are misaligned. This assessment is prior to the completion of the HSP 15 start-up and the replacement of HSP12. More information from the hydraulic model confirms this as shown in Figure 2.

As shown, the constant speed pumping approach left operators at KRS1 with areas that were difficult to pump without significant manual adjustment including:

- 0 – 6,500 GPM
- 11,000 – 13,000 GPM
- 17,000 – 18,000 GPM

FIGURE 2
KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 1
PUMP COMBINATIONS - MODELED



Financial Considerations

The replacement of each high service pump will provide both increased operational flexibility and economic benefits. However, the most cost-effective replacement strategies require an understanding of the payback or return-on-investment from the installation/replacement of the item. We have reviewed the available electrical rates for the site and approximated the savings that would be recognized.

Kentucky Utilities (KU) is the electric provider. Demand charges at the KRS1 Facility are detailed as follows:

- Basic Service Charge per month - $300.00
- Plus an Energy Charge per kWh of: $0.03432
- Plus a Maximum Load Charge per kVA of:
    - Peak Demand Period - $5.89
    - Intermediate Demand Period - $4.39

TABLE 6
KENTUCKY RIVER STATION NO. 1
ELECTRICAL PEAK DEMAND INTERVALS

RATING PERIODS		BASE	INTERMEDIATE	PEAK
May – September	Weekdays	All Hours	10 A.M. – 10 P.M.	1 P.M. – 7 P.M.
	Weekends	All Hours	-	-
October – April	Weekdays	All Hours	6 A.M. – 10 P.M.	6 A.M. – 12 Noon
	Weekends	All Hours	-	-

The details on the potential savings that could be realized are provided below. As the time of day and peak demand are integral to the calculation but require more detail than this study is charged with, an average of $0.064 per KW-Hr will be used for the energy savings and return on investment. The other assumptions at KRS1 include:

- Average Daily HS Pumping @ KRS1 (12 months) – 19.6 MGD
- Estimated Pumping Hours (12 months) – 8,760 Hours
- Estimated Hours Per Pump During 12 months (From Table 6)

TABLE 7
KENTUCKY RIVER STATION NO. 1
ESTIMATED POWER SAVINGS FOR NEW EQUIPMENT

Pump No.	Facility Run Time (Estimated)[1]	Pump Use (%)	Annual Pump Run Time	Pump Hp/Wire-Water Efficiency[3]	Estimated Power Rate ($/Kw-Hr)	Estimated Annual Current Power Costs	Increased Wire-Water Efficiency (%)	Estimated Annual Power Savings
10	8760	44%	3855	700/60	$0.064	$215,432	33%	$71,093
11	8760	64%	5605	700/61	$0.064	$308,093	30%	$92,428
13	8760	30%	2630	800/73	$0.064	$138,058	10%	$13,806
14	8760	67%	5870	800/75	$0.064	$299,920	6%	$17,995

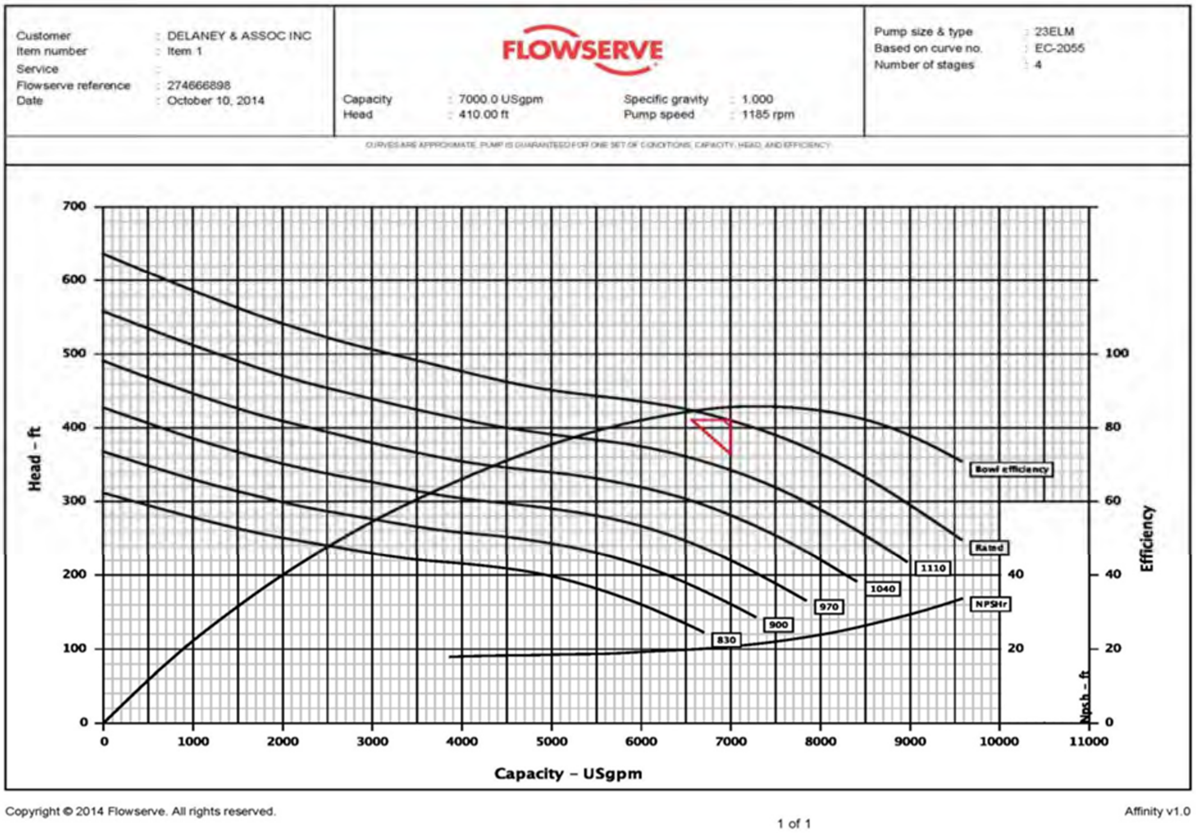
1) Hours based on 24hrs daily for a year. Pump usage accounts for plant closure.
2) Pump usage from Nov. 29, 2012 to Oct. 29, 2013. As seen in Table 4.
3) From KAW May 2012 Memorandum.

It should be noted that these savings are based on in-kind replacement of the high service pumps (i.e. similar motor horsepower and discharge requirements). As noted previously, the opportunity exists for reducing the high service pump horsepower in future replacements as the operating conditions at KRS1 have changed due to the load shifting resulting out of the addition of KRS2. While this offers a clear opportunity for energy savings, it could reduce system redundancy and limit the total output in the event of a loss of operations at KRS2 or RRS (when pump discharge pressures might need to revert to previous levels to accommodate demand).

Optimized Pumping at KRS1

HDR is looking at optimized pumping from two aspects. The first aspect is the ability of the station to deliver the needed flow on demand. The second metric is the review of the installation to be sure that the hydraulic/electrical efficiency of the delivery is optimized.

Finding No. 1 - Pumping optimization has already been improved with the installation of the new vertical turbine pump previously discussed. This pumps rate for 10.1 MGD will provide necessary flexibility to reduce operational gaps. It is reasonable to assume that the pumps will operate more effectively in ranges shown previously without significant loss of total efficiency (wire-to-water). From early data on the start-up, we are learning that the combination of the HSP 15 with the VFD (80% speed) and HSP 14 (constant) are producing flows within the “gap” range previously described. As evidence of this, we have included the HSP 15 combined performance curve which illustrates its operation over different speeds in order to provide a better understanding of the benefit.



Finding No. 2 – When any pumps are replaced going forward, a reduction in horsepower for each unit may be considered based on the current system pressure. However, this change must be understood in terms of possible impacts on system resiliency. The magnitude of reduction is estimated to be as follows:

TABLE 8
KENTUCKY RIVER STATION NO. 1
ESTIMATED POWER SAVINGS FOR REDUCED HEAD CONDITIONS

Pump No	Current Design Point		Nameplate Motor Size	Alternate Design Point		Alternate Motor Size	Potential Savings from Optimization[1,2]
	GPM	TDH	Hp	GPM	TDH	Hp	
10	5600	380	700	5600	265	500	$41,240
11	5600	380	700	5600	265	500	$61,619
13	7000	380	800	2800	300	600	$31,063
14	7000	380	800	3800	300	600	$70,481

1) Cost savings based on hours of operation shown in Table 7.
2) Optimization based on the energy savings between an equivalent (80% W-W) pump with a reduction in Hp.

Finding No. 3 – If KAW decided not to reduce the high service pump horsepower, the replacement of the existing pumps could still provide cost and efficiency benefits at their current size. The new pumps can be expected to obtain wire to water efficiencies of approximately 80% at their design point diminishing to approximately 72% (w-w efficiency) when the VFD is utilized to reduce speeds to 60% of design flowrate. When compared with the various remaining pumps, the following increase in delivery efficiency (reduction in power) may be seen.

- Pump 10 – 33% increase at design point, 12%-20% across all VFD flow ranges.
- Pump 11 – 30% increase at design point, 10 -18% across all VFD flow ranges.
- Pump 13 – 10% increase at design point, 5%-7% across all VFD flow ranges.
- Pump 14 – 6% increase at design point, 2%-4% across all VFD flow ranges.

Table 7 has provided an estimate of the potential energy savings through the implementation of this option.

Additional Considerations at KRS1

During our investigation, we identified several items that didn't fit within the scope of this study but were nonetheless relevant to the discussion of pumping efficiency and cost to KAW. These are offered below simply as considerations.

- KAW might consider confirming the fuel and power cost attributed to RRS included the cost of the KRS1 transfer station power, the intake power cost (proportionally) and the JRES costs. Our review did not observe where this occurred in the operating costs. This included raw water pumping and KRS1 transfer to the Jacobson Reservoir or RRS facility.
- KRS1 Transfer facilities to RRS included two (2) constant speed horizontal split case pumps. These two (2) pumps are rated for 18.2 MGD (12,600 GPM) with 1000 HP motors. The details on the economics of utilizing these pumps are detailed below. As part of the estimation of potential energy savings, we have considered only the energy charge and made some assumptions on total pump hours based on the following.

  <u>Transfer Station</u>
  - Average Daily KRS1 Transfer Pumping to RRS/JRES (12 months) – 4.43 MGD
  - Estimated Pumping Hours (12 months) – 2,373 Hours (Per 4.43 MGD Flow Rate / 18.2 MGD Pumps)
  - Pump Efficiency – N/A (Average of KRS1 HS W–W = 66%)
  - Estimated Annual Cost of KRS1 Transfer Pumps – $171,592
  - Estimated improvement – $36,034

  <u>Raw Water Considerations- KRS1</u>
  - Average Daily HS Pumping @ KRS1 (12 months) – 4.43 MGD
  - Estimated Pumping Hours (12 months) – 2,587 Hours (Per 4.43 MGD Flow Rate /15 MGD Pump)
  - Pump Efficiency – 72%
  - Estimated Annual Cost of Raw Water Transfer Pumps – $241,347

Both of these facilities have the potential for significant energy savings through pump replacement.

Kentucky River Station No. 2

Process Description

Kentucky River Station No. 2 (KRS2) utilizes four (4) vertical turbine high service pumps for transportation of treated water to the KAWC distribution system. Two of the pumps are each 500 horsepower and rated for 7 MGD (4,865 GPM) with the two other pumps each being 700 horsepower and rated for 10 MGD (6,950 GPM). The two 500 HP pumps are constant speed with soft starts while the two 700 HP are controlled by variable speed drive. Details of each of the pumps are provided below in Table 9.

Pump control valves are not provided but do utilize slow closing check valves on the 500 HP pumps. The 700 HP pumps utilize their variable speed controller to slowly ramp down the pumps to control potential water hammer.

All four high service pumps operate on medium voltage with electrical criteria of 460 volts, 3 phase, 60 hertz. The variable speed pumps normally operate at 40 – 60 Hz with a minimum operating range of 35 Hz..

Operators clearly favor the VFD-driven pumps at this facility. The individual operating hours of either of the twin 10 MGD pumps far exceed the joint hours on the constant speed units. This occurs even though the discharge flow is often near the 7 MGD. In discussions, operators have talked about using the VFD-driven, 700 Hp motors to pump as little as 4.5 MGD into the system.

TABLE 9
KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
SUMMARY OF HIGH SERVICE PUMPS

PUMP NO.	PUMP TYPE	DRIVE	DESIGN FLOW (MGD)	DESIGN HEAD (TDH)	MOTOR SIZE (HP)	% TOTAL TIME PUMP IS IN OPERATION[2]	WIRE/WATER EFFICENCY[1]
1	Vertical Turbine	Variable Speed	10.0	324	700	33%	82%
2	Vertical Turbine	Variable Speed	10.0	324	700	67%	82%
3	Vertical Turbine	Constant Speed	7.0	324	500	0%	82%
4	Vertical Turbine	Constant Speed	7.0	324	500	0%	82%

1) Wire to Water Efficiency is a combined efficiency reflection of the hydraulic efficiency of the pump impeller and the electrical efficiency of the motor at the design operating point. Values based on theoretical value, not empirically tested.

2) Pump usage based on data from August 1, 2014 through August 27, 2015.

High Service Pump Operation

Current daily production demand at the WTP staff set 7.0 mgd as the preferred minimum rate for pumping treated water with 7.0 – 10.0 MGD being the normal pumping rates. Of these rates, approximately 15% (approx. 1 mgd) is dedicated to the City of Owenton with 85% (6 mgd) to Lexington. Pump pressure ranges from 130 – 140 psi. Peak pumping rates have reached 20 MGD at times.

Per the SCADA data provided by KAW, it is understood that the high service pumps currently are operated in accordance with several preferred plant production rates. The typical plant production rates / required high service pumping rates and their percent of total time at each rate are seen in Table 10.

TABLE 10
KENTUCKY RIVER STATION NO. 2
PRODUCTION RATES

FLOW RANGE (MGD)	FLOW RANGE (GPM)	FLOW PERCENTAGE
Less than 6.5	0 – 4,500	11.6%
6.5 – 7.0	4,500 – 4,850	4.7%
7.0 – 7.5	4,850 – 5,200	18.5%
7.5 – 8.0	5,200 – 5,550	29.8%
8.0 – 8.5	5,550 – 5,900	9.1%
8.5 – 9.0	5,900 – 6,250	2.8%
9.5 – 10.0	6,250 – 6,950	12.0%
Above 10.0	9,950 +	11.5%

1) Pump usage based on data from August 1, 2014 through August 27, 2015.

As can be seen from the information above 79.6% of the time the station is being operated between 6.5-10.0 MGD. Another 9.6% of the time the station is operating below 6.0 MGD. For the purposes of this study, the less than 6.0 MGD flow ranges were not evaluated as very little changes in system head are at the lowest flow ranges and will be easily covered by the proposed pumping configuration.

The WTP staff prefer to operate one (1) 700 HP variable speed pump as it can easily adjust to the desired pumping ranges of 7.0-10.0 mgd. They have not experienced a problem with combining a variable speed pump with the operation of a constant speed pump, but still prefer the flexibility offered with the variable speed pump. Primarily use VFD pumps at 40-60 hz, but can go as low as 35hz (4.5 MGD).

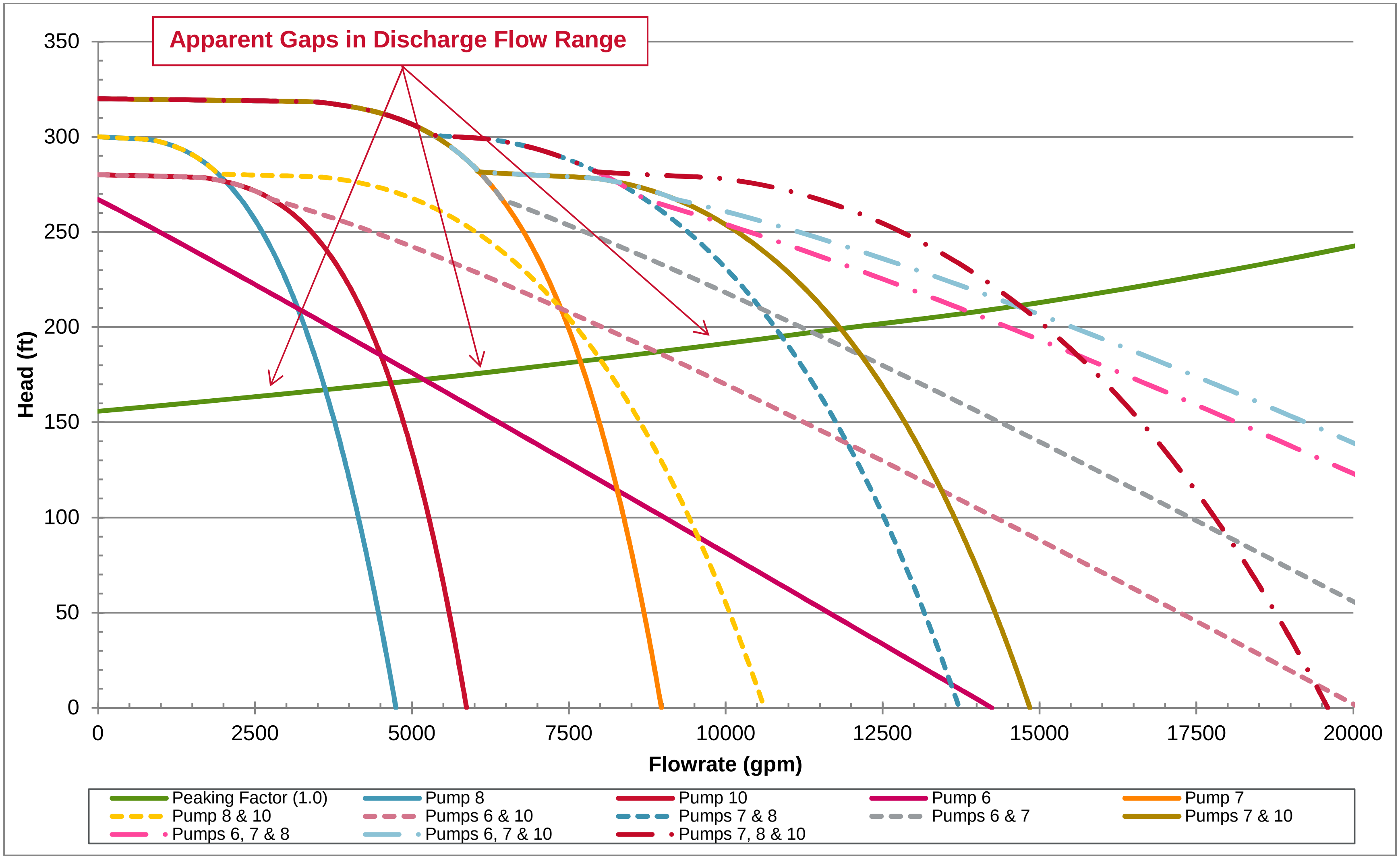
The rating and control structure for the existing pumps makes it difficult to efficiently pump flows in the 10.0 – 12.0 MGD range but staff stated that presently the demand does not normally call for that range and the criticality of pumping at 10.0 – 12.0 MGD is not seen as a priority.

Optimized Pumping

Optimized pumping must include the needs of the Woodlake Booster Pump Station and demand from KAW's Northern Division. The findings for KRS2 include the following:

Finding No. 1 – The addition of a VFD will add to the reliability and flexibility of the high service pumping approach. Based on the Table 8, the plant discharge flow is 7.0 MGD or less over 35% of the time. If a VFD were added to a 500 Hp pump, it could work throughout this range in a more electrically efficient manner. An estimation of the possible savings associated with this would require specific environmental and detailed design information to accomplish. However, it is apparent that the addition of a VFD from an operational perspective would be sensible as it would convert a pump that is not being used into a pump that could operate up to 35% of the time.

FIGURE 3
KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
COMBINATION PUMP CURVES (REDUCED PER OPERATOR NOTES)



Financial Considerations

Owen Electric is the electric provider. Demand charges at the KRS1 Facility are detailed as follows:

- Basic Service Charge per month - $1,521.83
- Plus an Energy Charge per kWh of: $0.04950
- Plus a Maximum Load Charge per kVA of:
    - Peak Demand Period - $5.89
    - Intermediate Demand Period - $4.39
    - Base Demand Period - $3.34

The commodity price for power is more than 30% higher than KRS1. As a result, the facility must be highly efficient in order to operate in a cost-effective manner. The pumps installed at KRS2 are relatively new (6-7 years old) and a replacement is not warranted. However, the wear of operation on two pumps rather than 4 pumps (as designed) may create a premature maintenance condition on the VFD and the pump.

Additional Considerations at KRS 2

No additional considerations are apparent. The cost of pumping from this facility is the highest because it is the most remote and requires 3 pumping steps to convey it to the largest KAW demand points in the Central Division.

Raw Water Facility Pumping Limitations

Currently, the facility has matching flowrates for the raw water and high service. Any changes to the high service pumps could potential cause a gap in range for the specifically around the 10.0-12.0 MGD flow range.

Woodlake Transfer Station

Process Description

Woodlake Transfer Station utilizes three (3) high vertical turbine service pumps for transfer of treated water from the KAWCs' Northern Distribution System (Owenton) to KAWC Central Distribution System. Two pumps are vertical turbine type rate for 10.0 MGD with variable speed drive with 800 horsepower. A third pump is a vertical turbine type constant speed with soft starts rated for 10.0 MGD and 800 horsepower. Details of each of the pumps are provided below in Table 11.

High Service Pump Operation

Woodlake is a booster station that supplies water from the Northern Division to the Central Division. The pump station typically delivers around 6.0 MG daily after the Northern Division demand is taken from KRS2 production. It should also be noted that Woodlake has a 3.0 MG storage tank onsite to facilitate fluctuations from KRS2.

Optimized Pumping

Woodlake's current pumping approach is largely optimized and the capabilities of the station are currently in place to maintain the best practice. A third VFD-driven pump should be considered after flow consistently exceeds 10 MGD.

Financial Considerations

Financial considerations at Woodlake offer no clear opportunities to optimize for energy savings at this time.

Additional Considerations at Woodlake

Woodlake like KRS 2 must pass a minimum flowrate daily in order to maintain water quality standards. KAWC prefers to transfer a minimum of 6.0 MG daily.

TABLE 11
KENTUCKY AMERICAN WATER
WOODLAKE
SUMMARY OF HIGH SERVICE PUMPS

PUMP NO.	PUMP TYPE	DRIVE	DESIGN FLOW (MGD)	DESIGN HEAD (TDH)	MOTOR SIZE (HP)	% TOTAL TIME PUMP IS IN OPERATION[2]	WIRE/WATER EFFICENCY[1]
1	Vertical Turbine	Variable Speed	10.0	460	800	-	80%
2	Vertical Turbine	Variable Speed	10.0	460	800	-	80%
3	Vertical Turbine	Constant Speed	10.0	460	800	-	80%

1) Wire to Water Efficiency is a combined efficiency reflection of the hydraulic efficiency of the pump impeller and the electrical efficiency of the motor at the design operating point.

2) Pump usage not provided by KAW.

Richmond Road

Process Description

The Richmond Road Station (RRS) facility utilizes six (6) constant speed high service pumps, identified as pumps No. 6 through 11. Details of the pumps are detailed in Table 12. The pumps are horizontal split case type with varying pumping capacities. Pumps No. 9 and 11 are diesel powered and presently out of service.

RRS typically operates with two of the four pumps running. As noted in Table 12 and confirmed in previous studies, nearly all of the pumping is accomplished with just three (3) pumps (No. 6, 7, and 10). The capabilities of the working pumps clearly limits the available discharge flows for RRS. These pumps are all constant speed and can only be varied in flow through the use of valve restrictions or flow controllers. These methods create an excessive loss of energy and efficiency.

TABLE 12
KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
SUMMARY OF HIGH SERVICE PUMPS

PUMP NO.	PUMP TYPE	DRIVE	POWER	DESIGN FLOW (MGD)	DESIGN HEAD (TDH)	MOTOR SIZE (HP)	% TOTAL TIME PUMP IS IN OPERATION[2]	WIRE/WATER EFFICIENCY[1]
6	Horizontal Split Case	Constant Speed	Electric	6.5	190	250	44.5%	70%
7	Horizontal Split Case	Constant Speed	Electric	12.0	240	500	61.1%	73%
8	Horizontal Split Case	Constant Speed	Electric	4.0	240	300	2.4%	63%
9	Horizontal Split Case	Constant Speed	Diesel	7.0	235	400	0.0% (OOS)	-
10	Horizontal Split Case	Constant Speed	Electric / Diesel	5.5	231	250 / 580	62.0%	54%
11	Horizontal Split Case	Constant Speed	Diesel	4.0	220	200	0.0% (OOS)	-

1) Wire to Water Efficiency is a combined efficiency reflection of the hydraulic efficiency of the pump impeller and the electrical efficiency of the motor at the design operating point. Values provided from *American Water – Evaluation of Pump Efficiency Improvement Opportunities for KYAW.*

2) Pump usage based on data from August 21, 2015 through May 3, 2015 & July 14, 2015 through August 26, 2015.

High Service Pump Operation

Like KRS1, recent changes in operating pressure have had an effect on the RRS discharge pump needs. As KRS2 has come on line, load has been shifted away from RRS which has lowered the typical discharge head requirements from 90 psi to 70 psi. This reduction creates and opportunity for investigating whether a smaller (lower Hp) pump can provide satisfactory flows during peak periods.

Normal demand periods for RRS have high service pumping facility operating as low as 6.0 MGD for extended period and as low as 4.0 MGD instantaneously. The current high service pumps are extremely inefficient at these low pumping rates.

The desired peak pumping rate is 25.0 MGD. Rates in excess of 25.0-30.0 MGD can be provided for only short periods. The Richmond Road staff prefers to operate high service Pump No. 7 the majority of the time. Selecting Pump No. 7 for principal use designates low run times for the remaining five pumps, which creates unbalanced pump run times.

Per the SCADA data provided by KAW and found in Appendix A, it is understood that the high service pumps currently are operated in accordance with peaking needs and several preferred production rates. The typical plant production rates / required high service pumping rates and their percent of the time each rate are provided in Table 13.

TABLE 13
RICHMOND ROAD STATION
PRODUCTION RATES

FLOW RANGE (MGD)	FLOW RANGE (GPM)	FLOW PRECENTAGE
Less than 6.0	0 – 4,160	2.0%
6.0 – 8.0	4,160 – 5,550	16.0%
8.0 – 10.0	5,550 – 6,950	0.9%
10.0 – 12.0	6,950 – 8,325	30.9%
12.0 – 14.0	8,325 – 9,700	0.0%
14.0 – 16.0	9,700 – 11,100	46.3%
16.0 – 18.0	11,100 – 12,500	3.2%
Above 18.0	12,500 +	0.6%

1) Pump Usage based on data from August 21, 2015 through May 3, 2015 & July 14, 2015 through August 26, 2015.

As seen from Table 13 over **93% of the time** the station is being operated within three distinct ranges (6.0 – 8.0 MGD, 10.0 – 12.0 MGD and 14.0 – 16.0 MGD). This fact shows the limitations associated with RRS and the challenge of having a facility of this nature. The three constant speed pumps can only generate a limited number of pumping opportunities especially when considering the disparity in flow conditions between Pump 6 and the other equipment. Table 14 provides more details on the composite pump flows as estimated by the hydraulic model.

TABLE 14
RICHMOND ROAD STATION
PUMP OUTPUTS BASED ON MODEL

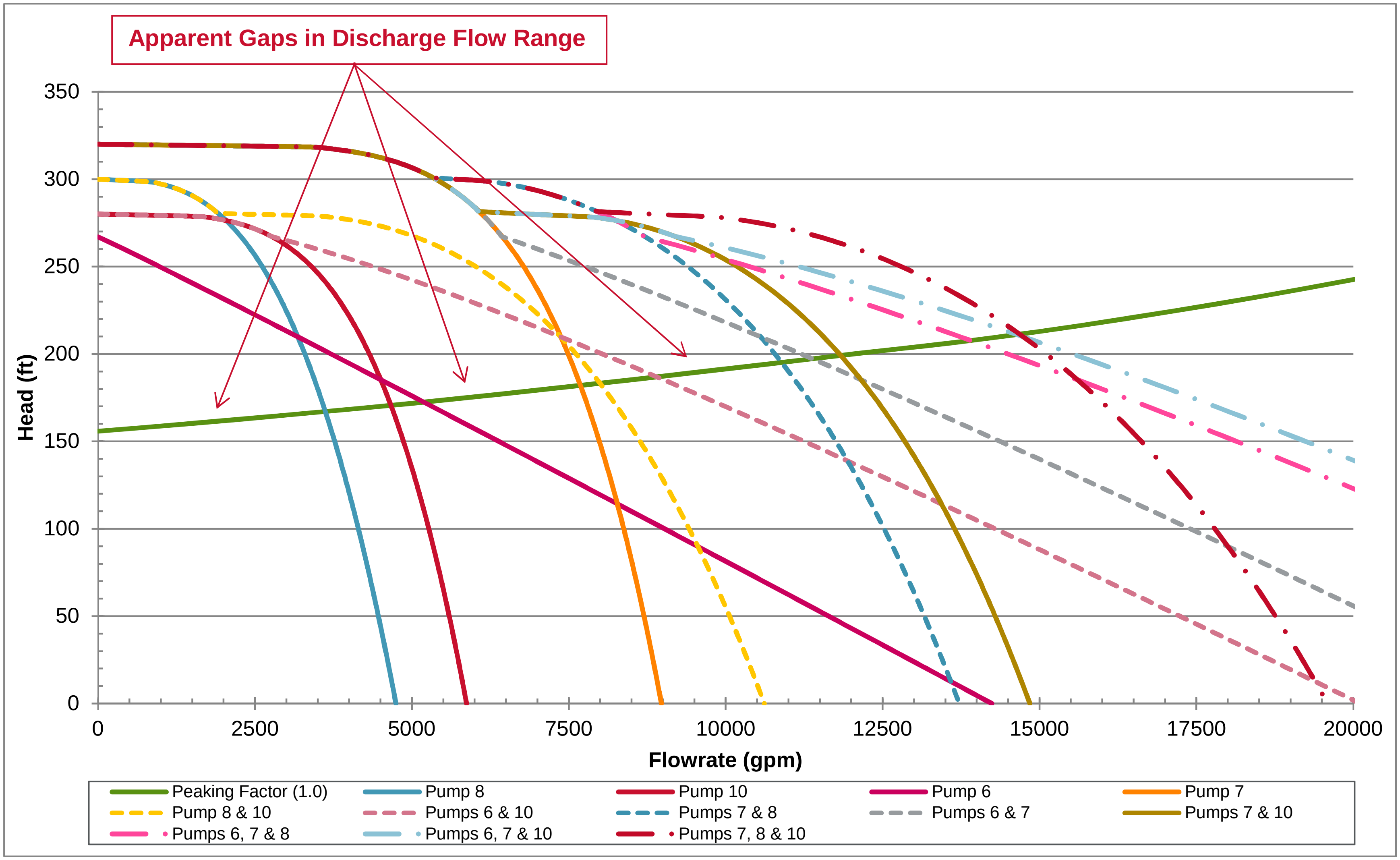
PUMP CONFIGURATION[1]	FLOW[2] (MGD)	FLOW[2] (GPM)
No. 8	5.22	3,610
No. 10	6.7	4,650
No. 6	7.5	5,205
No. 7	11.1	7,705
No. 8 & 10	11.5	7,980
No. 6 & 10	12.9	8,955
No. 7 & 8	15.7	10,895
No. 6 & 7	16.4	11,380
No. 7 & 10	17.1	11,870
No. 6, 7 & 10	21.1	14,645
No. 7, 8, & 10	21.2	14,715

1) Per Operators comments, no configurations with both Pumps No. 6 & 8 examined due to potential cavitation concerns.
2) Pump flows based on WaterGEMs model provided by KAWC utilizing system curves and pumps curves.

As evidenced from the findings of the hydraulic model and the SCADA production rates, it is clear that several gaps currently exist where the high service pumps can not effectively produce flow. More information hydraulic model confirms this as shown in Figure 4.

It is also apparent that the current pumps were designed to meet a different service condition than that presently in place. As a result of this, all of these constant speed pumps are operating to the right of their design point and in a less efficient manner. This is similar to the situation at KRS1. This is a result of the re-distribution of water supply in the Central Division in order to bring KRS2 into service.

FIGURE 4
RICHMOND ROAD STATION
COMBINATION PUMP CURVES (REDUCED PER OPERATOR NOTES)



Financial Considerations

The replacement of two high service pumps would provide both increased operation flexibility and economic benefits. For the purposes of understanding the payback or return-on-investment from the installation/replacement of the item, we have reviewed the available electrical rates for the site and approximated the savings that would be recognized.

Kentucky Utilities (KU) is the electric provider. Demand charges at the RRS Facility are detailed below and in Table 15:

- Basic Service Charge per month - $200.00
- Plus an Energy Charge per kWh of: $0.03527
- Plus a Maximum Load Charge per kVA of:
    - Peak Demand Period - $6.13
    - Intermediate Demand Period - $4.53
    - Base Demand Period - $5.20

TABLE 15
RICHMOND ROAD STATION
ELECTRICAL RATING PERIODS

RATING PERIODS		BASE	INTERMEDIATE	PEAK
May – September	Weekdays	All Hours	10 A.M. – 10 P.M.	1 P.M. – 7 P.M.
	Weekends	All Hours	-	-
October – April	Weekdays	All Hours	6 A.M. – 10 P.M.	6 A.M. – 12 Noon
	Weekends	All Hours	-	-

The details on the potential savings that could be realized are provided below and in Table 16. As part of the estimation of potential savings, we have considered only energy charges and made some assumptions on total hours based on the following:

- Average Daily HS Pumping @ RRS (12 month) – 11.1 MGD
- Estimated Pumping Hours (12 months) – 8760 Hours
- Estimated Hours Per Pump During 12 months (From Table 16)

TABLE 16
RICHMOND ROAD STATION
ESTIMATED POWER SAVINGS FROM NEW EQUIPMENT

Pump No.	Facility Run Time (Estimated)	Pump Use (%)	Annual Pump Run Time	Pump Hp/Wire-Water Efficiency	Assumed Power Rate ($/Kw-Hr)1	Estimated Annual Current Power Costs	Increased Wire-Water Efficiency (%)	Estimated Annual Power Savings
6	8760	44.5%	3900	250/70	$0.067	$69,991	14%	$9,799
7	8760	61.1%	5350	500/73	$0.067	$184,134	10%	$18,413
8	8760	2.4%	210	300/63	$0.067	$5,025	27%	$1,357
10	8760	62.0%	5430	250/54	$0.067	$126,322	48%	$60,635

Optimized Pumping

KAW typically utilizes Pumps 6 and 7 at RRS to provide flow into its system. These pumps have the highest efficiency of the units in high service duty at RRS. An optimized pumping approach is likely to include the installation of VFD-driven pumps in order in order to supply flow at wider ranges into the distribution system in order to have more flow flexibility. In order to achieve more optimized and efficient pump, several findings have been provided

Finding No. 1 – When any pumps are replaced going forward, a reduction in horsepower for each unit may be considered based on the current system pressure. However, this change must be understood in terms of possible impacts on system resiliency. The magnitude of reduction is estimated to be as follows:

TABLE 17
RICHMOND ROAD STATION
ESTIMATED POWER SAVINGS FROM REDUCED HORSEPOWER

Pump No	Current Design Point		Nameplate Motor Size	Alternate Design Point		Alternate Motor Size	Potential Savings from Optimization[1]
	GPM	TDH	Hp	GPM	TDH	Hp	
6	4500	190	250	4500	175	NA	$0
7	8300	240	500	8300	190	400	$33,144
8	2800	240	300	2800	165	150	$1,834
10	3800	231	250	3800	170	200	$13,138

1) Cost savings based on hours of operation shown in Table 15.

Finding No. 2 - Replace Pumps No. 9 &11 which are presently only diesel-only emergency pumps or out of service. The removal of these pumps may require an emergency generator to be installed but this is necessary for campus-wide power in the event of a power outage. The new pumps would be highly efficient and result in over a 20% increase in efficiency when operating. In addition, a VFD should be implemented which will increase the flexibility of the discharge pumping rate for the entire high service facility.

Finding No. 3 – If a reduction in horsepower is not acceptable to KAW, then the replacement of High Service Pumps 8 and 10 should be considered. These pumps are highly inefficient in their current condition and the potential savings is identified in Table 15. The new pumps can be expected to obtain wire to water efficiencies of approximately 80% at their design point diminishing to approximately 72% (w-w efficiency) when the VFD is utilized to reduce speeds to 60% of design. When compared with the various remaining pumps, the following increase in delivery efficiency (reduction in power) may be seen.

- Pump 8 – 27% increase at design point, 8 -14% across all VFD flow ranges.
- Pump 10 – 48% increase at design point, 24 -33% across all VFD flow ranges.

Finding No. 4 – A new High Service Pump Station/Clearwell Station could be beneficial. At RRS, none of the current pumps operate in an efficient manner as previously detailed. Further, the operational approach at RRS does not appear to require 6 pumps for efficient and proper delivery. In addition, Clearwell No. 1 is unbaffled, difficult to access, in poor condition and too small to provide the needed CT time for the plant. Clearwell No. 2 may be removed from service after the Filter Building Renovation project.

In order to remain compliant with finished water goals, KAW has built work-arounds to meet the CT requirements in the sedimentation basin and a contact chamber. A new, well-baffled and structurally sound clearwell could be beneficial to treatment by removing the need for pre-filtration CT compliance and offering flexibility to operations in how clarification is handled in order to maximize TOC/DBP precursor reduction.

Additional Considerations at RRS

Raw Water Facility Pumping Limitations

Raw Water can be delivered from KRS1 (via the Transfer Pumps) at a constant rate of either 18 MGD or 24 MGD (2 pumps running). With its limited finished water storage, this limits RRS in the treatment and high service pumping that it can offer. A second raw water supply is provided to RRS via the Jacobsen Reservoir Pump Station which supplies reservoir raw water to RRS. There is a complex relationship between the two supplies as Jacobson is typically less desirable as a raw water quality but offers greater flexibility in flow rates due to the VFDs at the pump station. The KRS1 transfer station either delivers at its stated rate or has to have a portion of flow diverted to the Jacobson Reservoir (via a control valve) based on the needs of RRS. The pumping (or diverting) of water from the Kentucky River to the Jacobson Reservoir does not seem to offer significant benefit except during early drought conditions. A review of the different raw water operating scenarios is provided below.

- Average Daily HS Pumping @ RRS (12 month) – 11.1 MGD

- Raw Water Transfer from JRES – 7.57 MGD or 63.1%
- Raw Water Transfer from KRS1 – 4.43 MGD or 36.9%
- Raw Water Transfer from KRS1 stored – 0.48 MGD

Jacobson Reservoir

Process Description

Jacobson Reservoir (JRES) facility utilizes three (3) horizontal split case pumps for transport of raw water to the Richmond Road Station from Jacobson Reservoir. All three pumps are each 250 horsepower and rated for 8.4 MGD. Two of the pumps are controlled by variable speed drive and one is a constant speed with soft start. Details of each of the pumps are provided below in Table 18.

Minimum reliable capacity of 16.7 MGD and 25.0 MGD capacity with all units in service.

High Service Pump Operation

Peak pumping rates have reached 20 mgd. Additionally, flow at JRES should be pumped to best match the high service pumps at RRS since those pumps are constant speed.

Optimized Pumping at JRES

JRES has multiple pumps on VFDs. This approach is optimized for flexibility and efficiency.

TABLE 18
KENTUCKY AMERICAN WATER
JACOBSON RESERVOIR
SUMMARY OF RAW WATER TRANSFER PUMPS

PUMP NO.	PUMP TYPE	DRIVE	DESIGN FLOW (MGD)	DESIGN HEAD (TDH)	MOTOR SIZE (HP)	% TOTAL TIME PUMP IS IN OPERATION[2]	WIRE/WATER EFFICENCY[1,2]
1	Horizontal Split Case	Variable Speed	8.4	123	250	-	80%
2	Horizontal Split Case	Variable Speed	8.4	123	250	-	80%
3	Horizontal Split Case	Constant Speed	8.4	123	250	-	80%

1) Wire to Water Efficiency is a combined efficiency reflection of the hydraulic efficiency of the pump impeller and the electrical efficiency of the motor at the design operating point.
2) Wire to Water Efficiency based on values from *KAWC Jacobson Reservoir Pump Improvements Operational Narrative*.

Conclusion and Recommendations

Findings

A summary of the findings are provided below.

KRS1

1. High Service pumping flexibility has already been improved with the replacement of HSP 15 and the installation of a VFD. Once HSP 12 is replaced (already scheduled), the flexibility will be greater for operators.
2. Potential reduction in horsepower on future pump replacements to match system requirements
3. If KAW decides not to reduce the horsepower of the current pumps, savings can still be found by installing more efficient pumps for HSP 10,12,13 and 14. Operational flexibility can also be advanced by installing a few more VFDs. Based on usage, HSP 14 would be the next highest priority replacement.

KRS2

1. Addition of a VFD to Pump 3 or 4 (or both) would enable these pumps to be utilized more frequently and the overall plant high service pumping would be more efficient when operating at 7 MGD or lower.

Woodlake Pump Station

1. Woodlake is generally optimized in its current state.

RRS

1. Potential reduction in horsepower on future pump replacements to match system requirements
2. Replacement of Pumps 9 and 11 which are now seldom used, diesel driven pumps could be operationally beneficial.
3. If KAW decides not to reduce the horsepower of the current pumps, savings can still be found by installing more efficient pumps. Operational flexibility can also be advanced b installing a few more VFDs.
4. A new HSP/Clearwell could be beneficial in addressing multiple issues associated with treatment and transmission.

Jacobsen Reservoir Station

1. JRES is generally optimized in its current state.

Potential Cost Savings/Payback of Alternatives

A review of the payback associated with the findings provided above is offered in this section. For the purposes of the review, capital costs have been established from recent project with KAW and in the region. We have assumed a 3% annual rate of increase in energy costs through the study period.

TABLE 19
KENTUCKY AMERICAN WATER
ESTIMATED CAPITAL PROJECT COSTS AND PAYBACK PERIOD

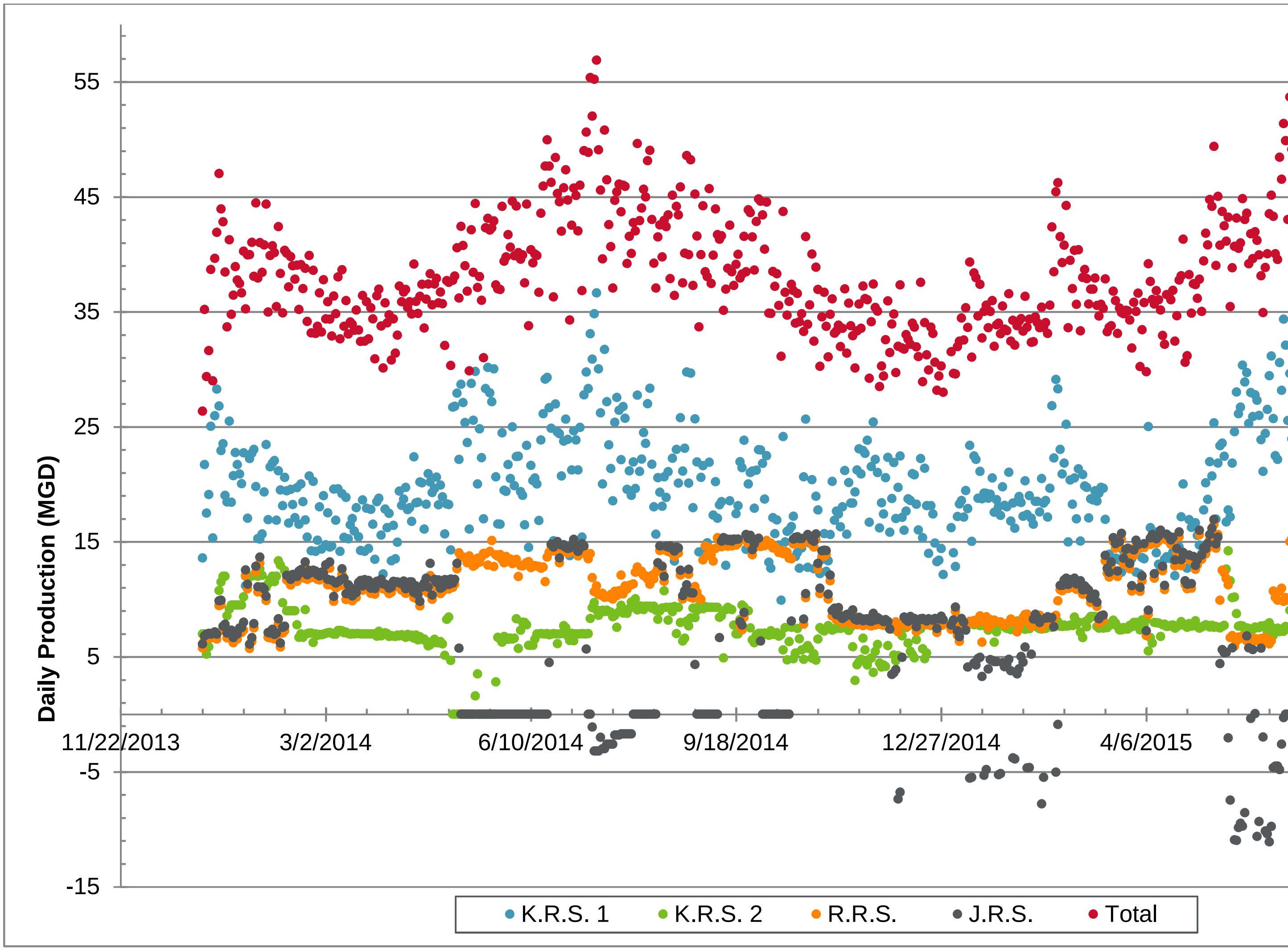
Facility/ Equipment	Description	Capital Cost of Project	Estimated Annual Savings			Estimated Payback Period
			Improved Efficiency	Hp Reduction	Total	
KRS1/ HSP 10	Pump Replacement	$650,000	$71,093	$41,240	$112,333	6.5
KRS1/ HSP 11	Pump Replacement	$650,000	$92,428	$61,619	$154,047	4.6
KRS1/ HSP 13	Pump Replacement	$850,000	$13,806	$31,063	$44,869	28.4
KRS1/ HSP 14	Pump Replacement	$850,000	$17,995	$70,481	$88,476	11.5
KRS2/HSP 3/4	VFD Installation	$200,000	$ -	$ -	$ -	NA
RRS/HSP 6	Pump Replacement	$650,000	$9,799	$0	$9,799	>20 Yr
RRS/HSP 7	Pump Replacement	$650,000	$18,413	$33,144	$51,557	16.1
RRS/HSP 8	Pump Replacement	$650,000	$1,357	$1,834	$3,191	>20 Yr
RRS/HSP 10	Pump Replacement	$650,000	$60,635	$13,138	$73,773	10.4

Appendix

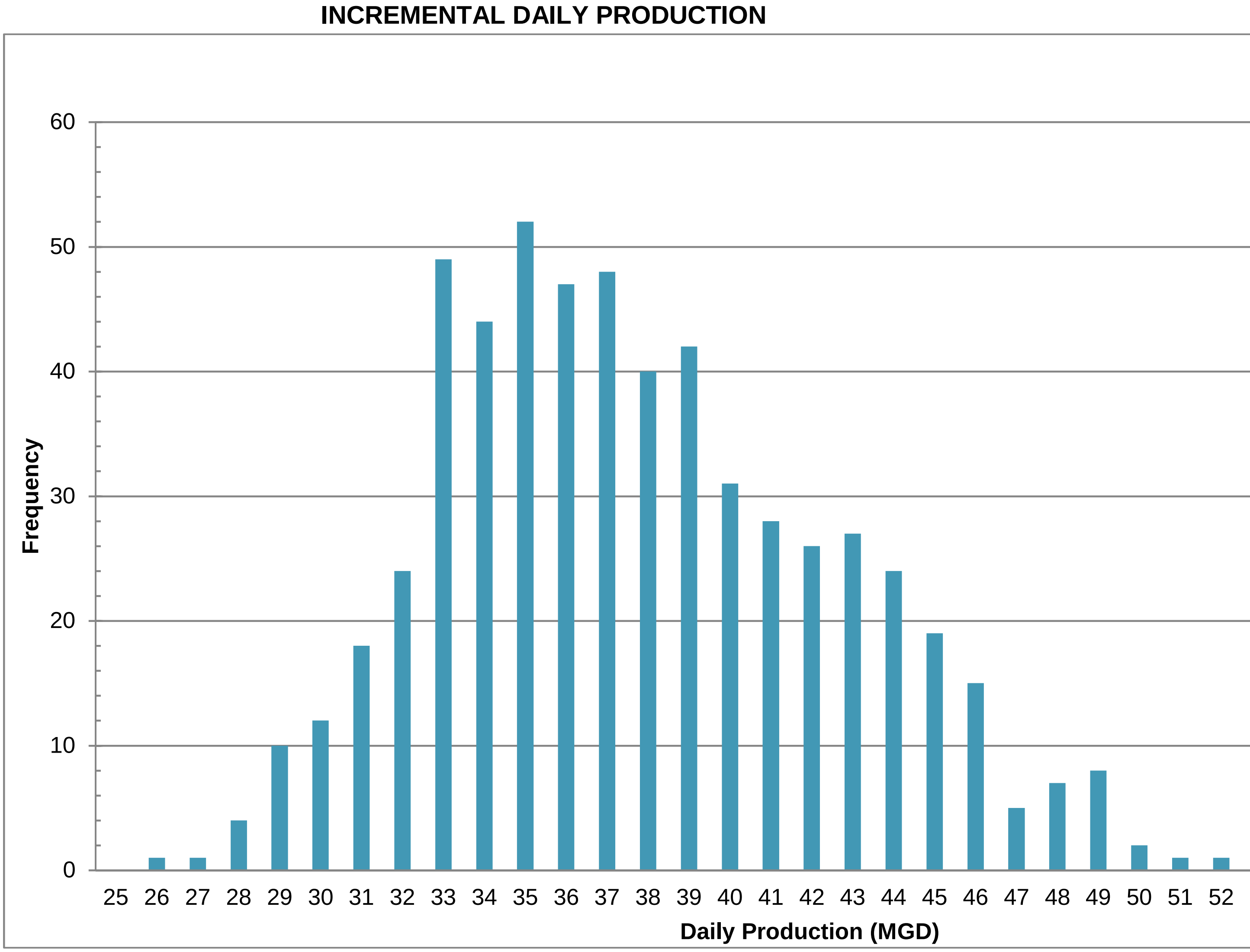
A. SCADA Graphs
B. Pump Curves
C. KAW Central System Schematic

Appendix A – SCADA Data

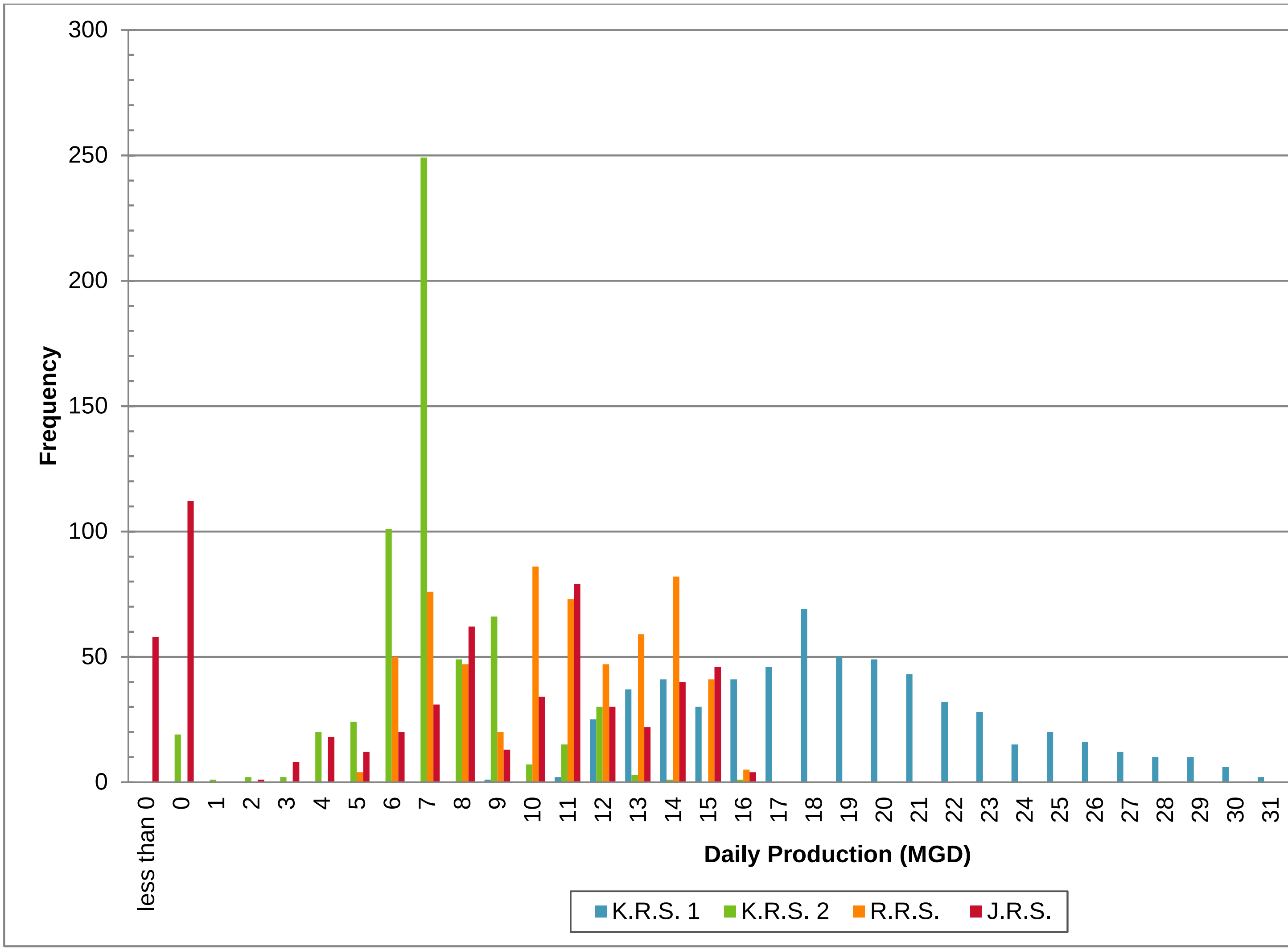
KENTUCKY AMERICAN WATER
CENTRAL SYSTEM
DAILY PRODUCTION



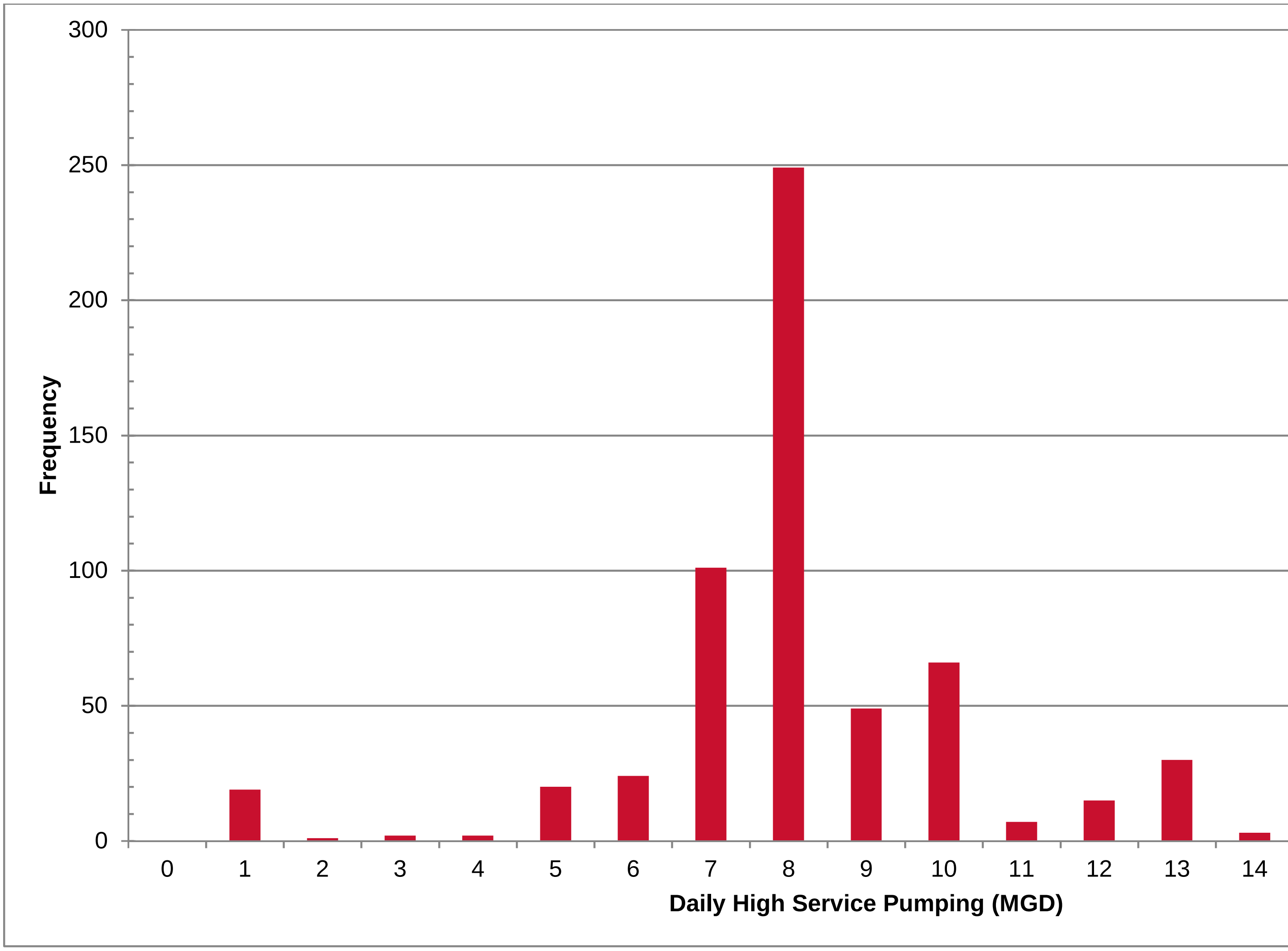
KENTUCKY AMERICAN WATER
CENTRAL SYSTEM



KENTUCKY AMERICAN WATER
CENTRAL SYSTEM
INCREMENTAL DAILY PRODUCTION

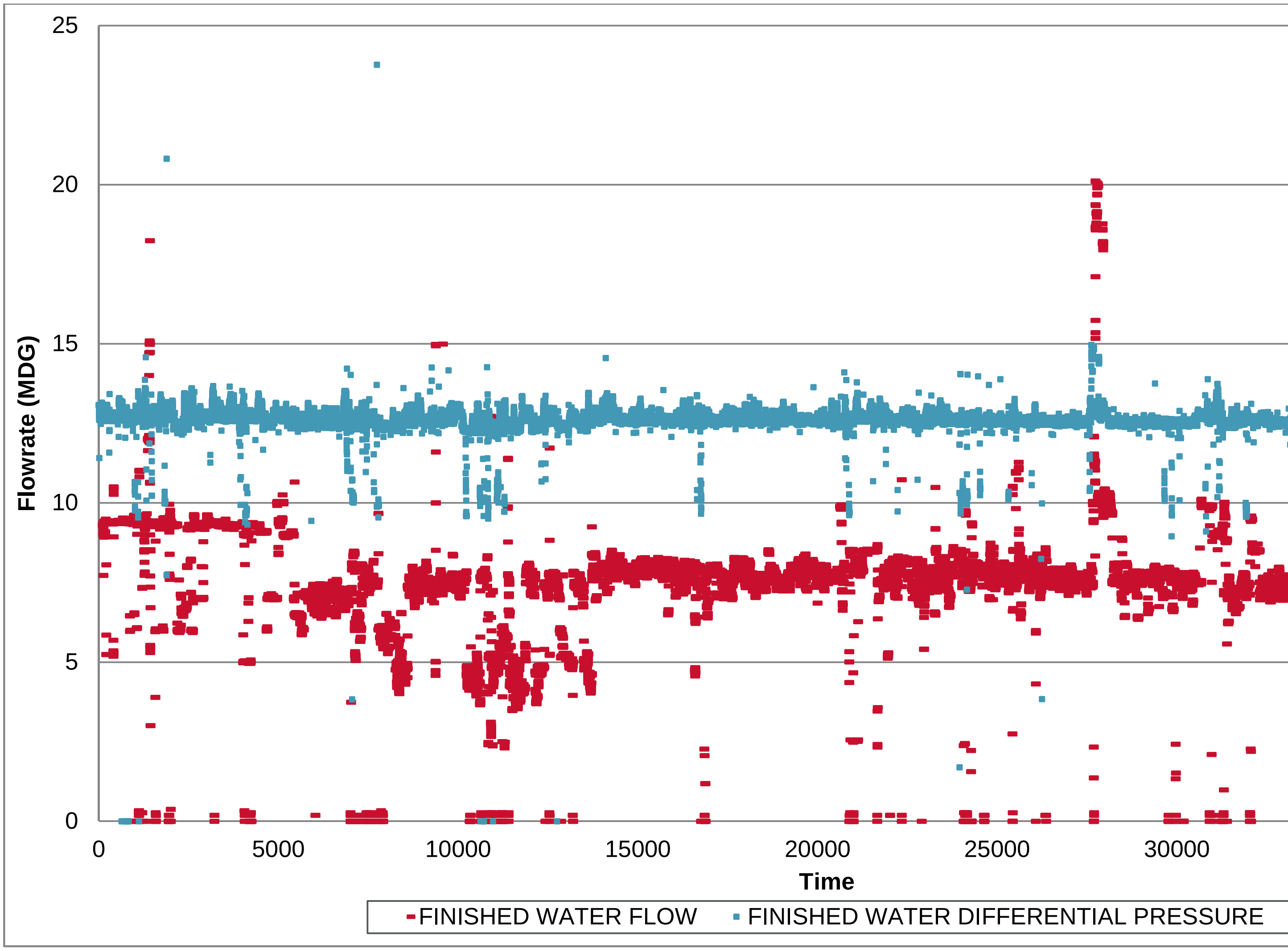


KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
DAILY HIGH SERVICE PUMPING

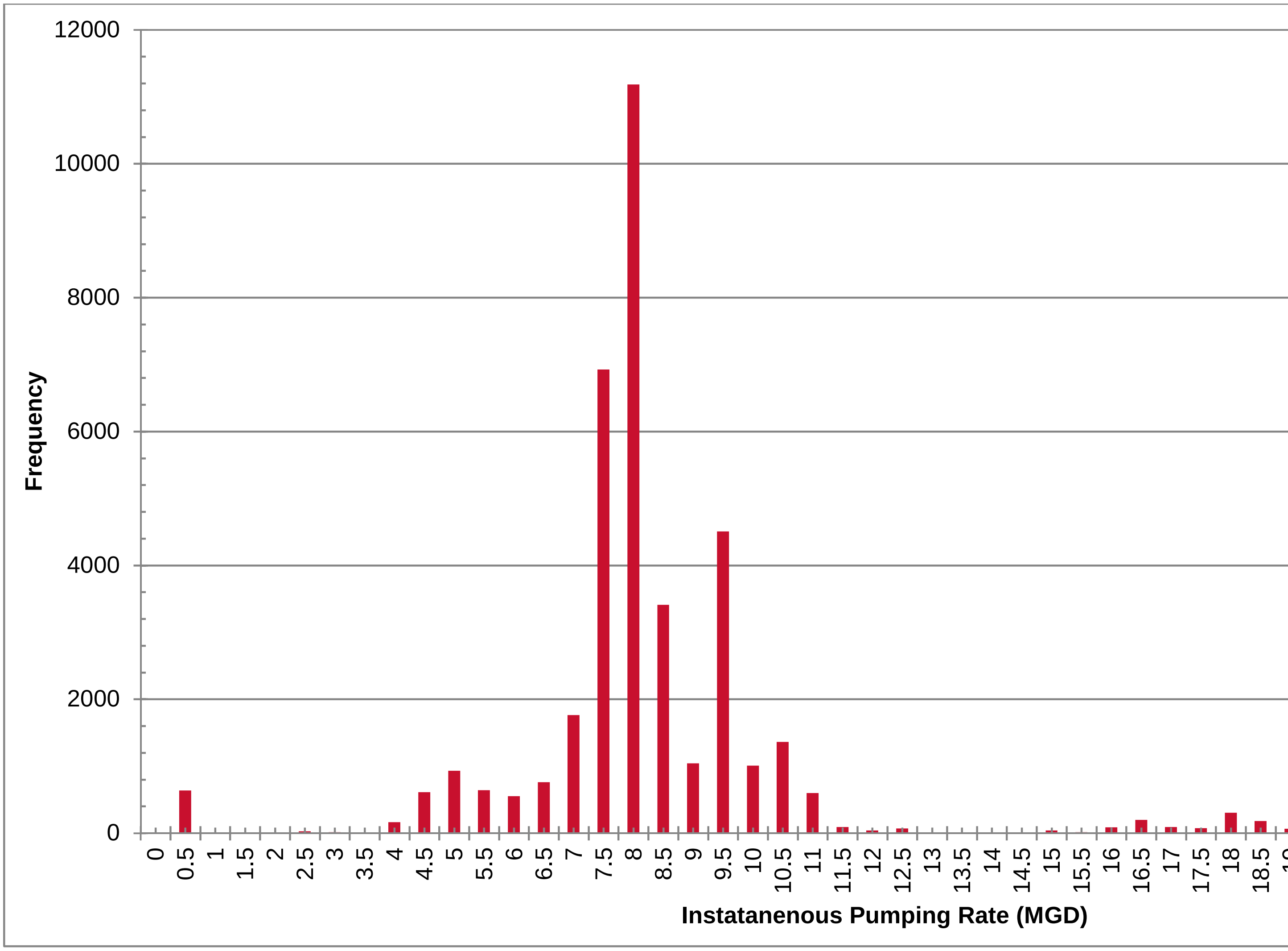


KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
INSTANTANEOUS HIGH SERVICE MOTOR SPEED

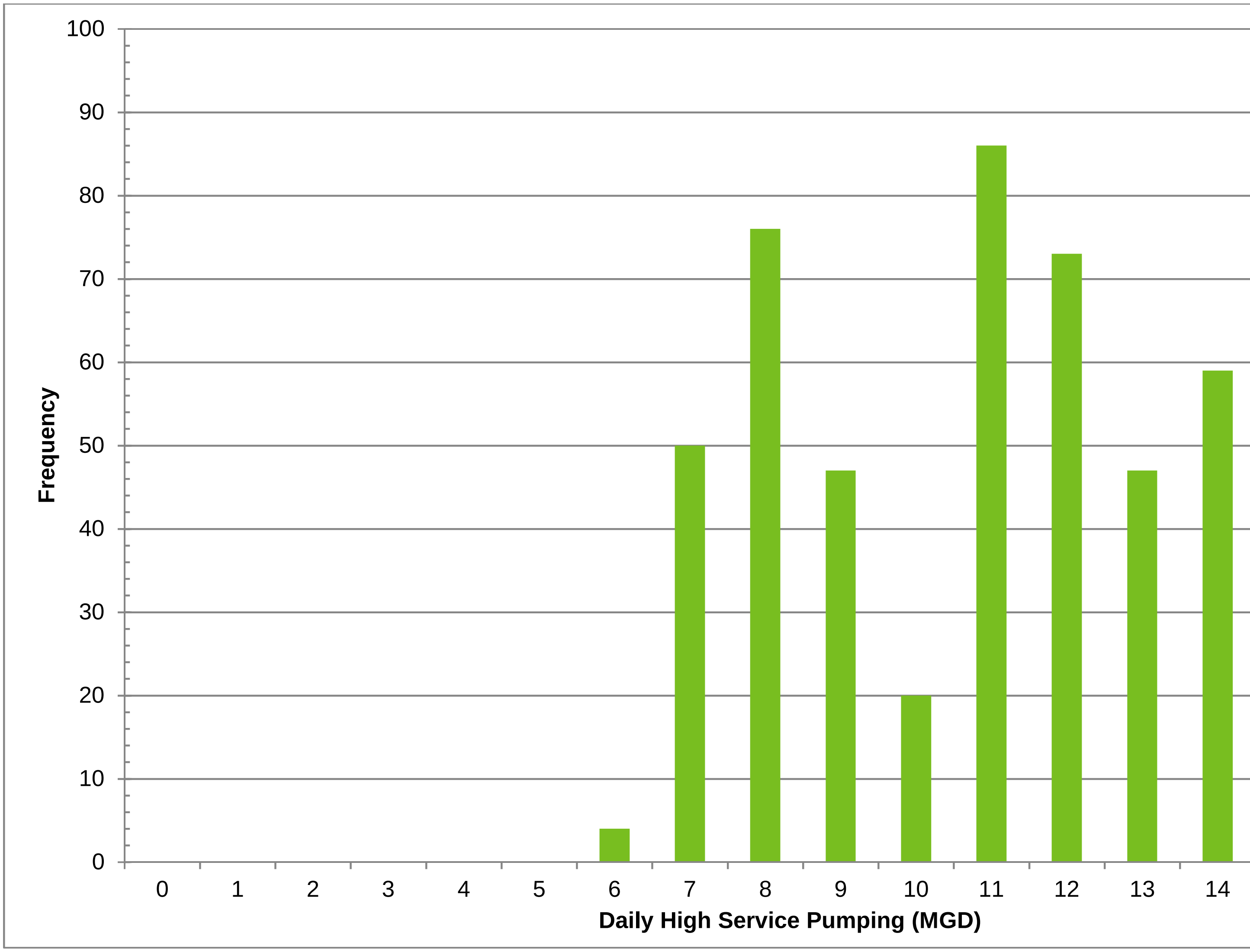
KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
INSTANTANEOUS HIGH SERVICE PUMP RATE & PRESSURE



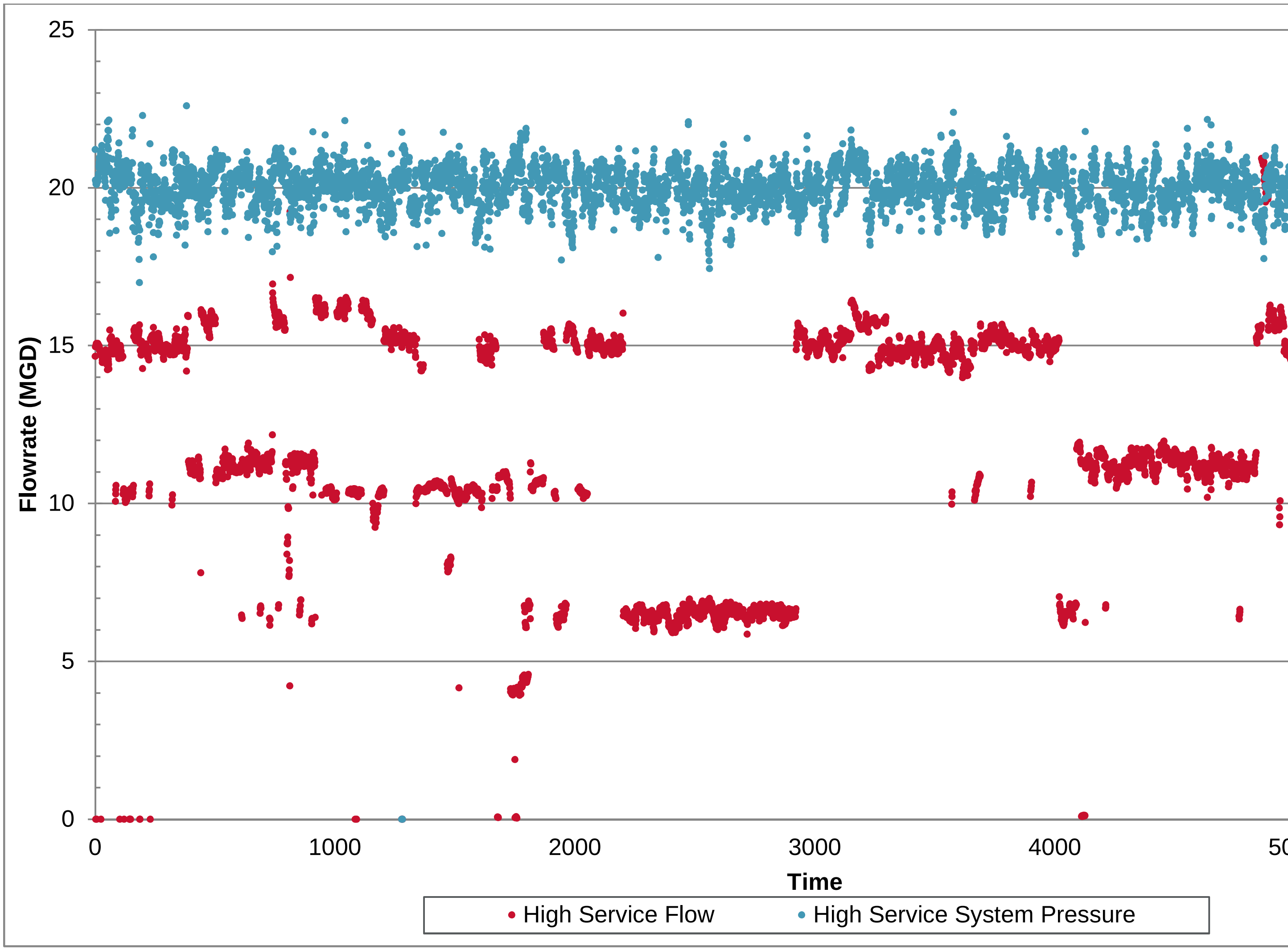
KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
INSTANTANEOUS HIGH SERVICE PUMPING RATE DISTRIBUTION



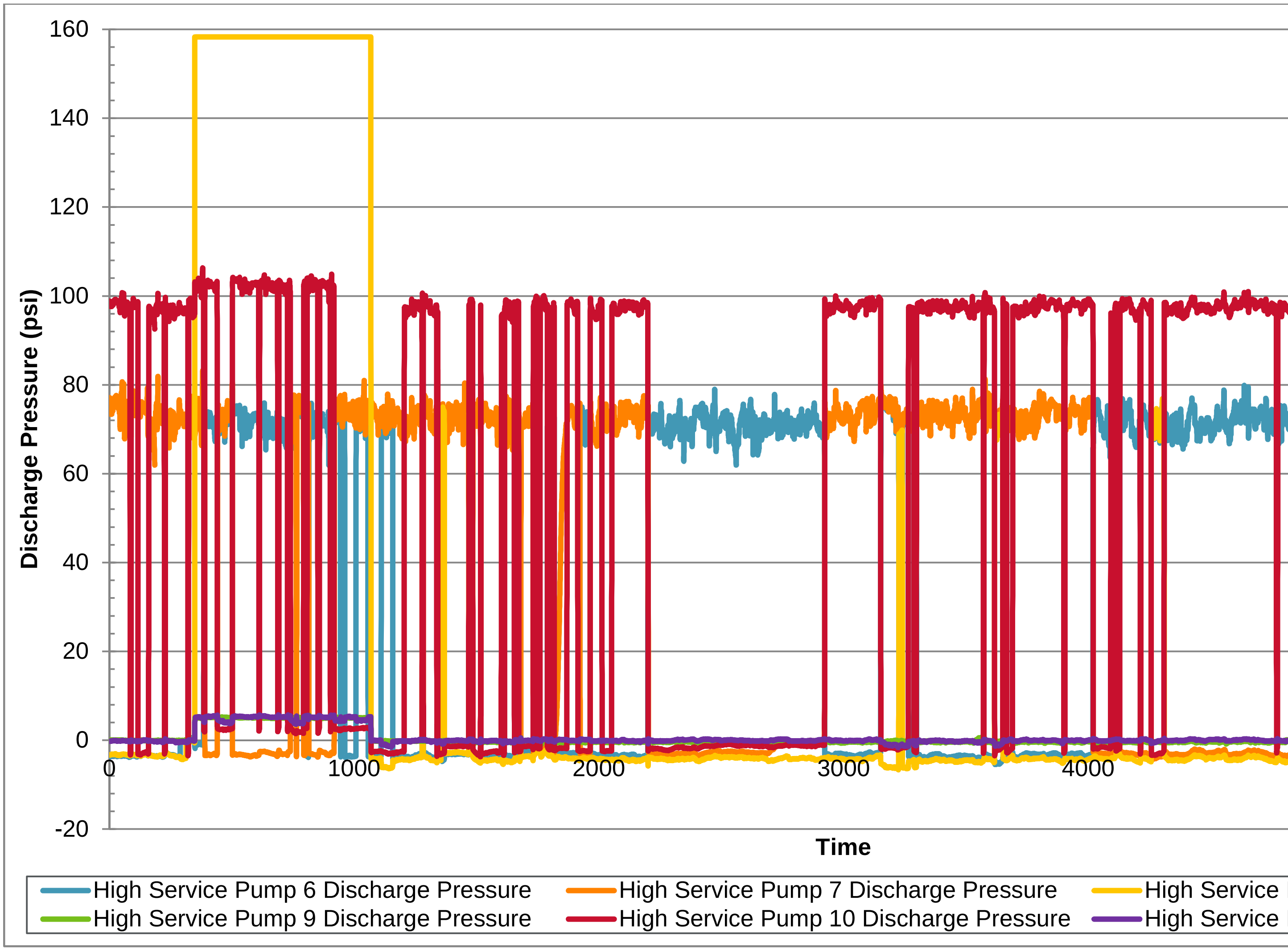
KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
DAILY HIGH SERVICE PUMPING



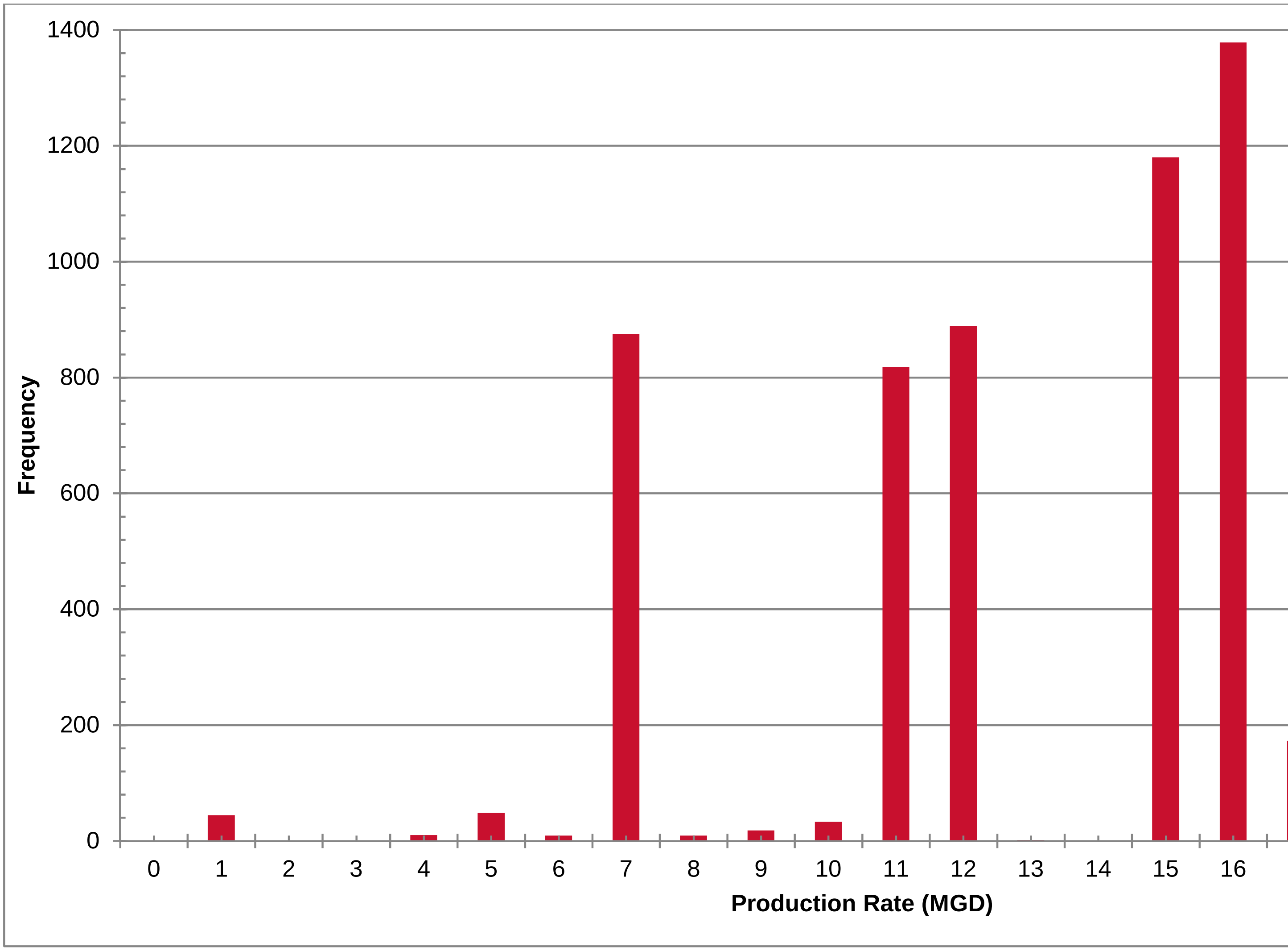
KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
INSTANTANEOUS HIGH SERVICE PUMP RATE & PRESSURE



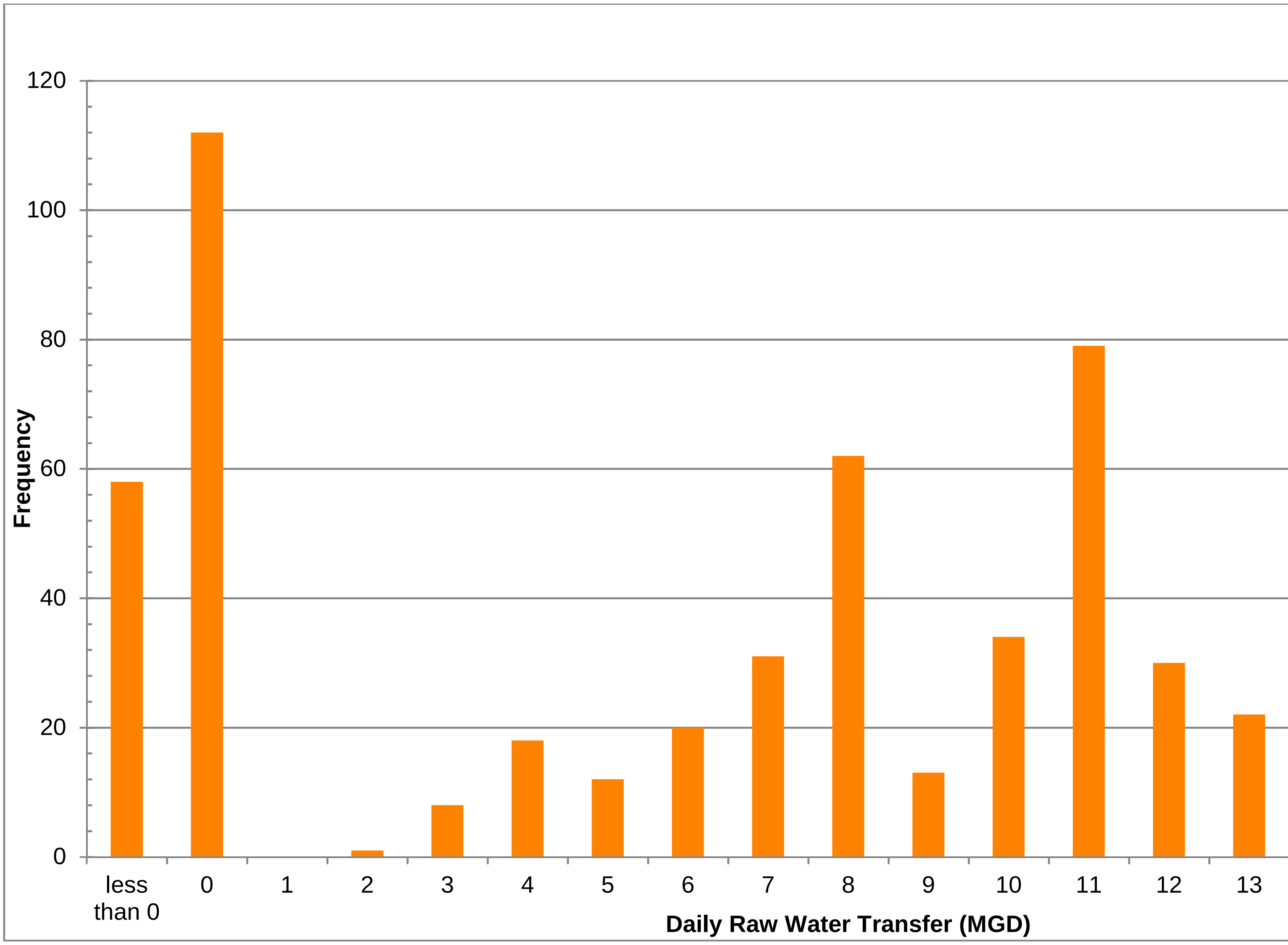
KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2
INSTANTANEOUS HIGH SERVICE PUMP PRESSURE



KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
INSTANTANEOUS HIGH SERVICE PUMPING RATE DISTRIBUTION

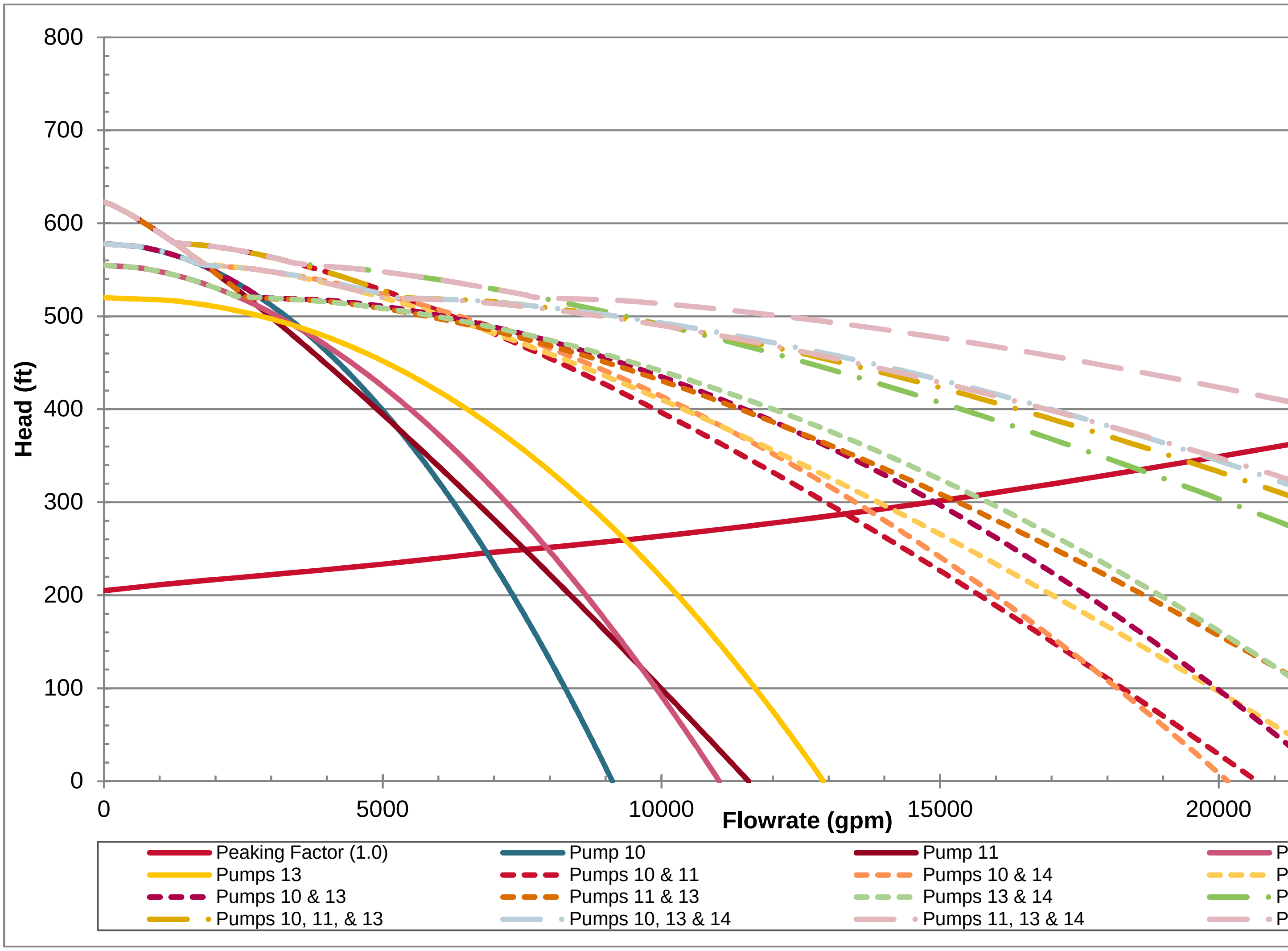


KENTUCKY AMERICAN WATER
JACOBSON RESERVOIR
DAILY RAW WATER TRANSFER PUMPING

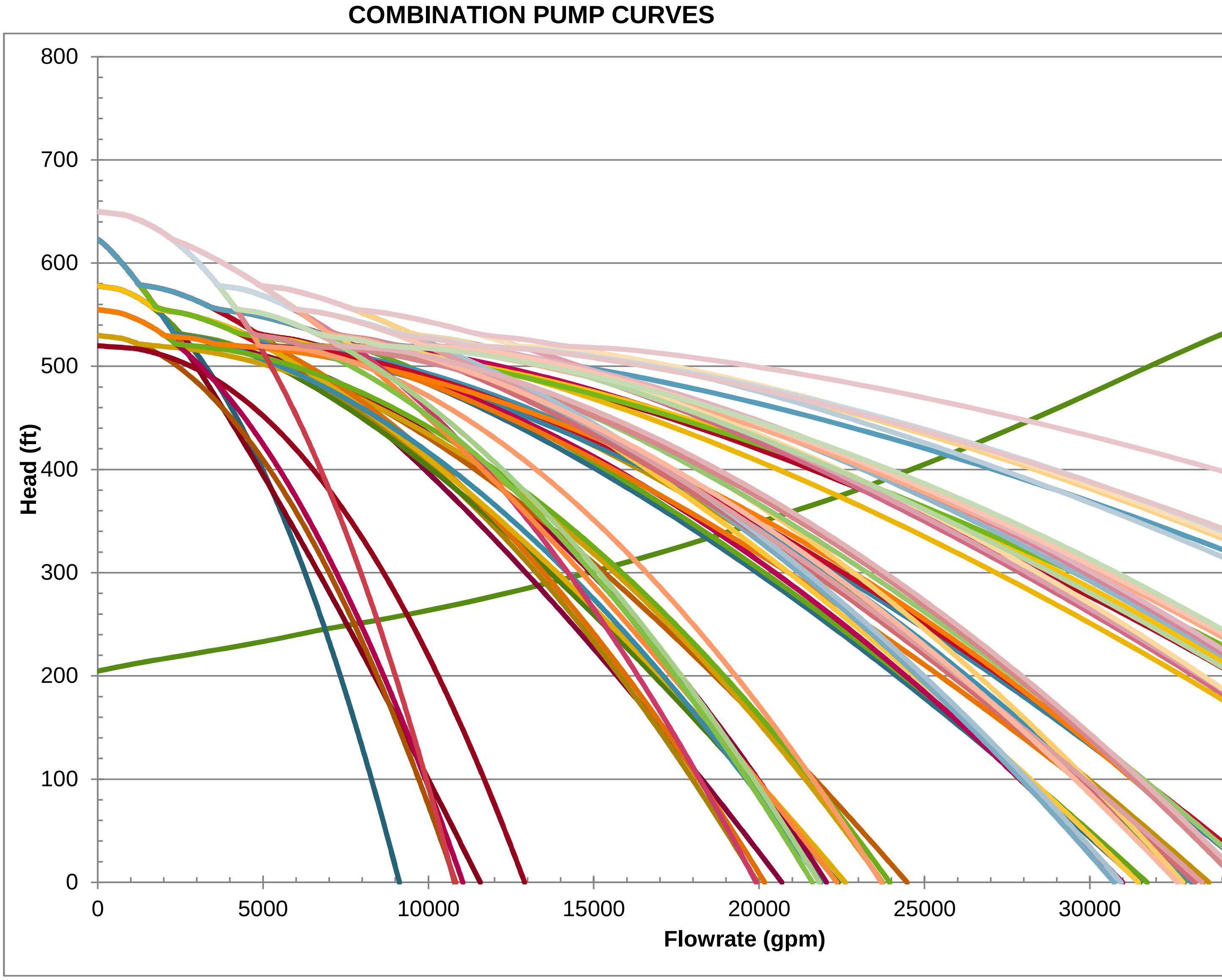

120
100
80
60
40
20
0
Frequency
less than 0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Daily Raw Water Transfer (MGD)

Appendix B – WaterGEMS Combination Pump Curves

KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 1
COMBINATION PUMP CURVES

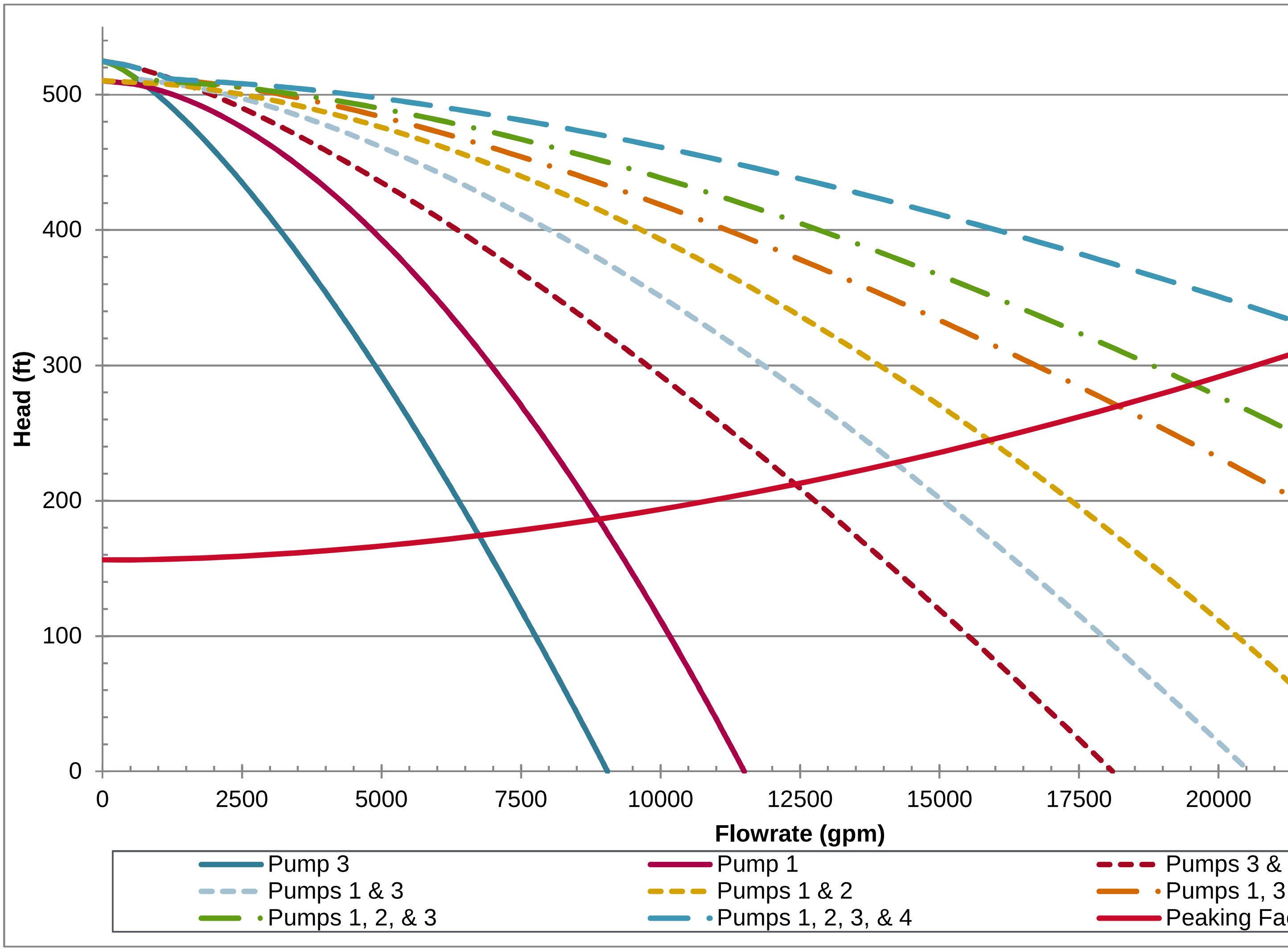


KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 1

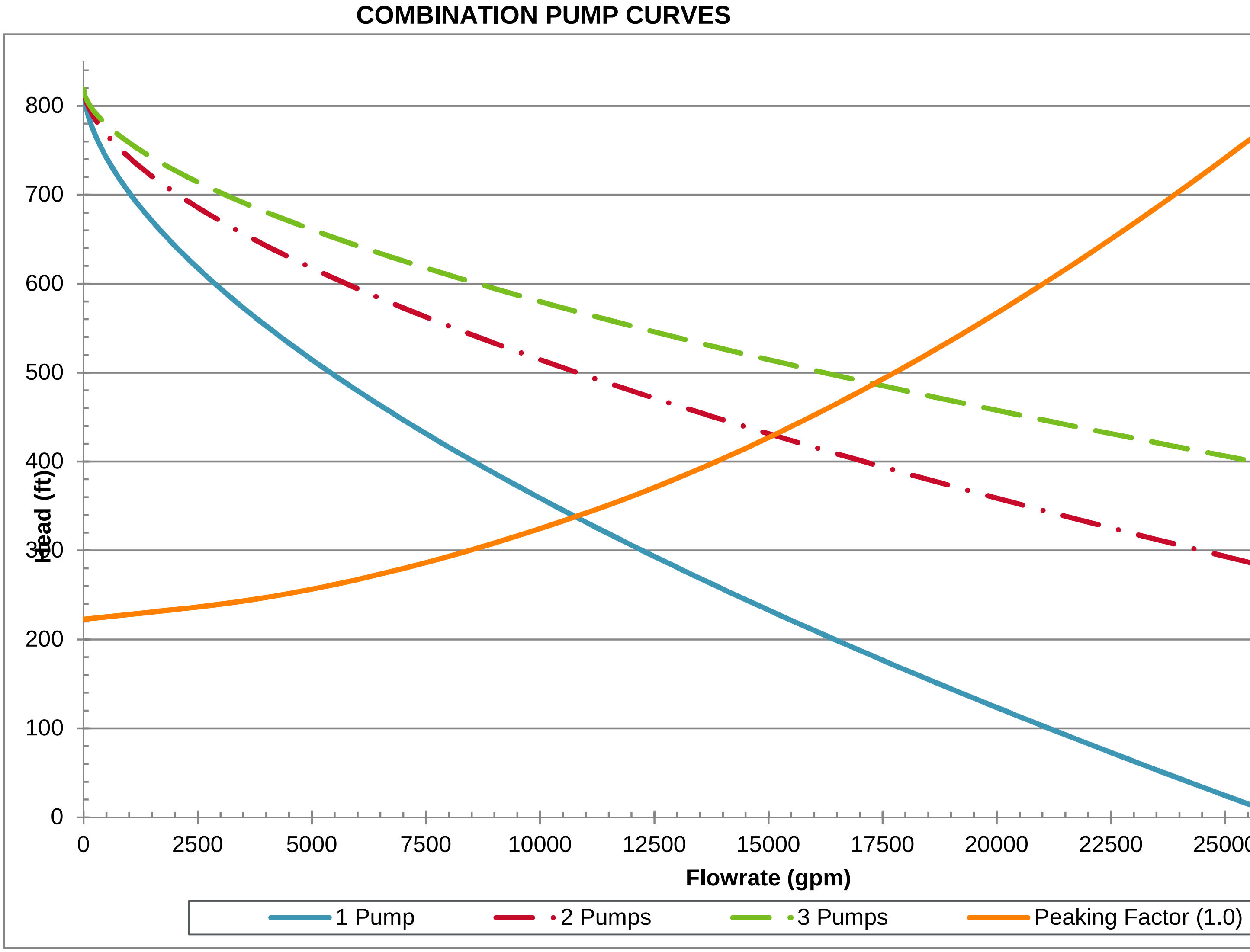


KENTUCKY AMERICAN WATER
KENTUCKY RIVER STATION NO. 2

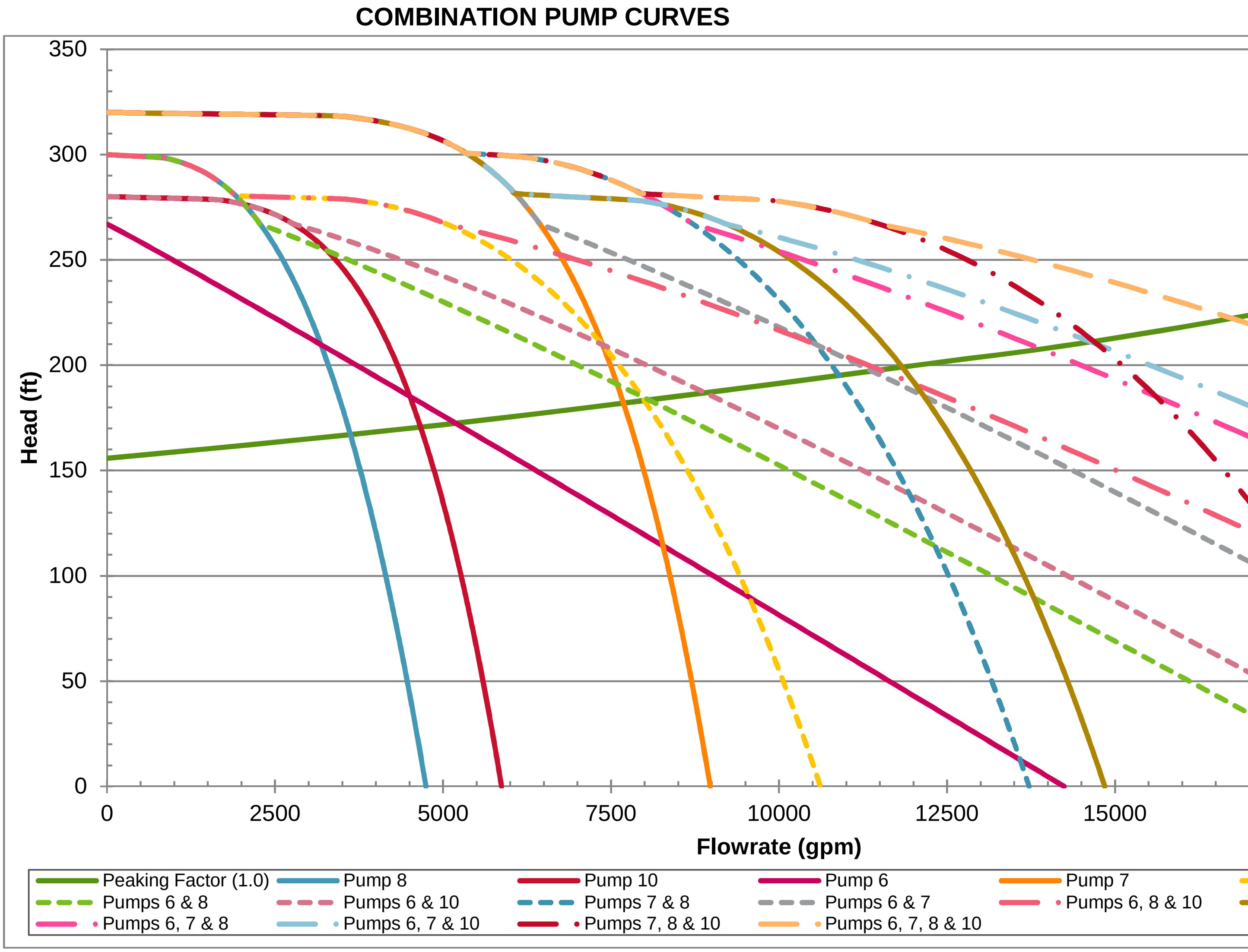
COMBINATION PUMP CURVES



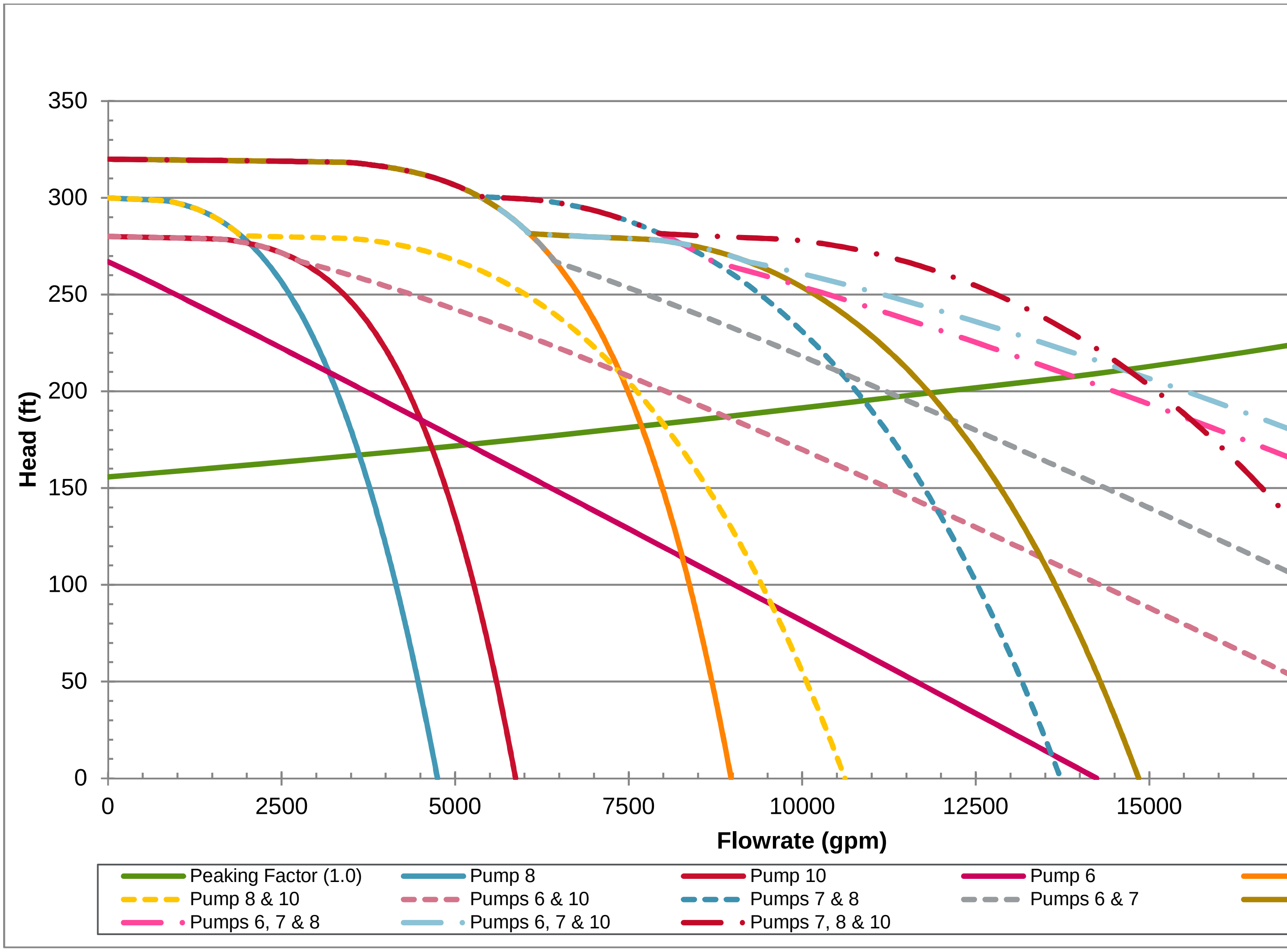
KENTUCKY AMERICAN WATER
WOODLAKE TRANSFER STATION



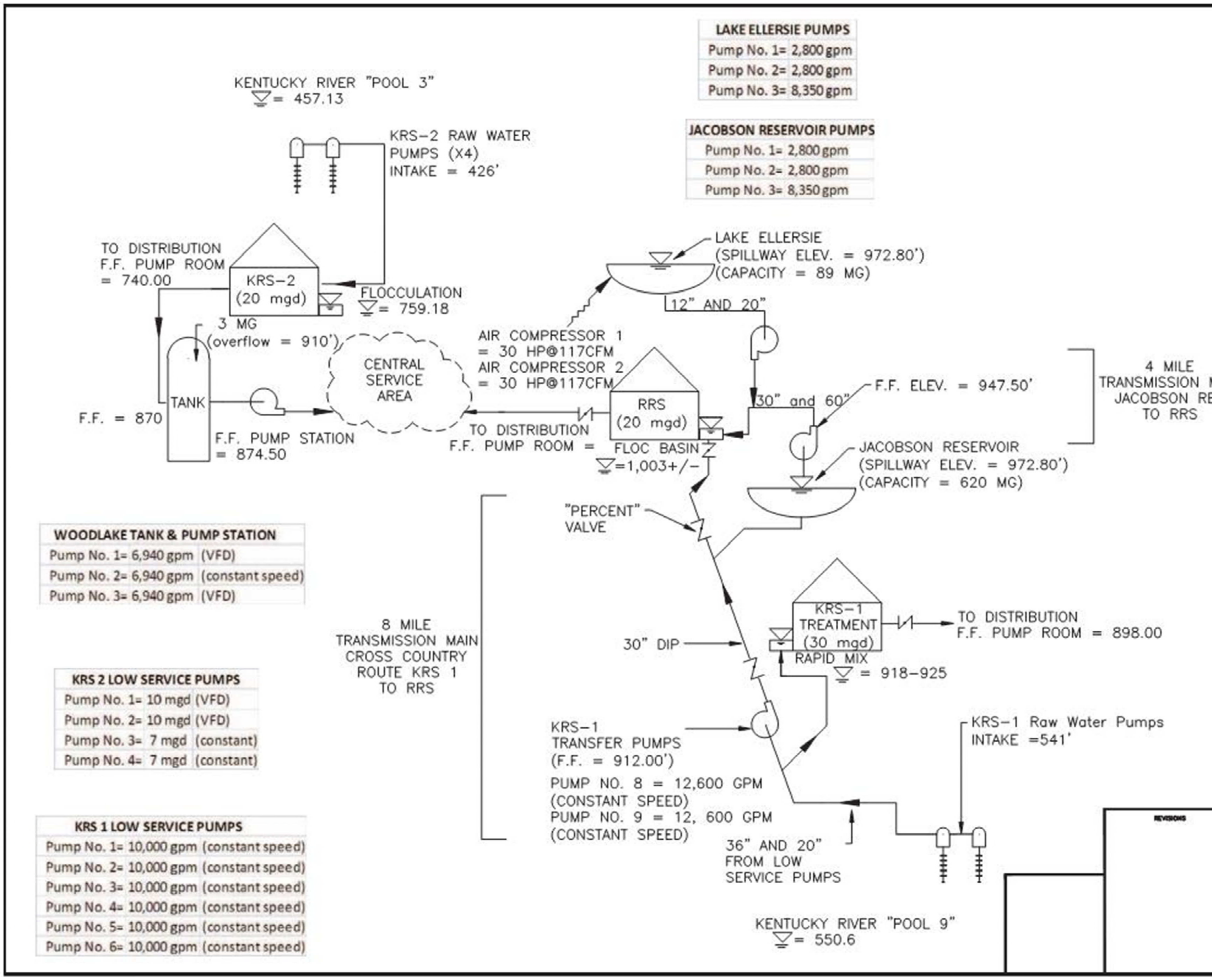
KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION



KENTUCKY AMERICAN WATER
RICHMOND ROAD STATION
COMBINATION PUMP CURVES (REDUCED PER OPERATOR NOTES)


350
300
250
200
150
100
50
0
Head (ft)
0
2500
5000
7500
10000
12500
15000
Flowrate (gpm)
Peaking Factor (1.0)
Pump 8
Pump 10
Pump 6
Pump 8 & 10
Pumps 6 & 10
Pumps 7 & 8
Pumps 6 & 7
Pumps 6, 7 & 8
Pumps 6, 7 & 10
Pumps 7, 8 & 10

Appendix C – KAW Central System Schematic


LAKE ELLERSIE PUMPS
Pump No. 1= 2,800 gpm
Pump No. 2= 2,800 gpm
Pump No. 3= 8,350 gpm
JACOBSON RESERVOIR PUMPS
Pump No. 1= 2,800 gpm
Pump No. 2= 2,800 gpm
Pump No. 3= 8,350 gpm
KENTUCKY RIVER "POOL 3"
= 457.13
KRS-2 RAW WATER PUMPS (X4) INTAKE = 426'
TO DISTRIBUTION F.F. PUMP ROOM = 740.00
KRS-2 (20 mgd)
FLOCCULATION
= 759.18
3 MG (overflow = 910')
TANK
F.F. = 870
F.F. PUMP STATION = 874.50
CENTRAL SERVICE AREA
AIR COMPRESSOR 1 = 30 HP@117CFM
AIR COMPRESSOR 2 = 30 HP@117CFM
LAKE ELLERSIE (SPILLWAY ELEV. = 972.80') (CAPACITY = 89 MG)
12" AND 20"
RRS (20 mgd)
TO DISTRIBUTION F.F. PUMP ROOM =
FLOC BASIN
=1,003+/-
30" and 60"
F.F. ELEV. = 947.50'
4 MILE TRANSMISSION M JACOBSON RES TO RRS
JACOBSON RESERVOIR (SPILLWAY ELEV. = 972.80') (CAPACITY = 620 MG)
WOODLAKE TANK & PUMP STATION
Pump No. 1= 6,940 gpm (VFD)
Pump No. 2= 6,940 gpm (constant speed)
Pump No. 3= 6,940 gpm (VFD)
"PERCENT" VALVE
8 MILE TRANSMISSION MAIN CROSS COUNTRY ROUTE KRS 1 TO RRS
30" DIP
KRS-1 TREATMENT (30 mgd)
RAPID MIX
= 918–925
TO DISTRIBUTION F.F. PUMP ROOM = 898.00
KRS 2 LOW SERVICE PUMPS
Pump No. 1= 10 mgd (VFD)
Pump No. 2= 10 mgd (VFD)
Pump No. 3= 7 mgd (constant)
Pump No. 4= 7 mgd (constant)
KRS-1 TRANSFER PUMPS (F.F. = 912.00')
PUMP NO. 8 = 12,600 GPM (CONSTANT SPEED)
PUMP NO. 9 = 12, 600 GPM (CONSTANT SPEED)
KRS-1 Raw Water Pumps INTAKE =541'
36" AND 20" FROM LOW SERVICE PUMPS
KRS 1 LOW SERVICE PUMPS
Pump No. 1= 10,000 gpm (constant speed)
Pump No. 2= 10,000 gpm (constant speed)
Pump No. 3= 10,000 gpm (constant speed)
Pump No. 4= 10,000 gpm (constant speed)
Pump No. 5= 10,000 gpm (constant speed)
Pump No. 6= 10,000 gpm (constant speed)
KENTUCKY RIVER "POOL 9"
= 550.6
REVISIONS

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

78. Reference O'Neill Direct, page 18, where Mr. O'Neill discusses the "Owenton Maintenance Garage."

a. Explain whether the Company has requested a CPCN for this project.
b. Provide support for the Company's need for the project.

Response:

a. Kentucky American Water requested an opinion letter from the Commission Staff on the need of a CPCN for the Owenton Maintenance Garage on September 28, 2018. KAWC received an Opinion Letter from the Commission Staff on October 10, 2018 (PSC Staff Opinion 2018-012) that it was in the staff's opinion that a CPCN was not needed for the Owenton Maintenance Garage.

b. This project will provide for the construction of a new, 9,900 square-foot maintenance garage to support the field crews for the Northern Division. The building will contain nearly 6,600 square feet of garage space to allow for climate-controlled storage of all of the division's equipment as well as its perishable material. The maintenance garage building will also contain nearly 3,400 square feet of support area for restroom and shower facilities, a break room and areas for support and supervisorial personnel. The garage will occupy 0.23 acres of the 4-acre site, allowing for the centralized storage of large material and equipment, consolidation of staff and the ability to accept deliveries of material in a safer, more organized manner.

<u>Needed Garage Space in Northern Division</u>

Following the cold weather event during January 2014 that caused a long duration service interruption it was determined that a location central to the service area was needed to house equipment and stage equipment. During the cold weather event several key pieces of equipment were inoperable due to the inability to have the equipment start since it was stored outside. It is believed that the several hours and partial days that were spent trying to revive pieces of equipment resulted in longer response times to broken mains leading to a quicker loss of the system during the January 2014 event. In addition, during the response to the January 2014 event by outside crews it was determined that not having material stored in a central location hampered the ability to respond efficiently to repairs and resulted in waiting for material to be located or resupplied from another location.

Operation of the system since 2005 has also allowed KAWC to determine that due to the lack of a central garage that allows equipment, material and support staff to be cohabitated together, brings an inefficiency to the response to day-to-day work and emergencies. Bringing all of the equipment and support together with the crews will allow for better management of the work and a better understanding of the material available to respond to the assigned tasks.

Review of Alternatives

Since 2014, KAWC has reviewed the alternatives and explored the opportunity to find additional garage and storage space for the Northern Division. It was determined that due to the access road and limited space at the WWTP that additional garage space at this facility was not appropriate.

Review of existing structures and the ability to repurpose space within Owenton was conducted. However, none of the existing structures provided the amount of storage to allow the division's equipment to be stored inside or extensive work was required to repurpose the space. Finally, the division found it was difficult to find willing sellers or appropriate priced structures to make this option viable.

It was determined that the construction of a new garage was appropriate to allow it to meet the requirements of the facility and allow for the efficient combination of equipment and material storage and integration of back office and supervisorial personnel. KAWC performed an analysis of the service area and determined the central location to minimize drive times and provide the most efficient response to orders was located near the intersection of Route 127 and State Highway 22 on the southeast side of Owenton. Three (3) properties were identified near this location and KAWC is currently completing the acquisition of a nearly 4-acre tract of land adjacent to the Owen County Judicial Center along State Highway 22.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill, Melissa L. Schwarzell

79. Reference O'Neill Direct, pages 13–21, where Mr. O'Neill describes proposed chemical facility upgrades and the expected price increase for the new chemicals that the Company plans to use once it upgrades certain facilities.

a. Provide the annual revenue impact for these proposed facility upgrades, if approved and completed, upon completion, assuming instantaneous ratemaking (i.e. no regulatory lag).

Response:

The annual revenue impact for the proposed facility upgrades discussed by Mr. O'Neill on pages 13-21 of his direct testimony, based on instantaneous ratemaking is $3,657,249 (calculation shown below). This is more revenue requirement than is being sought in this case for the facility upgrades, as they are not in service during the entire forecasted test year.

Utility Plant in Service	
KRS I Chemical Storage and Feed Imp	$8,445,806
RRS Chemical Facility Upgrade/Chlor	10,500,000
	18,945,807
Accumulated Depreciation	(266,993)
Deferred Income Taxes	(1,011,825)
Net Rate Base	17,666,988
Pre-tax Return	10.01%
Revenue on Rate Base	1,768,466
Depreciation Expense	533,986
Chemical Expense	1,121,764
Property Taxes	233,033
Total Revenue Requirement	$3,657,249

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

80. Reference O'Neill Direct, page 21.

a. Who is the AWWA?

Response:

a. AWWA is the American Water Works Association that is an international, nonprofit, scientific and educational society dedicated to providing total water solutions assuring the effective management of water. The association was founded in 1881, and is the largest organization of water supply professionals in the world.

According to AWWA, its membership includes over 3,900 utilities that supply roughly 80 percent of the nation's drinking water and treat almost half of the nation's wastewater.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

81. Reference O'Neill Direct, page 28, wherein Mr. O'Neill states that "The 'Nessie' analysis method . . . is regarded as the best baseline indicator of long-term infrastructure replacement needs."

a. Provide support for this assertion.

Response:

a. Economic models are used to determine the present worth of future pipe repair and eventual replacement costs. An example of such a model is the Nessie curve, which is an aggregate prediction of replacement capital needs projected over time to forecast reinvestment needs. The humps in the cumulative reinvestment shown in a Nessie curve are due to the echo effect where pipe reinvestment needs mirror, at a projected future date, the original installation date of pipes. The name comes from the belief that the curve with its humps and troughs resembles the legendary Loch Ness monster.

In its 2001 "Dawn of the Replacement Era" publication, AWWA analyzed the future investment needs for pipe replacement in 20 utilities and provided a forecast that it called a "Nessie Curve." The graph of the annual replacement needs in a particular utility, based on when pipes were installed and how long they are expected to last in that utility before it becomes economically efficient to replace them.

The Nessie Curve reflects an "echo" of the original demographics that shaped a particular utility. By modeling the demographic pattern and knowing the life expectancy of the pipes, we can estimate the timing and magnitude of that obligation.

During its 2012 "Buried No Longer" publication, AWWA expanded the Nessie Curve beyond the 20 initial utilities and developed a model that combined the data available from the USEPA, the water industry, and the US Census Bureau to allow for a regional analysis of regional pipe installation profiles by system size and pipe diameter.

The Nessie Curve forms a good starting point for an understanding of the investment waves, which will travel through utility in time. The curve generally postulates that the need to replace pipe will generally echo the original installation wave. The 2012 "Buried No Longer" publication was the most thorough and comprehensive analysis ever undertaken of the nation's drinking water infrastructure renewal needs.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

82. Reference O'Neill Direct, pages 27–28.

a. When did the Company become aware that its system included cast iron and galvanized steel lines?

b. When did the Company become aware that cast iron and galvanized steel lines had higher than average break rates?

Response:

a. When the material type is compared to the timeline of growth of the distribution system, certain periods were dominated by particular pipe materials that were in use by the water industry at the time. During the first part of the Lexington system development, from 1885 to 1950, Cast Iron Unlined and Lined were the predominant materials. During 1950 to 1980, Asbestos Cement pipe was used along with Cast Iron pipe, and Ductile Iron pipe was introduced into the system. After 1980, Ductile Iron pipe was the predominant material type used to meet system growth. During the 1960s, 1970s and 2000s with the acquisition of systems, Kentucky-American investigated the materials utilized in the distribution systems it had acquired.

b. The Company, like the industry, has understood that cast iron main was a dominant material as systems transitioned from wood, lead and galvanized mains due to its strength and durability. However, it was also known that cast iron had no elastic behavior, was brittle and was susceptible to changes in loading around the pipe. It was for these reasons that ductile iron main was developed to provide the durability of cast iron but bring an elastic behavior to the material that eliminated the brittle qualities of cast iron. It was not until the introduction of other material that the industry found the differences of the performances of the pipe material.

Similar to cast iron main, galvanized main was a material used to transition from lead mains and at its introduction was considered a superior material due to the reduction of corrosion due to the zinc coating of the main. However, we have learned that as the main has been in service for decades that the material is susceptible to corrosion from the inside. This realization took years of service of the material before it was determined it lost strength and its ability to maintain its designed flow rate as rust on the inside grew. As other material was introduced into the distribution system the differences in performance of each material is realized.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

83. Reference O'Neill Direct, page 25. Provide KAWC's projected total spend on asbestos cement main replacement during the 40 year period used in the model.

Response:

As indicated in the 2018 Replacement Program Report attached as Exhibit 2 to O'Neill Direct, the model suggests that asbestos cement main be replaced at a rate of $3 to $7 million each year during the 40 year period based on 2018 dollars.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill, Nick O. Rowe

84. Reference O'Neil Direct, page 30, wherein he discusses the "[d]eferral of pipe replacements."

a. Is the Company's current policy the deferral of pipe replacements? Explain any answer.

Response:

a. No. The Company's current policy is not the deferral of pipe replacements.

While American Water always ensures that each of its water utilities is afforded access to capital to provide safe, adequate, and reliable service, investment funding is not limitless. American Water is competing with other companies and industries in the marketplace for capital, and American Water's subsidiaries (including Kentucky-American) are competing within the American Water system for discretionary allocations of American Water's investment and financing capacity. Discretionary allocations within American Water can be influenced by a subsidiary company's capital requirements, as well as by market conditions and available funds. Investors have choices. The choices investors make must necessarily consider the returns available on invested capital. American Water is acutely aware that utility statutes and regulatory frameworks vary from state to state; regulatory commissions have different policies, administrative procedures, and precedents; and these differences affect American Water's investment decisions. Kentucky, like the rest of the United States is reaching a crossroads and facing difficult choices. Kentucky-American is looking to reach and maintain an optimal level of infrastructure investment, but if Kentucky's regulatory treatment does not keep up with ongoing capital expenditures and results in significant and persistent regulatory lag, it discourages expenditures in Kentucky verses alternative investments available to American Water.

Since 2009, the main replacement work has replaced 32.4 miles of cast iron main from the system and replaced it primarily with ductile iron main. This represents a replacement rate for cast iron main of 2.7 miles per year during the 9 year period including the accelerated rate of 5.4 miles per year over the past 4 years from 2014 and 2017. While this is making progress, it is still not enough to address the rapidly aging distribution system. At the current rate, it would take approximately 57.4 years to replace the remaining 310 miles of the cast iron main in the distribution system. At the end of the 57-year period, the possible age of a cast iron main could be nearly 200 years old or over twice the life expectancy for this type of material.

The referral to deferral of pipe replacement is a recognition by the company that if it maintains the current rate of replacement of 5.4 miles per year it will not be able to address the aging infrastructure in a timely manner. Due to the cumulative effect of the amount of cast iron main to replace as it reaches or surpasses the life expectancy of the material, future cost to replace the main will increase.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill, Kevin N. Rogers

85. Reference O'Neill Direct, pages 30–31. Has the Company seen an increase in the frequency of water main break and leaks over the past 10 years?

Response:

No. KAWC's frequency of water main breaks and leaks has varied over the past 10 years and it is difficult to determine a trend from year to year over that period due to the impact of a variety of factors on main breaks that leads to leaks. These factors include pipe age, pipe material, diameter, weather, and soil type.

The main break frequency over the past 10 years is as follows:

Year	Number of Main Breaks
2009	181
2010	203
2011	144
2012	191
2013	149
2014	163
2015	111
2016	196
2017	143
2018	146

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill, Kevin N. Rogers

86. Reference O'Neill Direct, page 31, wherein Mr. O'Neill states that "KAWC's non-revenue water is at or below the industry standard."

a. Provide the Company's non-revenue water percentage for the past 10 years.
b. Provide the industry standard non-revenue water percentage for the past 10 years.

Response:

a. The non-revenue water percentage for the past 10 years is 15.3 percent.

b. There is not a consistent industry standard for non-revenue water percentage for the past 10 years. The following are considerations for non-revenue water percentage:

- The World Bank recommends that non-revenue water should be "less than 25 percent."
- The average non-revenue water for the 10 largest Kentucky cities (minus Kentucky American Water) as reported through the Kentucky Infrastructure Authority was 20 percent.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Brent E. O'Neill

87. Reference O'Neill Direct, pages 38–39. For the other American-Water affiliates that have capital replacement riders, such as the proposed QIP, provide the annual O&M reduction for each utility that occurred as a direct or indirect result of the riders' implementation.

Response:

Annual O&M reductions, directly or indirectly, related to capital replacement riders are neither tracked nor available. O&M cost savings are influenced by a variety of factors, including QIP. Over time, there are cost savings resulting from a reduction in water leakage attributable to deteriorating and failing infrastructure from treatment costs and power costs as progress is made in the accelerated replacement of main. In addition, replacing aged infrastructure on an accelerated, and proactive rather than reactive, basis will achieve direct customer benefits in the form of improved and sustained water quality, increased pressure, improved fire protection, fewer service disruptions. See also KAWC response to Item 50 of the Commission Staff's Second Request for Information.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell

88. Reference Rowe Direct, page 8, wherein he states that the Company's 2017 O&M expense is relatively flat as compared to its total 2010 O&M expense.

a. Provide support for this statement.

Response:

Please see attached.

Kentucky-American Water
Summary Financial Information & Trends
Water Only

	2010	2011	2012	2013	2014	2015	2016	2017
Operating Expenses								
- Production Costs	$5,874,233	$6,075,011	$6,291,871	$5,984,488	$5,808,789	$5,990,196	$6,542,729	$6,509,645
- Employee Related	10,831,267	11,019,225	10,581,272	9,340,054	8,820,590	9,773,230	9,401,389	9,306,712
- Service Company	8,848,594	7,751,264	9,114,911	9,163,738	8,775,862	8,326,485	9,130,067	9,056,733
- Operating Supplies & Services	3,568,032	3,738,505	3,849,914	3,630,889	3,368,635	4,407,547	3,468,442	4,291,766
- Customer Accounting & Uncollectibles	1,774,991	1,748,501	1,645,242	2,140,324	2,093,092	2,005,676	2,046,173	1,798,548
- Regulatory Expense	562,344	214,599	213,119	260,448	249,916	289,304	233,816	289,565
- IOTG	582,987	609,869	595,164	675,836	736,231	934,769	663,174	531,372
- Maintenance	1,731,357	1,579,079	1,560,965	1,581,503	1,959,670	1,980,784	2,370,982	2,075,606
Total Operation & Maintenance	**$33,773,805**	**$32,736,053**	**$33,852,458**	**$32,777,280**	**$31,812,785**	**$33,707,989**	**$33,856,774**	**$33,859,948**

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell

89. Reference Rowe Direct, pages 5 and 9.

a. Reconcile the fact that the Company's last base rate case, Case No. 2015-00418, used a fully forecasted test year ending August 31, 2017 and Mr. Rowe's statement that "[t]he Company will have invested more than $100 million in capital improvements since the last rate case without realizing any capital cost recovery or depreciation expense on that investment."

Response:

In the current rate case, the Company is projecting a 13-month average test year balance for UPIS of $790.8 million. In the prior case, the balance for the projected 13-month average test year UPIS (including the impact for slippage) was $687.3 million or an increase of $103.5 million. Since the last rate case, the Company's base rates were reduced for the impact of the Tax Cut and Jobs Act. No other changes to the Company's rates were implemented that would have recovered the costs associated with the additional capital investment discussed above.

Forecasted 13 Month Average UPIS - TY 6/30/2020	$790,806,081
Forecasted 13 Month Average UPIS - TY 8/31/2017 (1)	687,293,723
Change Due Primarily to Capital Improvements	$103,512,358

(1) Reflects application of slippage factors

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Nick O. Rowe

90. Reference Rowe Direct, pages 10–11, wherein Mr. Rowe notes that "one of the reasons KAWC is asking the Commission to approve a QIP" is that "Kentucky's regulatory treatment . . . results in significant and persistent regulatory lag," particularly as compared with other American Water subsidiaries with whom the Company competes.

a. Explain what action Kentucky-American has taken within the American Water organization to request that affiliates seek regulatory changes to be more in line with Kentucky.

b. Explain what action American Water has taken within its organization to request that subsidiaries, and in particular Kentucky-American, seek regulatory changes to reduce regulatory lag.

Response:

a. Kentucky-American has not requested that other American Water affiliates seek out greater regulatory lag.

b. American Water provides its regulated subsidiaries with information regarding constructive regulatory measures, including ratemaking treatment and mechanisms that reduce regulatory lag. American Water is acutely aware that utility statutes and regulatory frameworks vary from state to state; regulatory commissions have different policies, administrative procedures, and precedents; and these differences affect American Water's investment decisions. Kentucky-American is looking to reach and maintain an optimal level of infrastructure investment, but if Kentucky's regulatory treatment does not keep up with ongoing capital expenditures and results in significant and persistent regulatory lag, it discourages expenditures in Kentucky verses alternative investments available to American Water.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell and Brent O'Neill

91. Reference Rowe Direct, page 11.

a. Does Mr. Rowe believe the Commission has not demonstrated commitment to infrastructure replacement?

b. Does Mr. Rowe believe the Company has not demonstrated commitment to infrastructure replacement?

Response:

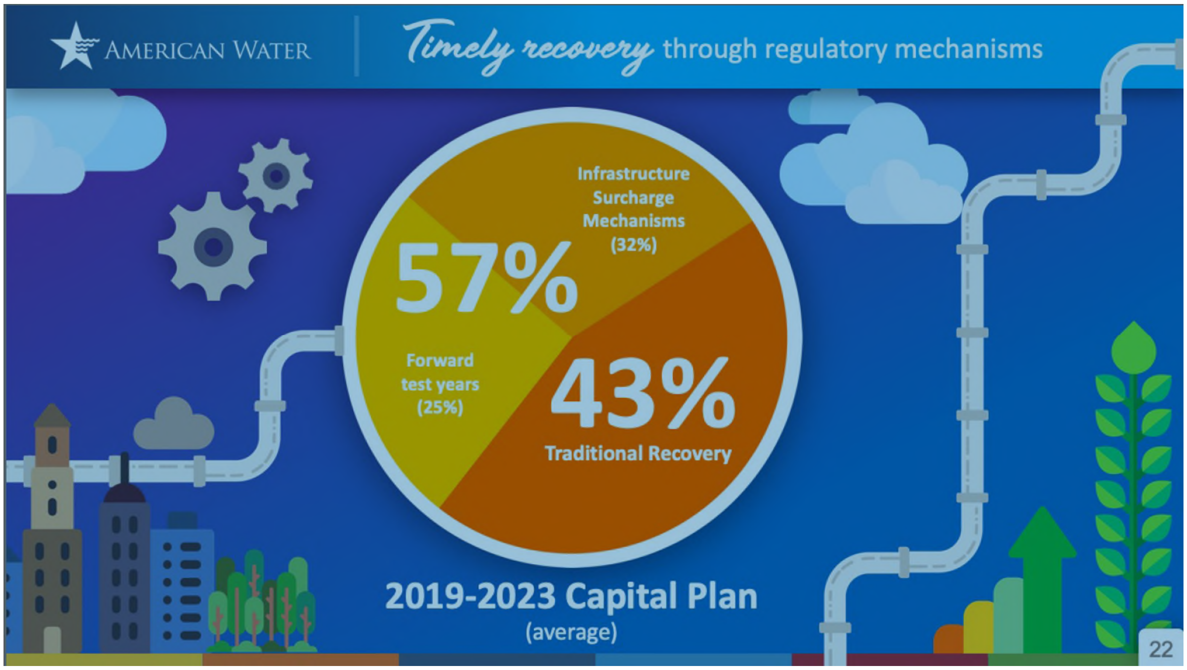
a&b. Mr. Rowe's statement on commitment to infrastructure replacement was affirmative, not negative. It comments on the positive impact a QIP would have toward public commitment for infrastructure replacement and does not imply a negative comment on the past.

As Mr. Rowe and Mr. O'Neill note, while the Company has made strides toward reducing the pipe replacement cycle and achieving a robust infrastructure program, more progress needs to be made. Likewise, the Commission has consistently allowed general rate case recovery of critical water infrastructure investment in Kentucky and has utilized a forecasted test year for many years. Nonetheless, additional constructive regulatory mechanisms will provide Kentucky American the opportunity to improve the replacement rate of its aging infrastructure and achieve a level of investment that is in the long-term interest of our customers.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell

92. Reference Rowe Direct, wherein he discusses the Company's QIP proposal and the below image from American Water's December 11, 2018 investor presentation.[1]



a. Using the terminology provided by American-Water's image, above, confirm that the Company's current method of regulatory rate recovery would be considered "Forward test years."

b. Using the terminology provided by American-Water's image, above, confirm the Company's proposed QIP would be considered "Infrastructure Surcharge Mechanisms."

Response:

a. Yes, but only for the capital spent during the future test year of the Company's rate cases. All other capital spent by the Company would fall into the "Traditional Recovery" bucket.

b. Yes, but only for the infrastructure investment recovered through the QIP mechanism.

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[1] The original content can be found at the following link: https://ir.amwater.com/cp-content-ms/documents/259581/387129/AWK+2018+Investor+Day+Presentation.pdf/bf8bddc3-ea9e-5480-71bc-17cc806330a7.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Nick Rowe

93. Reference Rowe Direct, page 15. Explain, in complete detail, how the proposed QIP helps "customers manage costs."

Response:

Mr. Rowe is referring to the statement he quotes in his testimony from the National Association of Regulatory Utility Commissioners (NARUC). The statements are from NARUC's 2013 resolution supporting alternative regulation. The quote indicates that "alternative regulatory mechanisms can enhance the efficiency and effectiveness of water and wastewater utility regulation by reducing regulatory costs [and] increasing rates for customers, when necessary, on a more gradual basis."

In addition to the gradualism and reduced regulatory costs noted by NARUC, QIP price changes can be easier for customers to predict and budget for than general rate case price changes. This is because infrastructure surcharges are typically filed on a predictable schedule, are often small in scale, and are usually resolved quickly with minimal changes. Periodic general rate cases, on the other hand, have the opposite characteristics: the filing of the case is not readily predictable, the requests are often large in scale, filings require up to 10 months to resolve, and the final prices authorized are often materially different than those proposed. Additionally, because infrastructure surcharges allow for incremental recovery between rate cases, they [may/will likely] reduce the size of any future general rate case, further limiting any issues associated with the potential budgeting challenges posed by periodic rate cases.

Predictability and gradualism can benefit not only residential households but also commercial businesses, public authorities, industrial manufacturers, and other communities who purchase water from regulated utilities. Consequently, QIP enables customers of all kinds to better predict and plan for the cost of their water service and thus better manage costs.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Melissa L. Schwarzell

94. Does the Company use credit cards that include rebates? If the response is in the affirmative, provide the following items:

a. Amount of rebate reflected in the cost of service base year and forecasted period. If the amount is allocated, provide the allocations.
b. Actual credit card rebates by year for 2016, 2017, 2018, and 2019 YTD. For each year, state the expense accounts where these credit card rebates are reflected and provide a detailed breakdown of those expense accounts.

Response:

a. The amount of rebate reflected in both the base year and forecast period is approximately $31,000.

b. The credit is originally made to account 52500000 by the Service Company. It then flows through the bill to credit Kentucky American's Support Services expense.

2016	2017	2018
-$51,469	-$40,434	-$31,792

PCard Rebate Allocation
Recorded through Co#1033 GL#52500000

Sum of General ledger amount	Column Labels			
	2016	2017	2018	Grand Total
Row Labels				
SE-0110-0042-332584	-75,774.92	-81,117.85	-66,199.76	-223,092.53
SE-0111-0044-332584	-21,077.36	-11,802.62	-9,172.27	-42,052.25
SE-0112-0060-332584	-51,469.29	-40,434.10	-31,791.84	-123,695.23
SE-0113-0062-332584	-2,284.97	-1,812.32	-1,999.43	-6,096.72
SE-0115-0022-332584	-59,238.96	-67,396.53	-67,656.52	-194,292.01
SE-0116-0046-332584	-2,276.89	-1,361.40	-1,015.41	-4,653.70
SE-0117-0048-332584	-94,281.93	-112,956.73	-118,256.32	-325,494.98
SE-0118-0082-332584	-399,695.25	-292,061.39	-221,768.92	-913,525.56
SE-0120-0086-332584	-4,551.05	-4,481.76	-4,984.57	-14,017.38
SE-0124-0064-332584	-425,981.71	-267,890.17	-194,948.08	-888,819.96
SE-0125-0040-332584	-140,137.46	-89,345.82	-56,243.34	-285,726.62
SE-0126-0066-332584	-17,125.33	-17,384.01	-25,482.62	-59,991.96
SE-0127-0068-332584	-29,265.64	-29,517.78	-96,563.35	-155,346.77
SE-0128-0070-332584	-90,236.98	-68,559.16	-47,277.60	-206,073.74
SE-0130-0028-332584	-4,013.82	-4,317.92	-5,075.35	-13,407.09
SE-0131-0196-332584	-272,264.67	-190,982.55	-179,152.77	-642,399.99
SE-0138-0084-332584	-57,991.15	-53,411.39	-39,112.44	-150,514.98
SE-3000-0001-332584	-203,826.65	-141,298.38	-159,689.68	-504,814.71
Grand Total	-1,951,494.03	-1,476,131.88	-1,326,390.27	-4,754,016.18
	2016 includes $275,000 Signing Bonus	2017 includes $125,000 Performance Bonus		

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: Timothy Willig

95. Reference the Direct Testimony of Timothy Willig ("Willig Direct"), generally. Provide a list of the full benefits considered in the Benefits Study.

a. Refer further to the table, page 3. Explain whether the "Benefit Cost Share as a Percentage of Base Pay" analysis was performed for the benefits not shown. If so, provide those percentages.

Response:

Summary of Kentucky American Water (KYAWC) Benefit Cost Share as a Percentage of Base Pay			
	Kentucky American Water	**Median, full BENVAL database**	**Median, energy industry subset of BENVAL database**
Full benefit program	24% employee / 76% KYAWC	22% employee / 78% employer	23% employee / 77% employer
Medical/prescription drug benefits	20% employee / 80% KYAWC	21% employee / 79% employer	14% employee / 86% employer
Dental benefits	15% employee / 85% KYAWC	35% employee / 65% employer	26% employee / 74% employer
Vision benefits	Not available	Not available	Not available
Disability benefits	0% employee / 100% KYAWC	3% employee / 97% employer	1% employee / 99% employer
Life insurance benefits	20% employee / 80% KYAWC	28% employee / 72% employer	36% employee / 64% employer
Vacation & holiday benefits	0% employee / 100% KYAWC	0% employee / 100% employer	0% employee / 100% employer
Retirement income program (defined contribution + stock purchase)	49% employee / 51% KYAWC	51% employee / 49% employer	50% employee / 50% employer

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

96. Reference FR 16(8)(f), KAW_APP_EX37F_112818, and the application in general. Identify any and all organizations, companies, associations or other entities to which KAWC pays any dues [hereinafter collectively referred to as "Dues Requiring Organizations"].

a. For each such Dues Requiring Organization, identify specifically which ones engage in any or all of: (i) legislative advocacy; (ii) regulatory advocacy; and (iii) public relations [hereinafter jointly referred to as "covered activities"].

b. For each Dues Requiring Organization identified in subpart a., above, provide the percentage of dues that KAW pays that the Dues Requiring Organization applies toward its expenses for covered activities.

Response:

Please see attached which provides all organizations, companies and associations to which the Company pays dues since the conclusion of the last case through December 2018.

Kentucky-American Water Company
Company Dues/Memberships

Vendor	2017/09	2017/10	2017/11	2017/12	2018/01	2018/02	2018/03	2018/04	2018/05
American Water Works Association - Company	$704	$704	$704	$704	$721	$721	$721	$721	$721
American Water Works Association - Individuals			417						2,600
Better Business Bureau	825								
Bluegrass Cross Connection Prevention Association									
Commerce Lexington					6,032				
Cynthiana-Harrison County Chamber of Commerce			135						
Downtown Lexington Partnership							750		
Frankfort Area Chamber of Commerce									
Georgetown/Scott County Chamber of Commerce							625		
Greater Lexington Apartment Association					371				
Home Builders Association of Lexington									
Jessamine County Chamber Commerce									550
Kentucky Association of Manufacturers				1,130					
Kentucky Association of Manufacturers									
Kentucky Association of Mapping Professionals					25				
Kentucky Chamber of Commerce					10,000				
Kentucky Engineering Center					132				
Kentucky League of Cities									
Kentucky Rural Water Association				500					
Lexington Forum									
National Association of Water Companies	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957
Owen County Chamber of Commerce									500
Owenton Rotary Club								179	
Paris-Bourbon County Chamber of Commerce									
Rockcastle County Chamber of Commerce							100		
Water Environment Federation									
Winchester County Chamber of Commerce	500								
Winchester County Chamber of Commerce									
Woodford County Chamber of Commerce							520		
Total	$6,986	$5,661	$6,213	$7,291	$22,238	$5,678	$7,673	$5,857	$9,328

Kentucky-American Water Company
Company Dues/Memberships

Vendor	2018/06	2018/07	2018/08	2018/09	2018/10	2018/11	2018/12	Total
American Water Works Association - Company	$721	$721	$721	$721	$721	$721	$721	11,461
American Water Works Association - Individuals								3,017
Better Business Bureau		825						1,650
Bluegrass Cross Connection Prevention Association						66		66
Commerce Lexington							5,862	11,894
Cynthiana-Harrison County Chamber of Commerce							135	270
Downtown Lexington Partnership								750
Frankfort Area Chamber of Commerce							865	865
Georgetown/Scott County Chamber of Commerce								625
Greater Lexington Apartment Association								371
Home Builders Association of Lexington			550					550
Jessamine County Chamber Commerce								550
Kentucky Association of Manufacturers								1,130
Kentucky Association of Manufacturers							1,245	1,245
Kentucky Association of Mapping Professionals								25
Kentucky Chamber of Commerce								10,000
Kentucky Engineering Center								132
Kentucky League of Cities		2,500						2,500
Kentucky Rural Water Association								500
Lexington Forum		350						350
National Association of Water Companies	4,957	4,957	4,957	4,957	4,957	4,957	4,957	79,319
Owen County Chamber of Commerce								500
Owenton Rotary Club								179
Paris-Bourbon County Chamber of Commerce						650		650
Rockcastle County Chamber of Commerce								100
Water Environment Federation			160					160
Winchester County Chamber of Commerce								500
Winchester County Chamber of Commerce				500				500
Woodford County Chamber of Commerce								520
Total	$5,678	$9,353	$6,388	$6,178	$5,678	$6,394	$13,785	$130,379

Kentucky-American Water Company
Company Dues/Memberships

Vendor	Legislative Advocacy	Regulatory Advocacy	Public Relations	Covered Activities %
American Water Works Association - Company	Yes	Yes	Yes	0%
American Water Works Association - Individuals	Yes	Yes	Yes	0%
Better Business Bureau	No	No	No	
Bluegrass Cross Connection Prevention Association	No	No	No	
Commerce Lexington	Yes	Yes	Yes	5%
Cynthiana-Harrison County Chamber of Commerce	No	No	No	
Downtown Lexington Partnership	No	No	No	
Frankfort Area Chamber of Commerce	Yes	Yes	No	
Georgetown/Scott County Chamber of Commerce	No	No	No	
Greater Lexington Apartment Association	Yes	Yes	Yes	12.28%
Home Builders Association of Lexington	Yes	Yes	No	
Jessamine County Chamber Commerce	No	No	No	
Kentucky Association of Manufacturers	Yes	Yes	Yes	0%
Kentucky Association of Manufacturers	Yes	Yes	Yes	0%
Kentucky Association of Mapping Professionals	No	No	No	
Kentucky Chamber of Commerce	Yes	Yes	Yes	15%
Kentucky Engineering Center	No	No	No	
Kentucky League of Cities	Yes	Yes	No	
Kentucky Rural Water Association	Yes	Yes	No	
Lexington Forum	No	No	No	
National Association of Water Companies	Yes	Yes	Yes	16%
Owen County Chamber of Commerce	No	No	No	
Owenton Rotary Club	No	No	No	
Paris-Bourbon County Chamber of Commerce	No	No	No	
Rockcastle County Chamber of Commerce	No	No	No	
Water Environment Federation	Yes	Yes	Yes	0%
Winchester County Chamber of Commerce	No	No	No	
Winchester County Chamber of Commerce	No	No	No	
Woodford County Chamber of Commerce	No	No	No	
Total				

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

97. Reference FR 16(8)(f), KAW_APP_EX37F_112818, Sch. F-5. Provide a breakout by name for each and every entity that falls within the categories: (i) "Legal;" (ii) "Accounting;" and (iii) "Other."

Response:

Please see attached.

Kentucky-American Water Company
Exhibit 37-F, Schedule F-5 Breakdown by Vendor

F5 Description	Vendor	Expense Breakdown	Rate Filing
Legal	Dickinson Wright PLLC	Legal Issues	
	Littler Mendelson PC	Legal Issues	
	STOLL KEENON OGDEN PLLC	Legal Issues & Rate Case	2015 & 2018 Rate Case
Accounting	American Water Works Service Co	Rate Case Preparation	2015 & 2018 Rate Case
	Price Waterhouse Coopers	Annual Audit	
Other	Gannett Fleming	Cost of Service	2015 & 2018 Rate Case
	Financial Strategy Associates	Rate of Return	2015 Rate Case
	Edward Spitznagel	Weather Normalization	2015 Rate Case
	Concentrict Energy Advisors	Rate of Return	2018 Rate Case
	Towers Watson	Compensation Study	2018 Rate Case
	Patrick Baryenbruch	Support Services Study	2018 Rate Case

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

98. Provide copies of the Annual Reports of every Dues Requiring Organization since the conclusion of Kentucky-American's last rate case.

Response:

The Company does not have possession of the Annual Reports for the Dues Requiring Organizations.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

99. State whether each Dues Requiring Organization provides a break-out of the dues that its members pay by operating expense category. For each Dues Requiring Organization that provides such a break-out, provide a copy of the most recent such break-out.

Response:

The Company does not have knowledge of the Dues Requiring Organizations breaking out dues by operating expense category.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

100. Provide any documents in Kentucky-American's possession that depict how each Dues Requiring Organization spends the dues it collects, including the percentage that applies to all covered activities.

Response:

The invoices from each Dues Requiring Organization, which are provided in the response to KAW_R_AGDR1_NUM104, show the percentage that applies to all covered activities. Otherwise, the Company does not have any other documents in its possession that depict how each Dues Requiring Organization spends the dues it collects.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

101. For each Dues Requiring Organization, provide: (i) the amount of dues KAWC paid during the base period; and (ii) the amount it is asking to be recovered from customers during the forecasted period. Provide the complete basis for KAWC's determination of whether dues should be recoverable or not recoverable.

Response:

Please see attached. Dues that are not utilized to pay "Covered Activities" should be recoverable.

Membership in professional groups and organizations allows employees to share industry knowledge and stay current in their field. Some employees also must maintain their professional credentials, and may do so through organization involvement and additional education activities in their fields. In addition, participation in local organizations allows the Company to stay connected with the communities it serves and its customers.

Kentucky-American Water Company
Company Dues/Memberships

Vendor	Base Year	Forecasted Period
American Water Works Association - Company	$11,390	$10,973
Better Business Bureau	1,650	1,590
Downtown Lexington Partnership	750	723
Georgetown/Scott County Chamber of Commerce	685	660
Greater Lexington Apartment Association	371	357
Home Builders Association of Lexington	550	530
Jessamine County Chamber Commerce	550	530
Kentucky Association of Manufacturers	1,130	1,089
Kentucky League of Cities	2,500	2,408
Kentucky Rural Water Association	500	482
National Association of Water Companies	16,657	16,047
Owen County Chamber of Commerce	500	482
Winchester County Chamber of Commerce	500	482
Woodford County Chamber of Commerce	520	501
Non-Dues Requiring Organizations	490	472
Total	$38,743	$37,326

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

102. Provide a copy of the formula(s) used to compute, and the actual calculation of the dues Kentucky-American paid to each Dues Requiring Organization since the conclusion of its last rate case.

Response:

The Company does not compute the amount of dues paid to each Dues Requiring Organization. Please refer to the response to KAW_R_AGDR1_NUM096 for the dollars paid since the conclusion of the last rate case.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

103. Is Kentucky-American relying upon any NARUC reports or other studies for the exclusion from or inclusion in rates of a portion of its dues payable to any Dues Requiring Organization? If so, please provide a copy of such report and indicate how the report's recommendations have been included in its filing.

Response:

The Company has not relied upon any particular reports or studies.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

104. Provide a complete copy of invoices received from each Dues Requiring Organization since the conclusion of Kentucky-American's last rate case.

Response:

Please see attached.

Kentucky-American Water Company
Company Dues/Memberships

Vendor	2017/09	2017/10	2017/11	2017/12	2018/01	2018/02	2018/03	2018/04	2018/05	2018/06	2018/07	2018/08	2018/09
American Water Works Association - Company	$704	$704	$704	$704	$721	$721	$721	$721	$721	$721	$721	$721	$721
American Water Works Association - Individuals			417						2,600				
Better Business Bureau	825										825		
Bluegrass Cross Connection Prevention Association													
Commerce Lexington					6,032								
Cynthiana-Harrison County Chamber of Commerce			135										
Downtown Lexington Partnership							750						
Frankfort Area Chamber of Commerce													
Georgetown/Scott County Chamber of Commerce							625						
Greater Lexington Apartment Association					371								
Home Builders Association of Lexington												550	
Jessamine County Chamber Commerce									550				
Kentucky Association of Manufacturers				1,130									
Kentucky Association of Manufacturers													
Kentucky Association of Mapping Professionals					25								
Kentucky Chamber of Commerce					10,000								
Kentucky Engineering Center					132								
Kentucky League of Cities											2,500		
Kentucky Rural Water Association				500									
Lexington Forum											350		
National Association of Water Companies	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957	4,957
Owen County Chamber of Commerce									500				
Owenton Rotary Club								179					
Paris-Bourbon County Chamber of Commerce													
Rockcastle County Chamber of Commerce							100						
Water Environment Federation												160	
Winchester County Chamber of Commerce	500												
Winchester County Chamber of Commerce													500
Woodford County Chamber of Commerce							520						
Total	$6,986	$5,661	$6,213	$7,291	$22,238	$5,678	$7,673	$5,857	$9,328	$5,678	$9,353	$6,388	$6,178

Kentucky-American Water Company
Company Dues/Memberships

Vendor	2018/10	2018/11	2018/12	Total	Attachment Page
American Water Works Association - Company	$721	$721	$721	11,461	1-2
American Water Works Association - Individuals				3,017	See P-Card data
Better Business Bureau				1,650	See P-Card data
Bluegrass Cross Connection Prevention Association		66		66	See P-Card data
Commerce Lexington			5,862	11,894	3-6
Cynthiana-Harrison County Chamber of Commerce			135	270	See P-Card data
Downtown Lexington Partnership				750	See P-Card data
Frankfort Area Chamber of Commerce			865	865	See P-Card data
Georgetown/Scott County Chamber of Commerce				625	7
Greater Lexington Apartment Association				371	8
Home Builders Association of Lexington				550	See P-Card data
Jessamine County Chamber Commerce				550	9
Kentucky Association of Manufacturers				1,130	See P-Card data
Kentucky Association of Manufacturers			1,245	1,245	10
Kentucky Association of Mapping Professionals				25	See P-Card data
Kentucky Chamber of Commerce				10,000	11-12
Kentucky Engineering Center				132	See P-Card data
Kentucky League of Cities				2,500	13
Kentucky Rural Water Association				500	See P-Card data
Lexington Forum				350	See P-Card data
National Association of Water Companies	4,957	4,957	4,957	79,319	14
Owen County Chamber of Commerce				500	15
Owenton Rotary Club				179	16-17
Paris-Bourbon County Chamber of Commerce		650		650	See P-Card data
Rockcastle County Chamber of Commerce				100	18
Water Environment Federation				160	See P-Card data
Winchester County Chamber of Commerce				500	19
Winchester County Chamber of Commerce				500	See P-Card data
Woodford County Chamber of Commerce				520	See P-Card data
Total	$5,678	$6,394	$13,785	$130,379	

Kentucky-American Water Company
P-Card Charges for Co Dues/Memberships

Company	Trans Date	Post Date	Amount	Trans ID	Vendor	GL Account	Transaction Note
1012	12/20/2018	12/21/2018	865.00	H380120181222pvfednnjq	Frankfort Area Chamber Of Commerce	52524000	Frankfort Chamber of Commerce Membership Dues
1012	11/15/2018	11/16/2018	66.00	H380120181117zbstbeehe	Bluegrass Cross Connection Prevention Association	52524000	Membership for BGCCPA
1012	11/14/2018	11/15/2018	135.00	H380120181116voshrvpqo	Cynthiana-Harrison County Chamber of Commerce	52524000	Cynthiana-Harrison County Chamber of Commerce membership dues
1012	11/5/2018	11/6/2018	650.00	H380120181107tgrnjordb	Paris-Bourbon County Chamber of Commerce	52524000	Paris Bourbon County Chamber membership Dues
1012	2/21/2018	2/22/2018	520.00	70426722	WOODFORD COUNTY CHAMBER	52524000	Membership renewal
1012	2/23/2018	2/26/2018	750.00	70557236	DOWNTOWN LEXINGTON CORP	52524000	Membership renewal
1012	4/28/2018	4/30/2018	1,300.00	73360735	AWWA.ORG	52524000	2018 Dues AWWA Partnership Treatment Program
1012	5/17/2018	5/17/2018	1,300.00	74173822	AWWA.ORG	52524000	2018 Dues AWWA Partnership Distribution Program
1012	9/7/2018	9/10/2018	500.00	H380120180911cesxezmfe	Winchester Clark County Chamber	52524000	Winchester Clark County Chamber membership dues
1012	7/31/2018	8/1/2018	550.00	H380120180802zkgadywgv	Hba Of Lexington	52524000	Membership dues
1012	7/25/2018	7/27/2018	160.00	H380120180728tlbnlofif	WEF Main	52524000	Membership dues
1012	7/20/2018	7/23/2018	825.00	H380120180724hglfddlei	Better Business Bureau	52524000	Membership dues
1012	6/18/2018	6/19/2018	350.00	H380120180620yhlttmndb	Lexington Forum	52524000	Lexington Forum membership dues
1012	11/1/2017	11/1/2017	206.00	66073123	AWWA.ORG	52524000	AWWA member dues 2017-2018
1012	11/13/2017	11/15/2017	132.00	66671887	KENTUCKY ENGINEERING CENTER	52524000	KSPE Membership Dues
1012	11/21/2017	11/22/2017	135.00	66973370	Cynthiana-Harrison County Chamber of Commerce	52524000	Cynthiana-Harrison County Chamber of Commerce mebership renewal
1012	11/23/2017	11/24/2017	211.00	67024674	AWWA.ORG	52524000	Membership renewal for Ellen Williams
1012	12/4/2017	12/6/2017	500.00	67395882	KENTUCKY RURAL WATER	52524000	Company membership for KY Rural Water Ass'n annual dues
1012	12/5/2017	12/6/2017	1,130.00	67395915	KAM KY ASSOC OF MFG	52524000	Kentucky Association of Manufacturers - Membership Dues
1012	12/5/2017	12/11/2017	25.00	67555757	KAMP	52524000	2018 Kentucky Association of Mapping Professionals membership dues
1012	8/29/2017	8/30/2017	825.00	63409247	BETTER BUSINESS BUREAU	52524000	Better Business Bureau Accredidation - Membership dues
		Total	11,135.00				

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

105. Provide a detailed description of the services each Dues Requiring Organization provided to Kentucky-American since the conclusion of its last rate case. Of these services or benefits, state which benefits accrue to ratepayers, and how.

Response:

Please see attached.

Kentucky-American Water Company
Company Dues/Memberships

Vendor	Description of Services	Benefit to the Ratepayers
American Water Works Association	The AWWA is an elite group of professionals who strive to create the best solution based approaches in the supply and protection of drinking water. Services provided include access to valuable tools, technical resources, training and publications, as well as discounts oon conferences, networking events, and initiatives with other water professionals.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Better Business Bureau	The BBB helps to advance marketplace trust and facilitate constructive interaction between consumers and businesses.	Consumer outreach and commitment to make a good faith effort to resolve consumer complaints.
Bluegrass Cross Connection Prevention Association	BGCCPA represents an alliance of individuals with the commone interest of protecting public water supplies by preventing unauthorized and possible dangerous connections.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Commerce Lexington	Commerce Lexington Inc. seeks to promote economic development, job creation, and overall business growth in Lexington and its neighboring communities, while strengthening its existing businesses through the many programs and services that the organization offers.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases.
Cynthiana-Harrison County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Downtown Lexington Partnership	The Downtown Lexington Partnership's mission is to make downtown Lexington a vibrant, economically vibrant urban core to positively affect the quality of life for those not only in downtown Lexington but throughout the community and region.	Community involvement and customer education.
Frankfort Area Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Georgetown/Scott County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Greater Lexington Apartment Association	This is a trade association for those in the multi-family housing industry and those who provide products and services to those in the industry. The association allows for education of members as well as knowledge sharing among members to better serve multifamily property owners and managers and their resdients.	Community involvement and customer education.
Home Builders Association of Lexington	The BIA is a trade association working to keep its members on the leading edge of the new home & commercial building and remodeling industry through networking, education, and industry advocacy.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Jessamine County Chamber Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Kentucky Association of Manufacturers	KAM's mission is to create and protect a manufacturing friendly environment in Kentucky. KAM educates, connects and provides cost saving products and programs to its members.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Kentucky Association of Mapping Professionals	KAMP's mission is to foster the understanding and improvement of the management and use of geospatial information throughout the Commonwealth of Kentucky in all levels of government, academia, and the private sector; and to provide a mechanism for dialogue and education regarding geospatial information issues of concern or interest to all Kentucky professionals involved in the collection, processing, analysis, use, and maintenance of geospatial information. KAMP provides education and a forum to actively promote issues pertaining to geospatial information.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Kentucky Chamber of Commerce	The Kentucky Chamber of Commerce supports a prosperous business climate in the Commonwealth of Kentucky and works to advance Kentucky through advocacy, information, program management and customer service in order to promote business retention and recruitment.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases

Kentucky-American Water Company
Company Dues/Memberships

Vendor	Description of Services	Benefit to the Ratepayers
Kentucky Engineering Center	The KEC serves as the professional home for Kentucky's engineers. The KEC hosts professional meetings and sessions with state leaders, and maintains a computer lab for technical training classes. The KEC houses the Board of Licensure for Engineers and Land Surveyors (KYBOELS) as well as the following organizations: Kentucky Society of Professional Engineers (KSPE), American Council of Engineering Companies of Kentucky (ACEC-KY), Kentucky Engineering Foundation (KEF).	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Kentucky League of Cities	The Kentucky League of Cities serves as the united voice of cities by supporting community innovation, effective leadership and quality governance.	Community involvement and customer education.
Kentucky Rural Water Association	KRWA is the largest utility organization of the state. KRWA's goal is to foster professionalism in the industry through non-regulatory training, technical assistance programs, and advocacy. KRWA is an affiliate of the National Rural Water Association (NRWA), the largest water and wastewater utility membership organization in the nation.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Lexington Forum	The Lexington Forum is an organization dedicated to facilitating monthly educational, ommunity conversations about key issues affecting the community so that members can be better engaged and impactful.	Community involvement and customer education.
National Association of Water Companies	Together with its members, NAWC engages with others looking for new solutions to water-related challenges, including aging water infrastructure, limited water supply, and budget deficits that are preventing much-needed investment in the people, technology and facilities required to help ensure reliable water and wastewater services across the country. Through its state and regional chapters, NAWC works closely with legislators at every level of government and support public policies that increase public and private investment in water infrastructure.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Owen County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Owenton Rotary Club	The Owenton Rotary Club members meet to learn about community issues and challenges in the community, discuss how to address them and work together to take action.	Community involvement and customer education.
Paris-Bourbon County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Rockcastle County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Water Environment Federation	The WEF is a not-for-profit technical and educational organization representing water quality professionals around the world. Its mission is to connect water professionals; enrich the expertise of water professionals; increase the awareness of the impact and value of water; and provide a platform for water sector innovation. WEF provides water quality professionals with the latest in water quality education, training, and business opportunities.	Professional development; more efficient and effective service through knowledge of latest trends and techniques.
Winchester County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases
Woodford County Chamber of Commerce	Advocates for members, promotes and enhances community.	Joint-effort to bring business and industry to improve the local economy and ultimately reduce rate increases

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

106. State whether Kentucky-American is aware of whether any portion of the dues it pays to any Dues Requiring Organization is utilized to pay for any Covered Activities.

Response:

The portion of the dues that is utilized to pay for Covered Activities that the company is aware of, has been provided in the responses to KAW_R_AGDR1_NUM096 and KAW_R_AGDR1_NUM104.

KENTUCKY-AMERICAN WATER COMPANY
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ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

107. List all travel and entertainment expenses that Kentucky-American employees incurred in the base period and are included in the forecast period, or that are expected to be incurred and included in the forecast period, in relation to Dues Requiring Organization activities. Show accounts, amounts, descriptions, person, job title and reason for the expense. Provide a copy of applicable employee time and expense reports and invoices documenting such expenses.

Response:

Please see attached p-card purchases for employee related expenses related to Dues Requiring Organization activities. The Company does not track the activities on employee time reports.

Kentucky-American Water Company
Travel & Entertainment Expense in Relation to Dues Requiring Organizations

Job Title	Trans Date	Post Date	Amount	Vendor	GL Account	Account Description	Transaction Note
Dir Engineering	4/18/2018	4/20/2018	$661	AMERICAN AIR0017137701640	52534000	Employee Expenses	Airline Reservation for AWWA Conference
Dir Engineering	4/24/2018	4/25/2018	910	AWWA EVENTS	52534000	Employee Expenses	Reservation for AWWA National Conference
VP Operations	4/29/2018	4/30/2018	7	MARKET FRESH LEX	52535000	Meals Deductible	Beverage at airport on way to NAWC conference in New Orleans
VP Operations	4/29/2018	4/30/2018	16	MARKET FRESH LEX	52535000	Meals Deductible	Breakfast at airport on way to NAWC conference in New Orleans
VP Operations	4/28/2018	4/30/2018	15	DELTA AIR SEAT FEES	52534000	Employee Expenses	Upgrade to exit row seat on way to NAWC conference in New Orleans
VP Operations	4/29/2018	4/30/2018	53	UBER TRIP AIHWT	52534000	Employee Expenses	Ride from airport to hotel in New Orleans while attending NAWC Conf in New Orleans
VP Operations	4/29/2018	4/30/2018	25	DELTA AIR BAGGAGE FEE	52534000	Employee Expenses	Baggage fee - NAWC Conference in New Orleans
VP Operations	4/29/2018	4/30/2018	5	BROTHERS FOOD MART 109	52534000	Employee Expenses	Beverage expense while attending NAWC Conference in New Orleans
VP Operations	4/29/2018	5/1/2018	19	KIOSKS - 87	52535000	Meals Deductible	Lunch in airport while traveling to New Orleans for NAWC Conference
VP Operations	5/1/2018	5/2/2018	297	RENAISSANCE HOTELS PER	52534000	Employee Expenses	Hotel expense 4/29 while attending NAWC conference in New Orleans
VP Operations	5/1/2018	5/3/2018	6	NEW ORLEANS AIRPORT	52535000	Meals Deductible	Snack at airport on way back to Lexington from NAWC conference in New Orleans
VP Operations	5/1/2018	5/3/2018	25	DELTA AIR BAGGAGE FEE	52534000	Employee Expenses	Baggage fee while returning from NAWC conference in New Orleans
VP Operations	5/1/2018	5/3/2018	30	RPS LEXINGTON	52534000	Employee Expenses	Airport parking expense while attending NAWC conference in New Orleans
VP Operations	5/2/2018	5/3/2018	234	RENAISSANCE HOTELS PER	52534000	Employee Expenses	Hotel expense for 4/30 while attending NAWC conference in New Orleans
Dir Engineering	6/10/2018	6/11/2018	9	Pp*odschauffeuredtrans	52534000	Employee Expenses	Purchase ODS chauffeured transportation - Transfer from airport to hotel for AWWA Conf
Dir Engineering	6/12/2018	6/12/2018	20	Uber Trip Jlidn	52534000	Employee Expenses	Purchase Uber Ride during AWWA Conference
Dir Engineering	6/14/2018	6/18/2018	1,346	Mandalay - Front Desk	52534000	Employee Expenses	Mandalay Delano Hotel Stay (4 nights) during AWWA Conference
Manager WQ & Env Compliance	7/8/2018	7/9/2018	400	Ky Tn Water Profession	52534200	Conferences & Registration	registration KY TN AWWA Conf
Manager WQ & Env Compliance	7/10/2018	7/11/2018	18	Pucketts Grocery	52535000	Meals Deductible	meal AWWA Ky Tn Conf
Supt Opns	7/10/2018	7/11/2018	15	Pucketts Grocery	52535000	Meals Deductible	Meal while at AWWA KY/TN WPC Conference
Supt Opns	7/11/2018	7/12/2018	191	Enterprise Rent-A-Car	52534000	Employee Expenses	Rental car for AWWA KY/TN Section WPC
Supt Opns	7/11/2018	7/12/2018	6	McDonalds F12878	52535000	Meals Deductible	Meal while traveling to AWWA KY/TN Section Board Meeting
Manager WQ & Env Compliance	7/12/2018	7/13/2018	976	Renaissance Hotels Nas	52534000	Employee Expenses	Lodging AWWA Ky Tn Conf
Supt Opns	7/11/2018	7/13/2018	1,455	Hilton Nashville Dwntn	52534000	Employee Expenses	Hotel expense while attending AWWA KY/TN WPC
Supt Opns	7/11/2018	7/13/2018	7	Starbucks Store 08349	52535000	Meals Deductible	Meal while attending AWWA KY/TN Section WPC
Supt Opns	7/19/2018	7/23/2018	9	Starbucks Store 13975	52535000	Meals Deductible	Meal while attending AWWA KY/TN Section WPC
Spec Ext Affairs	8/21/2018	8/22/2018	15	Paypal	52535000	Meals Deductible	Georgetown Scott County Chamber Luncheon
Mgr Ext Affairs	8/21/2018	8/22/2018	15	Paypal	52535000	Meals Deductible	Georgetown Scott County Chamber Luncheon: Susan Lancho
Mgr Opns	8/27/2018	8/28/2018	10	Parc-Parking Authority O	52534000	Employee Expenses	Parking Rural Water Conference
Mgr Opns	8/27/2018	8/28/2018	125	In *kentucky Rural Water	52534200	Conferences & Registration	Registration Rural Water Conference
Mgr Opns	8/27/2018	8/29/2018	51	Galt H - Cafe Magnolia	52535000	Meals Deductible	Lunch Sensabaugh and a water utility guest Rural Water Conference
Engineering Technician	8/28/2018	8/30/2018	250	Kamp	52534000	Employee Expenses	2018 KAMP (Kentucky Association of Mapping Professionals) Conference registration.
Engineering Technician	8/30/2018	8/31/2018	473	Priceline*hotel Rooms	52534000	Employee Expenses	Hotel accommodations for 2018 KAMP Conference
Admin Asst - Staff Supp	9/17/2018	9/18/2018	15	Paypal	52535000	Meals Deductible	Scott County Chamber luncheon - Ellen Williams
Dir Govt Affairs	9/18/2018	9/20/2018	6	Arbys	52535000	Meals Deductible	Kentucky League of Cities Conference lunch: James Keeton
Dir Govt Affairs	9/19/2018	9/20/2018	262	Enterprise Rent-A-Car	52534000	Employee Expenses	KY League of Cities Conference rental car: James Keeton
Dir Govt Affairs	9/19/2018	9/21/2018	40	Shell Oil 10009101006	52534000	Employee Expenses	Fuel for rental car: KY League of cities Conference
Dir Govt Affairs	9/20/2018	9/21/2018	190	Marriott Louisville	52534000	Employee Expenses	KY League of Cities Conference Hotel: James Keeton
Engineering Technician	10/22/2018	10/24/2018	14	Enterprise Car Tolls	52534000	Employee Expenses	Toll Charges
Engineering Technician	10/22/2018	10/24/2018	29	Shell Oil 10011459004	52534000	Employee Expenses	Fuel for Rental Car to go to Bowling Green for Annual KAMPRO Conference
Engineering Technician	10/24/2018	10/26/2018	14	Courtyard Bowling Gree	52534000	Employee Expenses	Breakfast on 10/24/2018 while at the 2018 KAMP Conference in Bowling Green.
Supvr Cross Connection	10/31/2018	11/1/2018	50	Kytn Section Awwa	52534200	Conferences & Registration	registration Ky Tn AWWA Non Revenue Workshop
Engineering Technician	12/3/2018	12/5/2018	25	Kamp	52534000	Employee Expenses	Annual Kentucky Association for Mapping Professionals (KAMP) membership dues.
Engineering Project Manager	12/19/2018	12/19/2018	211	Awwa.Org	52534000	Employee Expenses	AWWA KYTN dues for 2019
		Total	$8,551				

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock / Kevin Rogers

108. Do any of Kentucky-American's personnel actively participate on committees and/or perform any other work for any Dues Requiring Organization or any other industry organization to which the KAWC belongs?

a. If so, state specifically which employees participate, how they are compensated for their time (amount and source of compensation), and the purpose and accomplishments of any such association related work.

b. List any and all reimbursements received from industry associations, for work performed for such organizations by Kentucky-American employees.

Response:

(a and b).

Many of KAW's personnel participate in various community and civic organizations, but KAW does not track every single effort or participation each of its employees undertake for organizations such as the Red Cross or the Y organizations. Having said that, see the attached which identifies KAW employee participation on committees or boards of organizations that are directly related to the water industry. Additionally, although not tracked specifically, KAW states that it is aware that two of its employees participated in Commerce Lexington's Winners Circle fundraiser and they received a total of $240 for their efforts.

Kentucky American Water
Community Board Committee Engagement

Employee	Department	Organization	Involvement	Category
Bridwell, Linda	Rates and Regulation	Kentucky Infrastructure Authority	Representative, investor-owned utilities	Industry Advancement
Caudill, Amy	Customer Advocacy	AWWA KY/TN	Committee Chair	Diversity Community
Citron, Krista	Engineering	Kentucky Stormwater Association	Vice President/Secretary	Environment
Jackson, Jarold	Field Operations	Kentucky 811	Board Member	Community Development
Johnson, Dottie	Water Quality	AWWA KY/TN Section	Member, Operations Water Quality Committee	Industry Advancement
Lancho, Susan	External Affairs	AWWA KY/TN Section	Member, Public Affairs Committee	Industry Advancement
Rogers, Kevin	Operations	Kentucky Water Resources Board (DOW)	Board Member	Industry Advancement
Rogers, Kevin	Operations	Kentucky River Authority	Board Member	Community Development
Rogers, Kevin	Operations	Kentucky Water Utility Council (AWWA)	Board of Directors, Executive Committee	Community Development
Sensabaugh, Justin	Production	Drinking Water Advisory Council Work Group (DOW)	Member	Health and Wellness
Sensabaugh, Justin	Production	Water Utility Advisory Committee (ORSANCO)	Member	Industry Advancement

KENTUCKY-AMERICAN WATER COMPANY
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Witness: James S. Pellock

109. Reference Exhibit 37, Sch. F-3. Provide KAWC's justification for including the advertising expenses identified therein for recovery from ratepayers during the forecasted period.

Response:

Kentucky American is not including advertising expenses shown in Exhibit 37, Sch. F-3, in the rate case. Please see W/P – 3-17 for the adjustment to remove these costs from the Forecast Year. There are no expenditures in the cost of service for promotional activities, political advertising, or institutional advertising.

Customers benefit from the Company's messaging around conservation, customer education and safety. These outreach efforts provide information about how customers can reduce their bills or conserve water, how bills are rendered, as well as how the company's operations maintain or improve service. Such costs are included in the cost of service as part of Miscellaneous Expense (Pellock direct testimony, page 14).

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ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

110. Reference Exhibit 37, Sch. F-2.3. Provide KAWC's justification for including the employee service award expenses identified therein for recovery from ratepayers during the forecasted period.

Response:

A service award is an opportunity to recognize an employee for their longevity with the company. The award and recognition serves as an incentive to retain employees that are recognized for their service. The cost of a service award is much less than the cost to hire and train a new employee to replace an employee that has left the Company. The dollar amount requested for recovery is $13,293. Please see W/P – 3-1b.

KENTUCKY-AMERICAN WATER COMPANY
CASE NO. 2018-00358
ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

111. Reference Exhibit 37, Schedules F-1, F-2.1 and F-2.2. Confirm whether any of the donations identified in Schedules F-1 and F-2.1 are being included for recovery from ratepayers.

Response:

No donations in Schedules F-1 and F-2.1 are being included for recovery from ratepayers. Please see W/P – 3-20 for adjustment to remove Charitable Contributions from Forecasted Year Miscellaneous Expense.

KENTUCKY-AMERICAN WATER COMPANY
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ATTORNEY GENERAL'S FIRST REQUEST FOR INFORMATION

Witness: James S. Pellock

112. Reference Exhibit 37, Sch. F-7. State whether KAWC is seeking recovery of the $130,812 in civic activities during the forecasted period from ratepayers. If so, provide KAWC's justification.

Response:

Yes, KAWC is seeking recovery of the civic activities during the forecasted period from ratepayers.

Civic activities expenses are a necessary expense of doing business in the community in which KAWC is located. As a corporate citizen, there is an unstated obligation to support civic activities in the community. Company support of civic organizations builds a congenial relationship, or goodwill, between the community and the business. KAWC's customers benefit from the Company's support of civic organizations such as public parks, local commerce commissions and public schools, all in the interest of community betterment.