Investment in America's Drinking Water Infrastructure: Benefits, Financing Mechanisms, and Best Practices

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Table of Contents

Foreword

There is a huge but largely unrecognized need to find ways to more easily finance potable water delivery systems in the United States. The American Society of Civil Engineers' 2017 Infrastructure Report Card assigned a grade of D for U.S. water infrastructure. Quoting from the Water Infrastructure Report Card Overview, "Drinking water is delivered via one million miles of pipes across the country. Many of those pipes were laid in the early to mid-20th century with a lifespan of 75 to 100 years. The quality of drinking water in the United States remains high, but legacy and emerging contaminants continue to require close attention. While water consumption is down, there are still an estimated 240,000 water main breaks per year in the United States, wasting over two trillion gallons of treated drinking water. According to the American Water Works Association, an estimated $1 trillion is necessary to maintain and expand service to meet demands over the next 25 years."[1]

This report targets that need. The American Concrete Pressure Pipe Association is pleased to have had the opportunity to work with the College of William & Mary's Public Policy Program to complete this study. I believe leaders in industry, government, and academia will find it to be of considerable value. In addition to providing a comprehensive overview of the various financing tools available to support drinking water infrastructure investment, the report examines factors that mitigate their use by water system owners and explores both the economic and public health benefits associated with drinking water investment.

I hope that as the national debate over how to significantly increase investment in all forms of infrastructure plays out in the coming months, policymakers will use the findings of this report to help understand what the system needs, how to improve financing and funding tools, and how to articulate the benefits of rebuilding America's drinking water infrastructure. I hope our members will also take the findings of this study to heart and renew their commitment both to advocacy in support of additional investment and also to working with the water providers to help access all the financing tools available to them.

On behalf of ACPPA and its members, thank you to Spencer Murray, Daniel Aboagye, and Amanda Luketich for their excellent work on this study and to long-time ACPPA team members Christian Klein and Brett Levanto (who are also members of the W&M Public Policy Advisory Board) for working closely with the research team and facilitating the study's completion.

[1] American Society of Civil Engineers, Water Infrastructure Report Card Drinking Water Overview (2017). http://www.infrastructurereportcard.org/cat-item/drinking-water/

Thanks also to Professor John Gilmour, the program's director, for allowing us to undertake this research and to Professor Brian Beach for advising the research team.

Richard I. Mueller, P.E.
President
American Concrete Pressure Pipe Association
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N.B. Although ACPPA is proud to have initiated and supported this project, the findings and conclusions are those of the researchers and opinions expressed may not reflect those of ACPPA or its members.

I. Executive Summary

There is a severe pattern of underinvestment in water infrastructure across the United States. It is estimated that as much as $1 trillion will be needed to meet the needs of a growing society and repair our rapidly crumbling system. Adequate financing will be essential to keeping pace with this need for investment. This report provides an overview of the currently available sources of financing and distills available literature and interviews with water structure owners to offer a set of best practices for financing water infrastructure. Additionally, this report assesses the return on investment for funds spent on water infrastructure improvements with a unique focus on quantifying the public health benefits of those investments.

A. Current System

The current system for funding upgrades and expansions to drinking water infrastructure relies heavily on user-fees and the operating and maintenance budgets of water structure owners. Because of the large need for investment and low price of water to maintain affordability, this system does not provide enough funding to meet existing needs for upgrading and expansion.

Aside from the inadequacy of funding from current sources, in many cases water infrastructure owners do not know what their maintenance and expansion needs are. No standard auditing practices exist across the industry and, as such, it is the responsibility of water structure owners to develop their own monitoring and evaluation methods. For those water structure owners that are aware of their needs, there are often higher priorities to which funding is directed, leaving water systems to age past their useful lifespan.

B. Federal and State Funding Options

On the Federal level, a number of agencies offer loan or grant programs in support of water infrastructure including the Environmental Protection Agency (EPA), U.S. Departments of Agriculture and Housing and Urban Development (HUD) and the Bureau of Reclamation. However, our research finds that these programs are underutilized in large part because municipalities lack the technical or financial capacity or willingness to plan for a loan or meet stringent regulations.

This report also reviews the types of funding and financing offered at the state level. Grant programs, which appeal to debt-wary public officials, are the most popular. These are followed to a lesser extent by loan programs and, in a small number of states, dedicated revolving loan funds.

C. Best Practices

This report reviews a comprehensive sample of the current literature on financing mechanisms, combining these findings' qualitative information from interviews with water structure owners to synthesize a set of practices that most often lead to successful financing. These include:

- Tax-exempt bonds: Our research suggests that tax exempt bonds are the most popular and cost-effective financing mechanism for municipalities. However, access to low-interest

bonds as a method of financing depends on the economic stability of a municipality and thus may be out of reach of cities with low credit ratings.

- Promoting Collaboration: Our research found that municipalities and water structure owners are more successful when they work together. Creating consortia of public or private partners allows localities to build their technical capacity and increase the efficiency of their cost-models.
- Blending Funding and Financing: It is difficult for any one source to address extreme underinvestment. Combining a rate-based funding scheme with financing at the local, state, or federal level increases the feasibility of water infrastructure projects.

D. Return on Investment

This report presents an analysis of the economic impact of water infrastructure spending in two ways: pure economic impacts and public health impacts. The first is a measure of the economic activity that is generated when governments invest in water infrastructure. This report finds that each dollar invested in water infrastructure generates between $0.40 and $2.20 in economic activity. Public health impacts are analyzed in two ways: prevention of common waterborne diseases and reduction in lead content. A panel of specific diseases is used to estimate the value of preventing some common waterborne illnesses; lead content in drinking water is connected to a reduction in lifetime earnings via the detrimental effect lead has on human development. Our analysis finds that investment in water infrastructure generates between $142 and $1,438 in public health benefits per dollar spent.

E. Next Steps

There are several ways for water infrastructure advocates to leverage these findings:

- Urge Congress to maintain and expand tax-exempt financing and promote collaboration.
- Urge water structure owners to assess the condition of their infrastructure and plan for improvements.
- Request that the Government Accountability Office (GAO) investigate the effectiveness of federal financing options.

F. Conclusion

This report contributes to the literature on water infrastructure financing in several key ways. It identifies fundamental flaws in the federal financing landscape and uncovers ways in which municipalities have succeeded in investing despite the challenges. It also presents a new perspective on the return in investment associated with water infrastructure, revealing that the public health value of investment is substantial and worth taking into account when formulating policy.

II. Introduction

In 2010, it was estimated that every two minutes, a significant water line ruptures in the United States.[2] This translates to an estimated 240,000 water main breaks per year. These ruptures are symptomatic of the broader, ailing state of water infrastructure in the country.

Much of America's water treatment and delivery infrastructure was built in the mid-20th century and has since never been rehabilitated or replaced. Utilities across the country only replace components of their systems at a rate of approximately 0.5% per year. Based on the average useful lifespan for pipes, it is estimated that at the current pace of maintenance, it will take 200 years to replace the water system that is currently in place. This timeline far exceeds the lifespan of most pipes. Those that are left unmaintained past their useful lifespan pose a significant threat to the quality and availability of clean water in the country, as well as to the structures and roadways over and near the pipes. Water pipes across the country typically have a lifespan of somewhere between 15-100 years, depending on many factors, including "soil conditions, pipe material, climate and capacity requirements".[3] Even with long lifespans, many pipes nationwide have been in the ground long past their useful and safe life.[4] Moreover, our current system is woefully inefficient, wasting as much as 14-18% of treated drinking water every day because of old and leaky pipes.[5]

> ***Funding versus financing: What's the Difference?***
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> By funding, we mean direct sources investment that need not be repaid, including grants and other investment included in government budgets. Financing means mechanisms that facilitate borrowing to fund system upgrades and expansion.

Much of the poor condition of America's water infrastructure can be blamed on insufficient financing mechanisms for improving and replacing water systems. For decades, localities have relied primarily on rate-based financing schemes to pay for water infrastructure improvements. According to the American Water Works Association, it will require at least $1 trillion in additional investment to bring the system up to par with the needs of a growing society.[6] While several sources of funding and financing exist for these projects on the federal and state level, it is not feasible for many localities to avail themselves of these resources due to an unwillingness or inability to take on new debt. The current financing regime for water infrastructure places the onus on localities to raise funds for their own water projects.

This report seeks to examine the current state of water infrastructure funding and financing in the United States with particular emphasis on localities and municipalities. The report outlines the available sources of funding and financing and explores how water system owners are currently choosing to pay for their expansion and improvement projects. The unsustainable nature of the current financing structure is highlighted by this analysis and we explore several alternatives. Through this investigation, we are able to distill a common set of best practices for water infrastructure financing. Among these best practices is the availability of tax exempt bonds and

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[2]Duhigg, Charles. "Toxic Waters - Saving U.S. Water and Sewer Systems Would Be Costly." *New York Times*. March 14, 2010. http://www.nytimes.com/2010/03/15/us/15water.html.
[3]Water, EPA Office of. "The Clean Water and Drinking Water Infrastructure Gap Analysis." Washington, DC, 2002. https://nepis.epa.gov/Exe/ZyPDF.cgi/901R0200.PDF?Dockey=901R0200.PDF.
[4]Ibid; American Water Works Association. "Buried No Longer: Confronting America's Water Infrastructure Challenge," 2011. http://www.awwa.org/Portals/0/files/legreg/documents/BuriedNoLonger.pdf.
[5]Ibid.
[6]Ibid.

debt-free financing, as well as increased collaboration between localities and the use of blended funding and financing structures. Additionally, we provide qualitative case interviews from a sample of localities across the country which reinforce the concepts uncovered in the literature.

In order to quantify the value of investment in water infrastructure, this report projects the return on investment for each dollar spent on water projects. In doing so, the economic multiplier effects and public health benefits of water infrastructure improvements are considered separately. By examining these figures independently, we are able to capture the large difference between the two— an indication that public health returns are substantial when it comes to investment in water infrastructure. This report concludes by synthesizing these findings into a cohesive recommendation that states and municipalities consider the significant public health gains from investments in water infrastructure when planning their investments in the built environment over the coming decades.

III. The Current System of Water Infrastructure Financing

A. Who Are Water Structure Owners?

Water structure owners can be public entities, including localities and special districts.

- Localities include county, municipal and townships governments.
- Special districts are special purpose governmental units that have a good deal of independence in their decision making.[7] These special districts are often regional efforts and include several localities.

Water structure owners can also be privately held companies.

B. How Do Owners Pay for Updates and Expansions?

Currently, most public water structure owners pay for necessary upgrades and expansions of drinking water infrastructure with user-fees and their general operations and management budgets.[8]

C. The Current Funding System Is Unsustainable

User-fees and operational budgets do not generate enough money to properly maintain and upgrade drinking water infrastructure. In the American Water Works Association's (AWWA) 2017 State of the Water Industry Report, only 17% of utility respondents to AWWA's annual survey believed they would be able to cover the cost of existing services through user-fees.[9] This is especially problematic considering that as infrastructure systems age, they will require more maintenance and therefore the funding necessary to maintain them will continue to increase.[10] AWWA has estimated the need for over a trillion dollars in investment for replacement and expansion of drinking water infrastructure over the next two decades.[11] According to AWWA's *Buried No Longer* report, the amount of investment needed to pay for necessary upgrades would require "in the most affected communities… [to] triple household water bills".[12] Even with the EPA's more conservative investment needs estimate of $384.2 billion between 2011 and 2030,[13] the necessary level of funding simply cannot be met by intentionally low, highly-regulated user fees and operations and maintenance budgets in which water infrastructure is just one of many competing needs.

While there have been calls for simply raising the rates for water, this analysis has not found that to be a compelling option.[14] One primary reason user-fees will never suffice to pay for

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[7]Siegel, Gilbert B. "Special District | United States Government." Encyclopedia Britannica , 2017. https://www.britannica.com/topic/special-district.
[8]Locality interviews; EPA Office of Water. "The Clean Water and Drinking Water Infrastructure Gap Analysis."
[9]American Water Works Association. "2017 State of the Water Industry Report," 2017. https://www.awwa.org/Portals/0/files/resources/water utility management/sotwi/AWWA2017SOTWI.pdf
[10]EPA Office of Water. "The Clean Water and Drinking Water Infrastructure Gap Analysis."
[11]American Water Works Association. "Buried No Longer: Confronting America's Water Infrastructure Challenge."
[12]Ibid.
[13]Leighton, Jeff, Kurt Vause, Celine Hyer, Annie Vanrenterghem Raven, Kevin Campanella and John J. Galleher. "Committee Report: Business Practices to Help Utilities Better Manage Assets." *Journal of American Water Works Association*, 108, no. 1 (January 1, 2016): 61–67. https://doi.org/10.5942/jawwa.2016.108.0017
[14]Duhigg, Charles. "Toxic Waters - Saving U.S. Water and Sewer Systems Would Be Costly."

infrastructure is the paradox of the price of water. This issue has been plaguing the water industry since the beginning, as evidenced in Charles Haskin's article in the AWWA Journal from 1933, in which he famously notes "the profits in water-works operation are more of a social than financial nature".[15] From the perspective of water structure owners, it may appear that water is severely underpriced. Across the country water structure owners are not raising enough money from user-fees to pay for updates and expansion, but from the perspective of water users, it is very expensive. It is this paradox that makes the user-fee system alone an unsustainable model for financing infrastructure needs.

Issues of affordability have made increasing user rates to meet infrastructure needs very difficult.[16] Tracy Mehan and Ian Gansler note in an article in the *Journal of the American Water Works Association* (JAWWA) that "on average, water rates are increasing several times the rate of inflation."[17] This trend, coupled with the fact that personal incomes are not rising with these costs, means consumers cannot afford to pay for the massive increase that would be necessary to cover infrastructure costs. Even if rates were raised in an attempt to cover necessary costs, there will be a (potentially growing) sector of the population that will need assistance programs and those programs will require subsidies from some level of government.[18] Unfortunately, subsidies and public assistance programs in general, are not popular in the current political climate. More troublingly, the funds to back them often do not exist. Much like the operations and maintenance budgets, localities have to choose where to spend their limited financial resources.[19] To realistically meet needs, water structure owners would need to raise rates by "several hundred percent" over the next several years and by 2020 or 2030 at least 5% of the average household income will need to be spent on water and wastewater services.[20]

In addition, to protect consumers and their right to access water, user-fees are highly regulated by the government. To increase rates, water structure owners must often receive permission from the controlling government body, which in turn must answer to the customers (i.e., voters).

Another consideration is that often when rates are raised, consumers conserve water, which can lead to no gains in profits.[21] Studies have shown that "the price elasticity of water demand varies significantly among customer groups."[22] This means there are customers who can afford to conserve water when prices rise, for example by getting water-efficient household items, and the burden of the rising cost will then fall disproportionately on those who cannot or do not conserve.

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[15]Charles Haskins Haskins, Charles A. "Water, Cheaper Than Dirt." *Journal of American Water Works Association*, 25, no. 1 (1933): 87–93. https://doi.org/10.2307/41225823

[16]Black and Veatch. "Strategic Directions Water Industry Report: 2017," 2017. https://www.bv.com/docs/sdr/sdr-water-industry.pdf?mkt_to

[17]Mehan, III G. Tracy and Ian D. Gansler. "Addressing Affordability as a Necessary Element of Full-Cost Pricing." *Journal of American Water Works Association*, 109, no. 10 (2017): 46–50. http://aquadoc.typepad.com/files/affordability_full-cost_pricing_jawwa20o2017.pdf.

[18]Baird, Gregory M. "Water Affordability: Who's Going to Pick up the Check?" *Journal of American Water Works Association* 102, no. 12 (December 1, 2010): 16–23. https://www.awwa.org/publications/journal-awwa/abstract/articleid/26092.aspx.

[19]Ibid.

[20]Ibid, 23.

[21]Oelmann, Mark, Christoph Czichy and Norbert Jardin. "Water Worldwide -- New Water Pricing Models Respond to Decreasing Demand in Germany." *Journal of American Water Works Association*, 108 (January 1, 2016): 20–23. https://doi.org/10.5942/jawwa.2016.108.0024.

[22]Ibid.

D. Is Adjusting the Price Model the Answer?

One proposed solution to the problem of user-fees being too low to cover costs is introducing an adjusting price model. This model would decrease the price for the water used, but increase the fixed cost for each customer.[23] To ensure equity in pay allotment, the fixed cost still must represent the estimated amount of usage by each customer.[24] While this may one day be a fix, it is not currently a practical solution. There is currently no model to successfully accomplish this and finding the balance to ensure equity in the financial burden will be difficult. If there is a successful case of this model being used, it may become a viable option.

There has been a recent push to find innovative sources of revenue, for example leasing space on water towers or selling grid services to the electric utility, but it is unlikely these mechanisms will provide the necessary revenue to meet infrastructure needs.[25]

Regardless of how the new infrastructure is paid for, there will be an increased burden on the community, but there are more efficient methods than relying solely on user-fees.

E. Why Water Infrastructure Cannot be Funded Solely with Savings and Cash

While most water structure owners have capital improvement plans, water infrastructure often competes with a long list of other priorities. Since water infrastructure is generally invisible to the average citizen and their elected representatives, it is not high on the list. As evidenced by the interviews conducted for this study, water infrastructure is not a priority for locality owners. Even if money is set aside to update pipes, a model of "paying as you go" with user-fees does not produce enough capital for the large projects required to update the current water infrastructure.[26] This is also evidence in the interviews that water structure owners all took out some type of financing for large projects.

It may require decades for water structure owners to build up enough capital for larger projects.[27] For water infrastructure, the slow and steady pace of a replacing pipe piecemeal is akin to a large project and this may mean leaving the public vulnerable to increased levels of lead and other toxins in the water. Additionally, the longer we wait to invest and replace pipe, the costlier it will become.[28] Previous studies have found that this type of "pay as you go" model is more successful as a complement to debt financing, rather than an alternative.[29]

There are other things policymakers should keep in mind. First, there are regional differences in replacement needs.[30] According to AWWA's *Buried No Longer Report*, the greatest needs will

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[23]Ibid.
[24]Ibid.
[25]United States Environmental Protection Agency. "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers." Washington, DC, 2017. https://www.epa.gov/sites/production/files/2017-09/documents/financial_leadership_practices_document_final_draft_9-25-17_0.pdf.
[26]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future." Washington, DC, 2015. https://icma.org/sites/default/files/307554_15-08 Municipal Bonds and Infrastructure Development_web updated.pdf.
[27]Ibid.
[28]American Water Works Association. "Buried No Longer: Confronting America's Water Infrastructure Challenge."
[29]Wang, Wen, Yilin Hous and William Duncome. "Determinants of Pay-as-You-Go Financing of Capital Projects: Evidence from the States." *Public Budgeting & Finance* 27, no. 4 (December 1, 2007): 18–42. https://doi.org/10.1111/j.1540-5850.2007.00892.x.
[30]American Water Works Association. "Buried No Longer: Confronting America's Water Infrastructure Challenge."

be in the areas that are growing most rapidly, namely the South and the West.[31] This creates a challenge because, although pipes are fixed, the populations supporting them are "mobile and dynamic."[32] There are also differences based on the size of the water system.[33] AWWA's *Buried No Longer* asserts that "smaller communities may face steeper challenges" because they have smaller populations and often are more spread-out, which will lead to heavier costs on the small populations for replacement.[34]

F. Water Structure Owners Do Not Know Their Infrastructure Needs

One problem across the country is that many water structure owners are unaware of what their needs are for upgrading and replacement. Before financing mechanisms can be identified and employed, owners need to know what their drinking water infrastructure system looks like and how it needs to be updated.

AWWA's *2015 State of the Water Industry Report* found that the health of the water sector declined from previous years and that it is expected to continue to decline over the next five years.[35] AWWA's Asset Management Committee believes this decline can be directly attributed to the lack of asset management on the part of water structure owners.[36] According to the McGraw-Hill report on asset management, one of the main drivers for improving asset management is "the need to upgrade, repair and replace aging infrastructure".[37]

One example of why proper assessment and management of water infrastructure is important comes from Andrew Chastain-Howley et al.'s paper in JAWWA, *Outsmarting Costly Water-Loss Culprits*. The study found that the Florida Keys Aqueduct Authority was losing over $2.6 million a year just from leaks and other water losses and proper asset management could lead to recovery of more than half of that loss.[38] Similarly, according to the Center for Neighborhood Technology, in the Great Lakes area alone more than 66.5 billion gallons of water are leaked annually.[39] Unfortunately, because there are no standard auditing practices, it is impossible to know how much water, and therefore revenue, is lost across the country.[40] Proper auditing, maintenance, and asset management can save water structure owners considerable sums of money they might not even realize they are losing, which in turn can help fund upgrades and expansions.[41] There are many key practices to proper asset management, but they are beyond the scope of this paper.[42]

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[31]Ibid.
[32]Ibid.
[33]Ibid.
[34]Ibid.
[35]Leighton, Jeff, Kurt Vause, Celine Hyer, Annie Vanrenterghem Raven, Kevin Campanella and John J. Galleher. "Committee Report: Business Practices to Help Utilities Better Manage Assets."
[36]Ibid.
[37]Ibid; McGraw-Hill Construction. "Water Infrastructure Asset Management: Adopting Best Practices to Enable Better Investments." Bedford, MA, 2013. https://www.newea.org/wp-content/uploads/2014/11/Water-Infrastructure-Asset-Management-SMR-2013.pdf.
[38]Chastain-Howley Andrew, Jolynn Reynolds and Pam Kenel. "Tech Talk -- Outsmarting Costly Water-Loss Culprits." *Journal of American Water Works Association*, 108 (January 1, 2016): 24–26. http://dx.doi.org/10.5942/jawwa.2016.108.0023.
[39]The Center for Neighborhood Technology. "The Case for Fixing the Leaks," 2013. http://www.cnt.org/resources/the-case-for-fixing-the-leaks/.
[40]Ibid.
[41]DePonte, Brian. "Navigating New Options for Water Equipment Financing." *Journal of American Water Works Association* 109 (May 1, 2017): 53–58. https://doi.org/10.5942/jawwa.2017.109.0064.; American Society of Civil Engineers. "Drinking Water Infrastructure | ASCE's 2017 Infrastructure Report Card," 2017. https://www.infrastructurereportcard.org/wp-content/uploads/2017/01/Drinking-Water-Final.pdf.
[42]Please see previous footnotes and references for citations to papers related to improving asset management.

IV. Currently Available Public Financing Sources

A. Federal Financing

There are a variety of federal financing and funding options available to states and localities seeking to improve their water infrastructure.

1. Environmental Protection Agency

The Environmental Protection Agency (EPA) is the agency with the largest array of financing opportunities for water infrastructure.

a. Water Infrastructure Finance and Innovation Act

Among the largest of these sources are funds disbursed under the Water Infrastructure Finance and Innovation Act (WIFIA), managed by the EPA. WIFIA acts as a federal financing mechanism whereby large-scale water improvement projects are awarded loans or loan guarantees at low interest rates.[43] There are several significant requirements that a project must meet to be eligible for a WIFIA loan. Chief among these, the project must be of a sufficient scale to warrant federal support. For municipalities with populations less than 25,000, projects must have a total cost of at least $5 million to qualify, while larger communities must surpass $20 million in costs to be eligible.[44] In addition, WIFIA loans may not constitute a greater share than 49% of any project's costs.[45] These limitations are designed to ensure that municipalities have access to inexpensive credit for large projects, but also have the capacity to eventually pay back the project costs through user-fees or tax revenue.

In this sense, WIFIA is a method of financing, rather than direct funding. In 2017, WIFIA loans totaled $2.3 billion in support of 12 projects with $5.1 billion in combined project costs.[46] The benefit that WIFIA provides to localities is primarily in its scale. Projects that were previously unattainable based on municipal credit ratings can be made possible through a WIFIA loan. However, there are also several reasons why localities may choose not to apply for WIFIA financing. WIFIA loans are subject to a great deal of uncertainty because interest rates vary from project to project, sometimes exceeding treasury rates[47]. In addition, the requirement that projects be of such a large size often precludes smaller improvements from being awarded WIFIA financing.[48]

[43] United States Environmental Protection Agency. "WIFIA Program Summary" Washington, D.C. November 2016. https://www.epa.gov/sites/production/files/2017-08/documents/wifia-2-onepager-508-1-web-final2.pdf
[44] Ibid.
[45] Ibid.
[46] United States Environmental Protection Agency. "FY 2017 WIFIA Selection Round Overview" Washington, D.C. 2017 https://www.epa.gov/sites/production/files/2017-07/documents/fy17-wifia-selectionoverviewfactsheetv2.pdf
[47] American Water Works Association. "Key Issues in WIFIA Implementation" 2016. https://www.awwa.org/Portals/0/files/legreg/documents/KeyWIFIAIssuesPaper.pdf
[48] Ibid.

b. Revolving Funds

The EPA also administers the State Revolving Fund (SRF) programs. These funds are also loan and loan guarantee programs that are capitalized at the state level.[49] However, in the case of SRFs, loan repayments are channeled towards financing the bond obligations of the SRF itself. Through this method, SRFs are self-sustaining financing mechanisms. The two most commonly used SRFs for water infrastructure in the United States are the Drinking Water State Revolving Fund (DWSRF) and the Clean Water State Revolving fund (CWSRF), each with a slightly different scope. The DWSRF is most applicable to drinking water delivery systems, while the CWSRF deals most frequently with wastewater and watershed management.[50] Much like WIFIA, SRFs suffer from the disadvantage that it requires municipalities to accept an increased debt burden which must be repaid through user-fees. However, SRF financing is often more flexible than that of WIFIA and available for a wider variety of project types and sizes.[51] Additionally, the SRFs have existed for a longer period of time than the newly-initiated WIFIA program. As such, some localities have grown accustomed to the application process, reducing the overall cost in terms of time and resources associated with applying.

2. Department of Agriculture

For rural communities with small populations, the U.S. Department of Agriculture (USDA) administers the Rural Utilities Service Water and Environmental Programs (WEP). These programs provide grants and loans to communities with populations of 10,000 or fewer for water infrastructure improvements or technical assistance.[52] WEP projects are generally much smaller than those financed by the SRFs or WIFIA; however, WEP supports a greater number of projects overall. In 2016, WEP disbursed $1.5 million in grants and loans in support of 582 projects throughout the country.[53] The WEP program also maintains a portfolio of over 15,000 loans from past years which will be repaid over 40 years at very low interest rates.[54] The advantage of WEP financing is that it is available to smaller localities and for a wider variety of small-scale projects. In addition, the program sometimes distributes funds as grants rather than loans, meaning that municipalities may not have to increase their debt burden to take advantage of the program. However, most of the funds distributed through WEP must still be repaid through user-fees, which can often take longer for rural communities that serve smaller populations.

3. Department of Housing and Urban Development

The Community Development Block Grant Program (CDBG) administered by HUD provides middle and low-income localities with financing for public works projects. These grants are distributed based on a locality's size. Cities with populations of more than 50,000 and counties with populations of more than 200,000 are automatically eligible for the CDBG program as "entitlement communities."[55] The remainder of funds in the program are administered on the

[49]United States Environmental Protection Agency. "Drinking Water State Revolving Fund Annual Report 2016" Washington, D.C. September 2017. https://www.epa.gov/sites/production/files/2017-09/documents/2016_dwsrf_annual_report_508.pdf
[50] Ibid.
[51] Ibid.
[52]United States Department of Agriculture. "Water and Environmental Programs FY 2016 Progress Report" Washington, D.C. 2016. https://www.rd.usda.gov/files/WEP-AnnualProgressReport2016Final.pdf
[53] Ibid.
[54] Ibid.
[55]United States Government Accountability Office. "Community Development Block Grants: Sources of Data on Community Income are Limited" Washington, D.C. September 2016. http://www.gao.gov/assets/680/679528.pdf

state level and disbursed to non-entitlement communities as the state sees fit.[56] The primary advantage of this form of financing is that it does not need to be repaid and it does not increase the debt burden of localities. In this sense, municipalities will not need to raise user fees or divert revenue in order to pay for improvements. However, these improvements must be demonstrated to improve the lives of low- and middle-income residents and entitlement communities are required to formulate a consolidated plan every five years explaining how the grant will be allocated.[57] These requirements can be an impediment to localities seeking to take advantage of CDBGs.

4. Economic Development Administration

The Economic Development Administration (EDA) provides financing to localities that are suffering from sudden or systemic economic decline. This designation can include communities that have experienced a decline in manufacturing, coal production, or been subject to a natural or environmental disaster. The EDA administers these funds under the Economic Adjustment Assistance Program (EAA).[58] The EAA distributes its funds through two primary channels; strategy grants and implementation grants. While strategy grants are generally used for economic planning, implementation grants can be used to fund water infrastructure improvements.[59] This form of financing is advantageous because it does not require repayment, making it attractive to localities with unsteady credit situations. In addition, the EDA considers the relative financial distress of a community as a factor in awarding grants.[60] As such, this form of financing can be attractive to communities in fiscal crisis that may be unable to meet the eligibility requirements of other federal programs. However, EAA financing is inaccessible to some communities not deemed to be under significant enough financial stress.

5. Department of the Interior

In Western states, the Department of the Interior's Bureau of Reclamation (the Bureau) has historically been a major benefactor of water infrastructure improvements. Having constructed many hydroelectric dams and water systems, the Bureau is now the largest distributor of water in the 17 western states.[61] The Bureau owns and operates 53 power plants and maintains ownership over an additional 23 plants.[62] The Bureau also supports water infrastructure improvements throughout the Western states in the form of grants and loans. In fiscal year 2018, the Bureau has budgeted $510.8 million in financing at the project level for construction and development activities.[63] These funds are available through a variety of programs with different goals related to improving the capacity, security, and efficiency of water resources in the West. For example, the Bureau's WaterSMART grant program provides financing to municipalities or states for projects which will save water or improve environmental outcomes.[64] This form of financing is

[56] Ibid.
[57] Ibid.
[58] United States Economic Development Administration. "Economic Adjustment Assistance Program" Washington, D.C. 2016. https://www.eda.gov/pdf/about/Economic-Adjustment-Assistance-Program-1-Pager.pdf
[59] Ibid.
[60] Ibid.
[61] United States Bureau of Reclamation. "Fact Sheet" Washington, D.C. November 22, 2017. https://www.usbr.gov/main/about/fact.html
[62] Ibid.
[63] United States Bureau of Reclamation. "President Proposed $1.1 Billion Fiscal Year 2018 Budget for Bureau of Reclamation" Washington, D.C. May 23, 2017. https://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=59414
[64] United States Bureau of Reclamation. "WaterSMART Progress report 2010-2016" Washington, D.C. December 2016. https://www.usbr.gov/watersmart/docs/2016/2016watersmartprogressreport.pdf

advantageous because it is based on a cost-sharing model, meaning localities do not need to take on additional debt. However, the availability of these funds is limited to the 17 Western states and receiving funds from the Bureau requires localities to be subject to extensive environmental reviews to mitigate risk.[65] These caveats limit the usefulness of these funds for many localities

6. Lack of Owner Capacity Hampers Effectiveness of Federal Programs

A GAO report released in September 2017 identified a lack of technical and financial capacity as hampering the ability of localities to take advantage of federal financing.[66] Many smaller municipalities have no dedicated water engineers or staffers who are qualified to develop long-term plans for improving the system. Without a capacity to assess the needs of their system and create a detailed and specific proposal, these municipalities are unable to apply for most federal funds.[67] Moreover, many small communities lack the financial management capacity to plan for a large-scale loan. These programs have strict requirement for reporting how funds are used and many regulations on their permitted uses. Without the staff or technical capacity to ensure that these requirements can be met, municipalities find themselves ineligible for federal loans.[68]

B. State Funding and Financing

Several funding and financing mechanisms exist at the state level to improve water infrastructure, including grants, loans and State Revolving Funds (SRFs). Each form of financing has unique advantages and disadvantages that municipalities must consider when deciding which funds to seek.

1. Grants

Although grants are a form funding not financing, grants are included in this analysis because of their ubiquity on the current water infrastructure landscape. Grants are by far the most popular form of funding available on the state level for water projects. Thirty states across the country provide some form of grant funding to pay for water infrastructure improvements.[69] This form of funding is advantageous to municipalities because it does not increase the local burden of public debt. Meanwhile the investments the funding makes possible generate economic activity to improve local economies.[70] Additionally, grant-funded water infrastructure is a source of profit for localities that can channel revenue from water rates into future infrastructure improvements. However, winning grants requires localities to compete against one another and ultimately not every project can be grant-funded.

[65] Ibid. 59
[66]United States Government Accountability Office. "Drinking Water and Wastewater Infrastructure; Information on Identified Needs, Planning for Future Conditions and Coordination of Project Funding" Washington, D.C. September 2017. http://www.gao.gov/assets/690/687261.pdf
[67] Ibid.
[68] Ibid.
[69]United States Environmental Protection Agency. "Water Finance Clearinghouse" Washington, D.C. 2017. https://ofmpub.epa.gov/apex/wfc/f?p=165:1
[70]See related discussion in this report.

2. Loans

While less popular than grant programs, many states provide assistance to localities in the form of low-interest loan programs. Twenty-one states offer loans in support of water infrastructure.[71] These programs typically provide loans with low interest rates and very long-term repayment schedules. For example, the State Water Implementation Fund for Texas (SWIFT) and the Georgia Fund are two state-funded programs designed to provide low-interest loans to localities.[72] The advantage of this type of financing is that it is abundant and available to most municipalities with an average or better credit rating, making many projects feasible that would not be affordable using general obligation bonds alone. However, many municipalities are hesitant to take advantage of these loan programs because they necessitate an increase in their debt burden. Additionally, over many years accumulated interest payments result in projects costing more to complete in the long-term.

3. State Revolving Funds

While the EPA administers the federal SRFs, several individual states have created their own using a similar model. Eleven states provide loans to localities through state administered revolving loan programs which are designed to funnel interest payments back into the fund, which makes them self-sustaining.[73] For instance, California's Water Recycling Funding Program (WRFP) provides loans, grants and technical assistance to communities seeking to improve their water recycling and treatment capabilities.[74] These programs are advantageous because they do not require the state legislature to re-appropriate funds each fiscal year in support of the program. Accepting SRF money means municipalities are taking on additional debt, which make many wary of doing so if other options exist. Most States do not provide unique water infrastructure SRFs at all, instead choosing only to disburse federal funds through the EPA's DWSRF and CWSRF.

[71] Ibid.
[72] Texas Water Development Board. "State Water Implementation Fund for Texas (SWIFT) report" Washington, D.C. October 2016. http://www.twdb.texas.gov/publications/shells/swift_info_sheet.pdf?d=1513210133762 ; Georgia Environmental Finance Authority. "Georgia Fund" Atlanta. 2017. https://gefa.georgia.gov/georgia-fund
[73] United States Environmental Protection Agency. "Water Finance Clearinghouse" Washington, D.C. 2017. https://ofmpub.epa.gov/apex/wfc/f?p=165:1
[74] California State Water Resource Control Board. "Water Recycling Funding Program Guidelines" June 16, 2016. https://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/docs/wrfp_guidelines.pdf

V. Interviews with Water Structure Owners

As one way to identify best practices, the research team conducted interviews with water structure owners. This metric helped clarify how certain localities are using various funding and financing options, what factors influence their decisions, and best practices for system management. The owners were chosen based on geographic diversity and because they own water infrastructure in areas where ACPPA members are located.

A. Tracy, California

Tracy, California is a remote suburb of San Francisco. Over the last several decades, the locality's population has ballooned from 40,000 to 90,000 and about half of the infrastructure is less than 25 years old. The majority of the core part of the city, built around 1910, still has the original cast iron pipe. Pipe replacement is part of the maintenance conducted any time the city rebuilds a main street. For the last several years, the city has had an annual budget of approximately $2 million, collected from user-fees, dedicated to replacing drinking water pipes. Droughts in the last two years have led to cut backs in water consumption, which has led to the loss of approximately 28% of annual revenue. Because of this loss, the city has not replaced any pipe in the last two years and does not plan to replace any for at least the next two years. Additionally, the city has had to raise water rates by about 25% to make up for the revenue loses.

Tracy engages in some strategic planning and asset management. As part of its regular Capital Improvement Plan, pipes can be added based on their age and repair history. There are some pipes around the city that are 80 years old or older with good performance records that are not being replaced.

According to Steve Bayley, a water specialist for the city, its ability to update and replace pipes is at the "mercy of cash flow." All money for upgrades and replacements comes out of residents' water bills. The city does not generally take out bonds or loans from any sources because, according to Mr. Bayley, "we never issue bonds for what we can pay for ourselves." When the city has had pipe replacement projects for which bonds could have been used, it instead chose to raise rates until the city had the necessary resources to pay for the project. A consistent funding source would facilitate more regular replacements and upgrades.

In the past, the city has taken a loan from California's SRF to replace a water plant because the interest rate was so low and the project was so large that the only practical way to upgrade was to do the entire project at once. In the past the city has also utilized Mello-Roos financing, which is specific to California. Mello-Roos is a type of parcel tax that allows for an additional tax to be levied on properties, not based on the assessed value of the real property but on a fixed cost based on their use of the infrastructure. These taxes pay for municipal bonds that finance the chosen infrastructure projects or services.[75]

[75]California Tax Data. "What Is Mello Roos?" Irvine, CA. Accessed November 30, 2017. https://www.californiataxdata.com/pdf/Mello-Roos2.pdf.

Tracy does not utilize any federal financing sources and would not because of the strings attached. Similarly, Tracy does not qualify for grants from the state of California, which they believed are provided almost exclusively to disadvantaged communities. In fact, California provides ample funding and financing opportunities for public agencies.[76]

B. Rancho Cucamonga, California

Rancho Cucamonga is part of the regional special district known as Cucamonga Valley Water District (CVWD). Much of the area is newer than some of the surrounding localities and some of the pipe has been installed in the last 30 years. The district is slowly replacing the older pipe over time.

CVWD currently has $106 million in bonds outstanding to pay for various infrastructure projects, including a large expansion of its treatment plant and $40 million related to maintaining surface water. When CVWD issues bonds, it can change user fees to ensure they can pay for them. CVWD currently pays for updates and expansions primarily with user fees. Because it is a special district, it has a large amount independence. According to the interviewee, with this independence CVWD can set user fees that allow it to keep up with replacements and build up resources to pay for capital projects.

As a special district focusing solely on water, it also has access to a larger arsenal of employees. This includes an engineering department, which conducts studies to determine when pipe is getting too old or is receiving maintenance too often and needs to be replaced. For the district, a slow replacement is a better plan than a large overhaul because much of its pipe is new and it has the benefit of an engineering department to closely manage the infrastructure system.

The district has partnered with other agencies, localities, and private companies to both provide services and finance projects. In the recent past, it paired with another agency to finance a sewage treatment plant, for which they received a federal grant. The partner agency administered the grant. They have also partnered with another agency to utilize the state SRF to obtain a no interest loan to finance a recycled water pipeline. The district has also used several federal and state grants, including from the Bureau of Reclamation.

Although the district prefers to utilize user-fees for small projects and replacements, its preferred method of financing for large projects is tax-exempt bonds. Because long-term rates are currently so low, bonds are the only “real affordable” method to finance large projects, according to one financial officer for the district. The only downside to bonds are the “time value of money.” Bonds also give CVWD the ability to spread out payments over the useful life of the facilities.

C. Lubbock, Texas

The City of Lubbock, Texas is a fairly populous metropolitan hub in Northwest Texas that owns its own water infrastructure. The City’s water comes primarily from three sources: the Canadian River Municipal Water Authority, Bailey County Well Field, and Lake Alan Henry which is

[76] California Department of Water Resources. “Financial Assistance,” 2018. http://www.water.ca.gov/funding/

owned by the city.[77] In recent years, the city's population has been steadily growing, from a population of 229,573 in 2010 to at least 303,137 in 2016.[78]

Because of concerns about the long-term capacity necessary to supply a growing population with drinking water in an area with average annual rainfall less than 20 inches, Lubbock engages in strategic water supply and infrastructure planning.[79] The city has a 100-year strategic supply plan, as well as a 20-year master plan for the water distribution system. The system is on a continuous replacement schedule that aims to replace pipes every 30 years or in the case of emergency.

In order to finance expansion and maintenance of the water system, Lubbock officials prefer to issue general obligation bonds or tax exempt municipal bonds. For larger projects, Lubbock has received loans from the State Water Implementation Fund for Texas (SWIFT), which provides localities within Texas with water infrastructure financing at low interest rates on extended repayment plans and with the option for deferral of payments.[80] Based on an incremental repurchase model, municipalities like Lubbock can use SWIFT funds to pay for large-scale projects and slowly buy back their water system from the state.[81] In the 2016-17 fiscal year, the City of Lubbock received a $35 million interest-free loan from the SWIFT program to finance the Central Lubbock Stormwater Project.[82]

In the past, the city has also received small loans at favorable interest rates from the EPA's Drinking Water SRF and the Bureau of Reclamation. However, the city prefers not to utilize federal financing, in part because of a perception that such funds come with too great a burden of regulatory oversight and "red-tape". Additionally, city officials have expressed concerns about environmental regulations that the federal government might impose as a condition of financing. The Bailey County Well Field is home to the Greater Prairie Chicken, a threatened species that may soon be subject to federal protections.[83] As such, county officials are wary that accepting federal financing may require them to invest more in conservation efforts, imposing greater project costs and potentially limiting the future usefulness of Bailey County Well Field as a water source for the city.

D. Grand Prairie, Texas

Grand Prairie is suburb of the Dallas-Fort Worth Metroplex, home to more than 190,000 residents. Rapidly growing and situated between major urban hubs Dallas and Fort Worth, Grand Prairie has needed to rapidly expand its water system's capacity over the past 15 years to keep

[77]City of Lubbock "Strategic Water Supply Plan". February 2013. https://www.ci.lubbock.tx.us/docs/default-source/water-department-file-library/2013-strategic-water-supply-plan.pdf?sfvrsn=2
[78]"QuickFacts: Lubbock County, Texas." US Census Bureau , 2017. https://www.census.gov/quickfacts/fact/table/lubbockcountytexas/PST045216.
[79]Ibid.
[80]Texas Water Development Board. "State Water Implementation Fund for Texas (SWIFT) report" Washington, D.C. October 2016. http://www.twdb.texas.gov/publications/shells/swift_info_sheet.pdf?d=1513210133762
[81]Ibid.
[82]Matt Dotray, Lubbock Avalanche Journal, "City Preparing For Right of Way Cost for Loop 88" March 23, 2017. http://lubbockonline.com/news/2017-03-23/city-preparing-right-way-cost-loop-88
[83]The Nature Conservancy, "Greater Prairie Chicken", 2017. https://www.nature.org/newsfeatures/specialfeatures/animals/birds/greater-prairie-chicken.xml

pace with demand. For this reason, much of the water infrastructure in the city - distribution pipes and mains - were built within the last 10 years.

Following a citation issued by the Texas Commission on Environmental Quality in 2004 for water quality violations, the city has engaged in more proactive strategic planning for its water system. Grand Prairie adheres to a maintenance schedule whereby approximately 10-15% of the system is replaced each year. The replacement of any line with water quality issues affecting health is given the highest priority, followed by replacing the oldest lines in the system prone to losing water through leaks. The city is also actively engaged in the systematic replacement of cast-iron lines and asbestos cement lines that are still a part of the system, although this process is considered somewhat less urgent.

Geographically, Grand Prairie is a long and narrow municipality. As such, the city has been required to lay many miles of new pipes to connect growing housing developments to water treatment facilities. Many pipes have needed to be widened to allow for greater volume of flow throughout the system. The city typically uses easements to purchase the land required to expand old pipes and lay new ones; however, city planners have recently begun to run out of space on which easements can be placed. This issue has the potential to raise project costs and hamper feasibility in the future, as the cost of property may rise.

When upgrading old water infrastructure or constructing new lines and facilities, Grand Prairie usually uses a combination of funding and financing. Projects are funded using a rate-based system and financed through the issuance of general obligation bonds and loans from the SWIFT program. Grand Prairie enjoys a Aa3 credit rating for general obligation and water and wastewater system revenue bonds.[84] This high credit rating allows the city to borrow at very low interest rates. The city has not taken any federal loans to finance water infrastructure projects in recent years because state or municipal financing options are often more attractive in terms of lower interest rates and lessened regulatory burdens. However, the city did apply for federal grant funding under the economic stimulus package of 2009, which was not awarded at that time.

E. Somerville, New Jersey

The water structure in Somerville, New Jersey, and a large portion of the state, is owned by the publicly-traded company American Water. In the beginning of 2017, the New Jersey subsidiary of American Water invested almost $2 million in just one town to replace pipes that dated back to 1920.[85] The company invests about $350 million annually in its water infrastructure.[86] American Water prioritizes replacement based on many factors, including “material, age and number of leaks” and has a dedicated team “continually” performing analysis on all pipes.[87]

New Jersey American Water serves approximately one-third of the entire population of the New Jersey, or approximately 2.5 million people. Its revenue model is based on charging rates that are

[84]Moody’s Credit Ratings, 2017.
[85]Waterworld. “New Jersey American Water Continues to Invest in Service Area.” Waterworld, 2017. http://www.waterworld.com/articles/2017/01/new-jersey-american-water-continues-to-invest-in-service-area.html.
[86]New Jersey, American Water Works Company. “Water System Updates.” American Water Works Company, Inc., 2017. https://amwater.com/njaw/water-quality/system-updates.
[87]Ibid.

higher than its cost-of-service. For this reason, localities like Somerville that are served by American Water or other private companies on average pay higher rates than localities that own and finance their own water infrastructure. However, American Water is keen to invest heavily in expanding and updating its water system because increased investment ultimately translates to profit for the company.

It costs approximately $1 million per mile for American Water to replace a water main. When financing new projects, the company most often proactively invests in upgrades, then petitions the state legislature to allow a rate increase based on the size of their investment. Additionally, the company sometimes borrows to finance water infrastructure projects and is able to do so at very low interest rates because of its sterling credit rating. The company also has access to and occasionally avails itself of loans from New Jersey's Drinking Water SRF. While these loans already have very low interest rates, in the past portions of loans to American Water from New Jersey's SRF have been granted loan forgiveness.

F. South Beloit, Illinois

South Beloit Illinois is small city in Northern Illinois with a population of just under 8,000. The local water provider in South Beloit is Illinois American Water— a private water utility company which purchases water from the City of Beloit. Municipal authorities however are responsible for wastewater management in the city.

Illinois American Water in South Beloit has been making recent upgrades involving investing in additional looping in recent years; however, much of the system is more than 15 years old. Illinois American Water is likely to continue to invest in the area's distribution system at a pace proportional to population growth. The rate-based model the company uses allows it to spread the cost of investment across a large customer base, increasing its capacity to modernize the distribution system. However, municipal authorities in South Beloit have struggled to keep pace with the costly maintenance demands of an aging wastewater system. The water treatment facility in South Beloit is 30 years old in its newest sections and 60 years old in its oldest.

Expansions and improvements to the distribution system in South Beloit are funded by Illinois American Water. These efforts are typically funded by rate-increases, which require the approval of the Illinois Commerce Commission. For this reason, citizens of South Beloit pay relatively high rates compared with the rest of the state. Wastewater infrastructure improvements in South Beloit are funded by the municipality. Typically, the city will finance new projects by issuing general obligation bonds, supplemented by revenue from the rate-based system. In 2016, the city increased the wastewater rate by 7% in order to "keep infrastructure sound" due to concerns that the aging system will incur significant maintenance cost increases in the coming years.[88] While the city addresses maintenance concerns as they arise, there is not a long-term strategic plan for updating wastewater infrastructure.

[88] Austin Montgomery, Beloit Daily News, "Council Gets a Look at Proposed Budget" October 03, 2017. http://www.beloitdailynews.com/article/20171003/ARTICLE/171009952

VI. Best Practices for Drinking Water Infrastructure Financing

A. Metrics for Determining Best Practices

Best practices are the policies that promote effective investment in drinking water infrastructure. Before determining best practices, it was necessary to identify metrics to measure the value of best practices. Metrics were chosen by consulting the literature and interviewing representatives from localities across the country, as well as American Concrete Pressure Pipe Association's and AWWA's executive staffs.

B. Identifying Best Practices

Our team used three approaches to identify best practices:

1. Current Research. This is a necessary aspect of any best practice, because researchers are constantly adding to the pool of knowledge.
2. Interviews with Water Structure Owners. Interviews are essential to complement current research, because best practices are useless if they are not based on practices that water structure owners utilize.
3. Availability of Financing Type. While this was not the most important metric, it is an important consideration because the intent of this paper is to recommend practices that can be utilized in the current environment and so current availability of financing types must be considered.

C. Best Practices Overview

These best practices focus on water structure owners who are in the public sector. The public and private sectors have fundamentally different models. The public sector is customer-focused, while private companies are profit-driven. In 2011, approximately 10% of nationwide water systems were privately owned; however, ownership has increased since then.[89] Best practices for private sector water owners are beyond the scope of this analysis.

While our study includes some discussion about potential practices that could be developed in the future, the focus of this discussion is to provide practical financing options that can be utilized today.

There are two main themes woven throughout the best practices:

1. Maintaining access to tax-exempt financing. Whether it is through bonds or public private partnerships, tax-exempt financing is essential to ensuring infrastructure projects continue to be undertaken.
2. Effective financing mechanisms must happen at the local level. From bonds to partnerships, it is the water structure owners who will be able to best understand and invest in their own needs.

[89] American Society of Civil Engineers. "Failure to Act: The Economic Impact of Current Investment Trends in Electricity Infrastructure." Washington, DC, 2011. http://www.asce.org/uploadedFiles/Infrastructure/Failure_to_Act/energy_report_FINAL2.pdf.

1. Best Practice: Maintaining Tax-Exempt Bonds

Bonds are currently the most common type of the financing for water structure owners across the United States.[90] Bonds are essential to water infrastructure financing because they are a stepping stone to many other investment options. Bonds are versatile and offer the opportunity for localities to take risks and try new types of financing. Both the literature and our interviewees emphasized the importance of bonds in water infrastructure.

There are many different types of bonds, but the most commonly utilized is the municipal bond. Research suggests that capping or eliminating the tax-exemption for municipal bonds would have a significantly negative effect on infrastructure investment and increase financing costs for water infrastructure by as much as 15%.[91] Tax-exempt municipal bonds are a main factor in maintaining affordable user-rates and are "vital … to eliminat[ing] the funding gap" for water infrastructure in the coming decades.[92] Several organizations, including ACPPA and the American Society of Civil Engineers (ASCE), support maintaining the tax-exempt municipal bonds because of their key role in providing access to infrastructure financing for public water structure owners.[93] Maintaining the tax-exemption is critical to continued infrastructure investment because it makes public bonds an attractive option for some investors.

Another type is the private activity bond. ACPPA, ASCE and other organizations have urged Congress to eliminate the cap on private activity bonds, thereby encouraging greater use. Eliminating the state cap would increase the amount of available private financing in water infrastructure by $6 to $7 billion a year.[94]

Bonds have many benefits:

- Tax-exempt bonds are the most cost-effective tool for water structure owners.[95]
- Bonds provide low-cost access to financing to communities of all shapes and sizes.[96]
- They allow the owner to spread the cost over the lifetime of the project.[97]
- For water structure owners with good credit ratings, interest rates will be low because of the high probability of pay back.[98]
- Bonds appeal to lenders, because they are "reliable, fixed income streams."[99]

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[90]Nolan, Bruce. "Funding Water and Wastewater Projects: Growing Communities Seek Strategic Alternatives." *Journal of American Water Works Association* 99, no. 5 (2007): 42–46. https://doi.org/10.2307/413.; National Association of Clean Water Agencies and Association of Metropolitan Water Agencies. "The Impacts of Altering Tax-Exempt Municipal Bond Financing on Public Drinking Water & Wastewater Systems," 2013. https://www.amwa.net/sites/default/files/AMWA-NACWA_MuniBondAnalysis_July13.pdf.
[91]Ibid.
[92]Ibid, 15.
[93]American Society of Civil Engineers. "Drinking Water Infrastructure | ASCE's 2017 Infrastructure Report Card."
[94]Ibid.
[95]LaFrance, D.B. "Open Channel- Who Knew Where the Path Would Lead?" *Journal of American Water Works Association* 108, no. 1 (2016): 10. https://doi.org/http://dx.doi.org/10.5942/jawwa.2016.108.0201.
[96]American Society of Civil Engineers. "Drinking Water Infrastructure | ASCE's 2017 Infrastructure Report Card."
[97]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."
[98]Andersen, Farrah, Christina Becker-Birck, Liz Hanson, Sasha Shyduroff, Will Sloan, Kathryn Wright, Dakota Gangi, Namrita Kapur and Amy Morse. "Unlocking Private Finance in Sustainable Infrastructure," 2017. http://business.edf.org/files/2017/09/EDF_Unlocking-Private-Capital-to-Finance-Sustainable-Infrastructure_FINAL.pdf.
[99]Ibid.

- According to our interviews, one reason bonds are preferred is that they do not come with the same reporting or performance requirements associated with federal or state grants and loans.

However, bonds present challenges as well:

- They are only an optimal option if interest rates are low.
- Public water structure owners must be fiscally sound to be able to access bonds at reasonable and low rates. With local governments currently having more than $1.7 trillion in long-term debt, many water structure owners cannot afford to take on more bonds.[100]
- The bond market fluctuates and can at times be weak. One example of this was the expiration of the Build America Bond Program in December 2010, which meant losing $185 billion in available financing.[101]
- There is some concern that that the condition of the market may be insufficient to withstand the needed level of investment.[102]
- When municipalities default it can have a destabilizing effect on the market.
- Bonds can be costly, requiring time, underwriting, legal review and issuance.[103]

There are many examples of creative bond initiatives:

One example is Mello-Roos financing, discussed earlier in this study and utilized by Tracy, California to pay for infrastructure improvements. Green bonds and a current pay-for-success project in D.C. offers other examples of how bonds are used.

Green bonds are "earmarked specifically for green projects." These bonds have both helped attract investors to the bond market and led to an increase in the availability of funds earmarked for sustainable infrastructure projects.[104]

Another innovative form of financing that is currently being tested for viability is pay-for-success (PFS), an outcomes-based financing model. PFSs only require payments contingent on meeting performance measures and are "tied to long-term, multi-year success."[105] This model has been historically used to fund social services, but is slowly being tested in other areas.[106] These projects involve a combination of "nonprofit expertise, private sector financing and

[100]Kane, Joseph. "Investing in Water: Comparing Utility Finances and Economic Concerns across U.S. Cities." *Brookings Institution*, December 14, 2016. https://www.brookings.edu/research/investing-in-water-comparing-utility-finances-and-economic-concerns-across-u-s-cities/.; Puentes, Robert and Patrick Sabol. "Why Isn't Cheap Debt Supporting More Infrastructure Investment?" *Brookings Institute*, October 30, 2014. https://www.brookings.edu/blog/the-avenue/2014/10/30/why-isnt-cheap-debt-supporting-more-infrastructure-investment/.
[101]Lazerov, Manuel; Fleming, Hu. "Practical Use of Private Equity as a Solution to Infrastructure Development." *Journal of American Water Works Association* 103, no. April (April 1, 2011). https://www.awwa.org/publications/journal-awwa/abstract/articleid/27384.aspx.
[102]Ibid.
[103]Nolan, Bruce. "Funding Water and Wastewater Projects: Growing Communities Seek Strategic Alternatives."
[104]Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."
[105]Ibid; Appel, Todd, Bethany Bezak and John Lisle. "DC Water Green Infrastructure Financing: Pay for Success Can Help Water Utilities Pursue Innovative Solutions." *Journal of American Water Works Association* 109 (October 1, 2017): 26–31. https://doi.org/10.5942/jawwa.2017.109.0131.
[106]North, Jennifer and Gloria Gong. "DC Water Environmental Impact Bond," 2017. https://govlab.hks.harvard.edu/files/siblab/files/dc_water_eib_project.pdf.

rigorous measurement and evaluation," where the government will only pay for the program if it measurably improves the lives of participants.[107]

One current is example is Washington, D.C., where PFS financing is being used to finance storm water infrastructure. The nation's capital utilized a true municipal bond as the financing method and it initiated one of the first PFS projects to utilize a true bond. Investors receive payment contingent on the effectiveness of the infrastructure.[108] This means the risk of the project is distributed between the private market and government. Although it is a unique structure, the bond was still able to qualify as tax-exempt.[109] The related user-fees would make water infrastructure attractive to private investors because of the reliable revenue stream. One potential downside is that projects like this may only find success in large communities, where it is easier to attract private investors. The bond also requires rigorous evaluation and evaluation standards would have to be created and tailored for drinking water. Currently, PFSs are being tested in different landscapes, including testing by the Department of Agriculture and U.S. Forest Service.[110] PFSs are a good potential use for bonds and their use may be expanded in the future. Going forward, these types of projects have room for flexibility and provide opportunities to test different types of structures.

2. Best Practice: Promoting Collaboration

One of the greatest benefits of collaboration is that it provides water structure owners with the opportunity to leverage capacity, human resources, and expertise, thereby overcoming a major roadblock to accessing federal financing. Another essential aspect of collaboration is that it is locally driven because local water structure owners are the ones who are best positioned to understand their needs.[111] There are two distinct types of collaboration that can have a positive effect on water infrastructure financing.

a. Public-Public Partnerships

The benefits of regional public collaboration are highlighted by special districts like the Cucamonga Valley Water District. These districts can more easily work on large projects and have large teams to manage the infrastructure. Both the EPA and ASCE recommend public-public collaboration as a key element of improving infrastructure nationwide.[112] Public-public collaboration allows water structure owners to take advantage of economies of scale, save on operating costs and potentially attract financing individual system owners would not be able to

[107]Ibid; Appel, Todd, Bethany Bezak and John Lisle. "DC Water Green Infrastructure Financing: Pay for Success Can Help Water Utilities Pursue Innovative Solutions."
[108]Ibid; North, Jennifer and Gloria Gong. "DC Water Environmental Impact Bond."
[109]Ibid.
[110]Ibid.
[111]EPA Office of Water. "EPA's Drinking Water Action Plan."
[112]American Society of Civil Engineers. "Drinking Water Infrastructure | ASCE's 2017 Infrastructure Report Card."; EPA Office of Water. "EPA's Drinking Water Action Plan," 2016. https://www.epa.gov/sites/production/files/2016-11/documents/508.final_.usepa_.drinking.water_.action.plan_11.30.16.v0.pdf.

access on their own, both in terms of qualifying for financing and receiving lower interest rates.[113]

Economically disadvantaged and minority communities and those with aging populations can benefit in particular from regional collaboration. According to the EPA's 2016 *Drinking Water Action Plan*, this is the case because they face disproportionate financing challenges compared to other communities.[114] These communities may be unable to access sufficient financing, which leaves their water infrastructure suffering. Of the over 50,000 community water systems in the United States, more than 90% serve fewer than 10,000 people and more than 27,000 systems serve fewer than 500 people.[115] The formation of larger partnerships allows communities to "leverage limited resources and enhance system capacity."[116] Beyond small systems benefiting from shared resources, large systems can benefit from shared expertise and technical support.

Another type of public-public partnership is integrated water resource management (IWRM). This type of intra-city collaboration works to bring together all types of water infrastructure needs, including drinking and waste water, and considers them holistically and systematically as one large issue.[117] IWRM emphasizes information sharing and collaboration and "holds promise in bridging the gap between different public and private stakeholders while improving financial and environmental outcomes".[118]

b. Public-Private Partnerships

A public-private partnership is defined at as a "formal, contractual agreement between a government entity and private company." These types of arrangements have been used for a range of financing mechanisms.[119] Partnerships are often misused and misunderstood. In a true partnership, the public sector keeps ownership, while the private company is responsible for some facet of the project in exchange for some benefit, often a payment or a long-term share of the revenues from the service.[120]

Outside of the United States, public-private partnerships are a pillar of public infrastructure investment.[121] In the United States, it is currently cheaper to use long-term tax-exempt bonds than to create a partnership, even if there is a higher expected rate of return.[122] Currently, these partnerships are only utilized when bonds are not a feasible option. That being said, if bonds lost their tax-exempt status, these partnerships could be the next best option.

[113]United States Environmental Protection Agency. "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers."
[114]EPA Office of Water. "EPA's Drinking Water Action Plan."
[115]Ibid.
[116]Ibid, 4.
[117]Kane, Joseph. "Investing in Water: Comparing Utility Finances and Economic Concerns across U.S. Cities."
[118]Ibid.
[119]Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."
[120]Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."; DePonte, Brian. "Navigating New Options for Water Equipment Financing."
[121]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."
[122]Ibid.

On the private side, research indicates there is a bevy of private investors interested in a safe, guaranteed, long-term steady stream of revenue.[123]

c. Benefits of Collaboration, Both Public-Public and Public-Private

Because there is overlap between the benefits of public-private and public-public collaboration, this study combines the assessment of their benefits and challenges.

Benefits are as follows:

- When done properly, partnerships drive down public costs and improve the water infrastructure's "overall efficiency and effectiveness," including higher quality return per dollar and faster turnaround on projects.[124]
- Public-public collaboration allows water structure owners to take advantage of economies of scale, save on operating costs, and potentially attract financing they would not be able to access on their own, both in terms of qualifying for financing and receiving lower interest rates.[125]
- Public-private partnerships provide public water structure owners the opportunity to "preserve or expand infrastructure capacity" in a unique way.[126] For example, it may provide them with access to "new technology, equipment or business processes unique to that private partner".[127]
- Private-public partnerships can provide water structure owners with "expedited and less complicated financing procedures, financially competitive rates, [and] flexible legal arrangements".[128]
- For public-private partnerships, the water structure owner can contractually obligate the private party to maintain a specific rate for the water.[129]
- Public-private partnerships can eliminate upfront, capital investment costs for the public water structure owners.[130] The costs that are incurred can be considered an operating expense because of their pay-as-you-go nature and their contractual ties to the parties.[131]

Challenges are as follows:

- Depending on the state and locality, there are different rules about how partnerships can be conducted and structured.[132]

[123]Ibid; Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."; Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."; DePonte, Brian. "Navigating New Options for Water Equipment Financing."
[124]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."; U.S. Department of the Treasury. "Expanding the Market for Infrastructure Public-Private Partnerships," 2015. https://www.treasury.gov/connect/blog/Documents/Treasury Infrastructure White Paper 042215.pdf
[125]United States Environmental Protection Agency. "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers."
[126]Ibid; Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."
[127]Ibid: Lazerov, Manuel; Fleming, Hu. "Practical Use of Private Equity as a Solution to Infrastructure Development."
[128]Lazerov, Manuel; Fleming, Hu. "Practical Use of Private Equity as a Solution to Infrastructure Development."
[129]Allender, Bruce and Francesca McCann. "Sustainable Water Supply," 2017. https://www.bv.com/docs/sdr/sdr-water-industry.pdf
[130]Ibid; Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."; DePonte, Brian. "Navigating New Options for Water Equipment Financing."
[131]DePonte, Brian. "Navigating New Options for Water Equipment Financing."
[132]Ibid; Andersen, Farrah, et al. "Unlocking Private Finance in Sustainable Infrastructure."

- For the projects to be of interest to the private sector, they must produce stand-alone revenues.
- If the partnership fails, there can be significant consequences (financial, legal and political).[133]
- It can be difficult to appropriately assess risk and ensure that it is equitably distributed.
- For public-private partnerships, the private partner assumes the risk that the partnership will change with the political winds.
- For both types of partnerships, partners must do their due diligence to ensure the financial stability of their chosen partner(s).
- Partnerships must be built on trust, sharing of risks and long-term planning.

d. Examples of Partnerships

One example of a public-public partnership comes from Rancho Cucamonga, which participates in a special water district. To learn more about the arrangement, see the discussion in the interview section of this report. Another example of a public-public partnership comes from Allentown, Pennsylvania, which illustrates how public-public partnerships are similar to public-private ones. The City of Allentown was struggling to pay city expenses and needed a creative solution to raise revenue. It found a solution in partnering with Lehigh County Authority (LHA) (a public utility). Under the agreement, Allentown leased its drinking and wastewater systems to LHA for 50-years and received $211.3 million; in return the LHA receives user-fees from the systems.[134] This lease allowed the city to pay off all its bonds related to water infrastructure and cover other city expenses.[135]

Another example of public-private cooperation comes from the City of Seattle. In 2015 Seattle partnered with CH2M Hill to build a new water filtration plant.[136] CH2M was given standards it had to meet and the latitude to decide how to do so. The company created cutting-edge technology that allowed the City to provide cleaner water "at a lower overall cost for virtually no up-front investment."[137]

Tax-exempt leasing is another form of public-private partnership. In this type of arrangement, water structure owners set up an "installment sale financing transaction" with equipment manufacturers.[138] This relationship allows the manufacturer to sell equipment to water structure owners with a loan. The manufacturer pays no income tax on the interest of the lease and in turn the interest rate on the water infrastructure owner's loan is decreased.[139] We found an example of this type of arrangement in Colorado City, Colorado, which needed to expand and upgrade its drinking water treatment facilities to meet the growing community's need. The city needed to complete the project quickly and cost-effectively but did not have the available financing or time

[133]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."
[134]Mastracchio, John, Eric Petersen and Tom Huestis. "New and Emerging Capital Providers for Infrastructure Funding."
[135]Ibid.
[136]Marlowe, Justin. "Municipal Bonds and Infrastructure Development – Past , Present and Future."
[137]Ibid; DePonte, Brian. "Navigating New Options for Water Equipment Financing."
[138]Nolan, Bruce. "Funding Water and Wastewater Projects: Growing Communities Seek Strategic Alternatives."
[139]Ibid.

to deal with other financing sources.[140] Utilizing a tax-exempt lease with one of its main contractors, the city was able to start construction quickly and because their one private partner was providing both financing and equipment, the process was more efficient, "streamlined[,] and less costly."[141]

3. Best Practice: Blending Funding and Financing

Finding a single source that can fully fund infrastructure projects is a challenge for water structure owners.[142] Blending funding and financing provides an avenue to deal with this all-too-common issue.

As both the interviews and literature have shown, user fees provide a large portion of current budgets for repair and maintenance. Because user fees are the preferred method of paying for infrastructure, they should be maintained as a funding option but paired with other sources to allow for the financing of larger projects.

Blending funding and financing and partnerships are closely connected. Blending funding and financing is a way to make public partnerships successful.[143] Blending sources via a partnership can provide water structure owners with access to different, and oftentimes larger, funding streams than they could have access to on their own.[144] Creating partnerships can also be a piece of blending funding and financing options. For example, water structure owners can work with private organizations to close the gap if they have inadequate funding for projects.[145]

Blending funding and financing has many benefits:

- Blending sources provide water structure owners with more options to pay for infrastructure.[146]
- Combining funding and financing, in conjunction with partnerships, allows water structure owners to conduct larger, more comprehensive infrastructure projects than they may be able to complete on their own, or with just a single source of funding or financing.[147]
- Finance blending can lower overall costs, for example by allowing water structure owners to manage their interest rates on bonds and other financing mechanisms.[148]

However, blending funding and financing also presents challenges. For example, balancing several sources of funding and financing can be complicated and requires oversight, management

[140]Ibid.
[141]Ibid.
[142]United States Environmental Protection Agency. "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers."
[143]Ibid.
[144] Ibid.
[145] Lazerov, Manuel; Fleming, Hu. "Practical Use of Private Equity as a Solution to Infrastructure Development."
[146]United States Environmental Protection Agency. "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers."
[147] Ibid.
[148]Ibid; Mastracchio, John, Eric Petersen and Tom Huestis. "New and Emerging Capital Providers for Infrastructure Funding," 2016. http://www.waterrf.org/PublicReportLibrary/4617.pdf.

and continual coordination, which may be difficult for water infrastructure owners who already lack the administrative capacity to apply for federal financing.[149]

One example of blending funding and financing comes from the City of Bend, Oregon. The city needed to build a new water treatment plant and paid for it three ways: 1) with money the city had saved in its water fund, 2) with user-fees, and 3) with a loan. After the plant was completed, the city took out municipal bonds at a lower interest rate and used them to pay back the loan. The bonds were "tied to the revenue generated from the operation … of the City's water system and … fees."[150]

[149]Ibid.
[150]Ibid.

VII. Economic and Public Health Benefits of Water Infrastructure Investment

Thus far this analysis has explored financing options and best practices. This section explains economic and public health benefits associated with water infrastructure investment.

A. Background

1. Area of Study

The area of study in this instance will be all 50 states. Since we are seeking a nationwide estimate of the value of water infrastructure investment, the area of study will necessarily include the entire nation. Since the area of study is the United States, there will be minimal financial leakage outside of the study area (most of this would go to manufacturers in Canada or Mexico). For the purposes of this analysis, no direct estimate of financial leakage will be obtained, but rather will be implicitly included in the multiplier.

2. Counterfactual

The counterfactual for this analysis is a continuation of current funding levels. Based on the "Economic Impact of Water Infrastructure" report, aggregate annual capital expenditures on water infrastructure are approximately $41 billion.[151] This includes national, state and local spending. To determine the direct economic impact of these capital expenditures, a multiplier is used to estimate indirect and induced spending.

3. Time Horizon

This study is based on the expected useful life of a new drinking water pipe. A report by the Texas Association of Clean Water Agencies cites the expected useful life of water pipes to be between 70 and 100 years, depending on the material the pipe is made of and the conditions of the ground in which it is placed.[152] The EPA has cited an effective useful life of between 60 and 100 years. For a conservative estimate, this analysis will round those estimates down to a 50-year expected useful life.

B. Direct Economic Impact

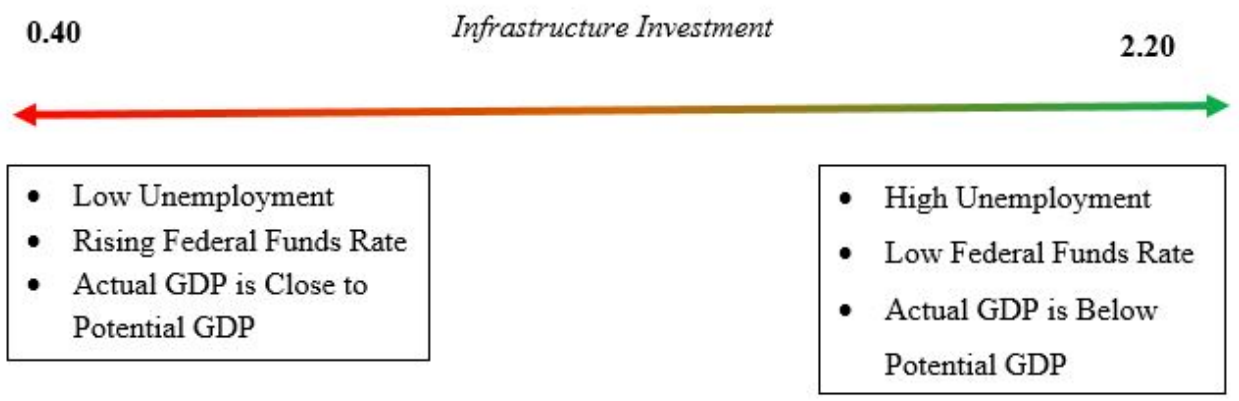
Previous studies have found that economic impact of government spending depends partly on both current economic conditions and on the form of government spending. Generally, government spending increases economic output more when the economy is worse overall. While there are ranges of potential forms of government spending on water infrastructure, this report will focus on direct government spending. In the short term, increased government spending is likely to boost economic output, while potentially dragging down long-term economic output (if the spending is debt-financed).[153]

The multiplier used in this analysis is based on the Congressional Budget Office's range of estimated multipliers for infrastructure spending. We used this multiplier because CBO's analysis most closely resembles the type of investment needed for water infrastructure. For

[151] "The Economic Benefits of Investing in Water Infrastructure."
[152]Randy McIntyre, "Determining Condition and Effective Useful Life of Pipelines Using Statistical Models," Presentation, Event by Texas Association of Clean Water Agencies, July 29, 2016.
[153]Jeffrey M. Stupak, "Economic Impact of Infrastructure Investment," *Congressional Research Service* 18 July 2017.

example, it directly includes water infrastructure as an example of federal transfer payments to states and localities for infrastructure spending. CBO's estimate is based primarily on macroeconomic forecasting models, with some input from time series models and dynamic general-equilibrium models.[154] In its latest analysis of the American Reinvestment and Recovery Act, CBO estimated output multipliers between 0.4 and 2.2 for transfer payments from the federal government to states and localities for infrastructure (the provisions of the ARRA that apply directly to water infrastructure spending).[155] Essentially, that means, depending on a variety of factors, **$1 of investment in water infrastructure may generate between $0.40 and $2.20 in economic activity**. It may be confusing to see that a $1 in investment could generate less than a dollar in economic activity (in other words, the spending costs more money than it generates). This occurs primarily when the spending by the government, generally debt-financed, crowds out private investment, which leads to reduced output over the long-term. The range presented by CBO includes a certain amount of uncertainty, but the majority of the difference between the high estimate and the low can be attributed to underlying economic conditions as well as Federal Reserve responses to changing economic conditions and government policies. Figure 1 (below) presents some examples of conditions that could depress or elevate the economic multiplier.

Figure 1: How Economic Conditions May Influence the Multiplier Associated with Infrastructure Investment



C. Public Health Impacts

Aside from economic impact, the value of investing in water infrastructure can also be demonstrated by examining the impacts it has on public health. Here, the public health impacts will primarily be examined through two channels: disease prevention and educational outcomes.

1. Disease and Loss of Life

Aging water infrastructure can be tied to outbreaks of certain waterborne illnesses resulting in particular from cross-connections and backsiphonage.[156] Aging water infrastructure heightens the risks of waterborne disease. The impact of investing in water infrastructure on preventing

[154]Felix Reichling and Charles Whalen, "Assessing the Short-Term Effects on Output of Changes in Federal Fiscal Policies," Congressional Budget Office, 2012.
[155]Congressional Budget Office, *Estimated Impact of the American Recovery and Reinvestment Act on Employment and Economic Output in 2014*, Washington: CBO, 2015, 6.
[156]Craun and Calderon, "Waterborne Disease Outbreaks Caused by Distribution System Deficiencies."

diseases and life loss will be assessed based on a panel of select illnesses that tend to be waterborne. This panel is based on Centers of Disease Control and Prevention (CDC) studies of major water borne illnesses and includes *E. coli*, Legionnaires Disease and other pathogens.

Since 1971, the CDC has published annual waterborne disease outbreak reports in which the agency tracks outbreaks of certain waterborne illnesses that can be linked to drinking water systems. From 1971 to 2014, CDC estimates that there was an average of 711 drinking water related infections (95% confidence interval: 698 to 724) for this panel of illnesses. Of those, the plurality are norovirus infections (about 38%), followed by *Shigella*, non-*Legionella* bacteria (the vast majority of which are *Campylobacter* infections), *E. coli* and *Legionella* infections (in that order).

USDA estimates the annual costs of various illnesses through its Economic Research Service. These estimates include analysis of productivity losses, hospital stays, and the cost of treatment. Table 1, below, presents the mean, low and high per infection cost estimates for each of the diseases analyzed in this report. The data on *Legionella*, the agent that causes Legionnaires' Disease comes from a separate article.[157]

Table 1: USDA ERS Estimates of the Costs for Certain Illnesses

Illness	**Low Cost Estimate**	**Median Cost Estimate**	**High Cost Estimate**
E. coli	$1,488.91	$4,421.65	$8,195.68
Legionella	-	$26,912.18	-
Non-*Legionella*	$2,348.30	$2,759.51	$2,965.21
Norovirus	$409.33	$424.92	$439.08
Shigella	$419.59	$1,081.43	$1,961.52

Source: US Department of Agriculture, Economic Research Service and Collier et al. (2012)

Since 1971, approximately 10% of drinking water outbreaks have been linked to deficiencies in public water distribution systems. That is likely an underestimate because, as the infrastructure ages beyond its useful lifespan, problems are likely to be more severe. This means that the recent rate is probably larger than 10%, if not significantly larger. For a conservative estimate, however, a 10% reduction will be used to give an estimate for the effect of preventing these illnesses. That would result in about 71 fewer infections per year (28 norovirus, 20 *Shigella*, 18 non-*Legionella*, 5 *E. coli* and 1 *Legionella* infection) and that reduction would be worth between $102,411.52 and $175,808.53 per year. Once a discount rate is applied, the total benefit over the time frame, then, would be between $1,869,617.08 and $3,209,547.42.

[157]Collier, S.A., L.J. Stockman, L.A. Hicks, L.E. Garrison, F.J. Zhou and M.J. Beach. "Direct Healthcare Costs of Selected Diseases Primarily or Partially Transmitted by Water." Epidemiology and Infection 140, no. 11 (2012): 2003–13.

2. Impact of Lead on Educational Outcomes

Until 1986, U.S. law allowed lead service lines to be used in water systems. This is a primary contributor to elevated blood lead levels in the country, especially in young children who are more vulnerable to lead exposure for a variety of reasons. Children are more likely to ingest lead at a young age due to natural infant instincts. Most infants exhibit "mouthing" behavior, or placing objects in their mouths, as a way of discovering their environments. Second, children's gastrointestinal tracts absorb more than older adults. Finally, lead is more toxic for a developing nervous system as compared to a fully developed one. As recently as 2012, the CDC released an advisory on the effect of low-level lead exposure on children.[158] This indicates that lead is an environmental contaminant that continues to affect children, despite a spate of regulations designed to reduce the public's exposure to lead and a vast reduction in the average blood lead level of an American child. The CDC National Health and Nutrition Examination Survey estimates that the average blood lead level for a survey period from 2011 to 2012 was between 1.28 µg/dL and 1.36 µg/dL.[159]

Lead service lines are linked to worsened educational outcomes and thus lower earning potential for those exposed, especially those exposed around the age of two. Lead service lines corrode over time and lead infiltrates the water. The waterborne lead is ingested by humans and ends up in the body, resulting in elevated blood lead levels (one way of measuring how much lead is in a particular person). Those blood lead levels have been linked to lower IQs as well as other measures of intellectual development. That, in turn, tends to result in lower educational outcomes, which results in lower earnings.[160]

3. Lead Service Lines and Lead Levels in Drinking Water

A national survey that attempted to estimate how many lead service lines were in use and how many households receive their water from those lines concluded that there are between 5.5 and 7.1 million lead service lines in use. Those lines are estimated to serve between 15 and 22 million people (between 5 and 7.5% of the U.S. population at the time of the survey). That is estimated to be between 975 thousand and 1.43 million children living in households served by lead service lines.[161]

One way to estimate how much lead service lines contribute to lead in drinking water is to examine how replacing lead service lines lowers or raises the lead level in drinking water. Trueman, Camara, and Gagnon found that full replacement of lead service lines was associated with a reduction in waterborne lead between 50% and 80%.[162] In a study of its water system, District of Columbia Water and Sewer Authority (now DC Water) estimated that lead service lines contributed 58 µg/dL (95% Confidence Interval: 42 µg/dL to 74 µg/dL) of lead to drinking water on average.[163]

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[158] "Low Level Lead Exposure Harms Children: A Renewed Call for Primary Prevention."
[159] Survey, "Cadmium, Lead, Total Mercury, Selenium, & Manganese - Blood, 2011-2012."
[160] Blundell, Dearden, and Sianesi, "Evaluating the Effect of Education on Earnings: Models, Methods and Results from the National Child Development Survey."
[161] Cornwell, Brown, and Via, "National Survey of Lead Service Line Occurrence."
[162]Trueman, Camara and Gagnon, "Evaluating the Effects of Full and Partial Lead Service Line Replacement on Lead Levels in Drinking Water" (2016).
[163] Sandvig et al., "Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues."

4. Blood Lead Levels

Lanphear et al. (1998) showed that an increase in water lead concentration from background levels to 0.015 mg/L was associated with an increase the percentage of children with blood lead levels exceeding 10 µg/dL by nearly 14%.[164] Similarly, Deshommes et al. found that the presence of a lead service line could be responsible for an increase in blood lead level in children of 0.73 µg/dL.[165] For this analysis, the EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children will be used to estimate how water lead levels will impact the blood lead levels of children under the age of 5.[166] The model estimates that the above water lead level would result in those children having an average blood lead level between 5.76 µg/dL and 7.8 µg/dL. Even the lower bound estimation would be above the current EPA level for children with abnormally high blood lead levels of 5 µg/dL.

5. Lead's Effect on IQ

There is extensive evidence that exposure to lead at a young age impairs cognitive development.[167] Bellinger et al. found that concentrations of lead in children's blood at 24 months was associated with decreased cognitive performance at age 5 and age 10.[168] Specifically, they found that a 10 µg/dL increase in blood lead level at 24 months was associated with a 5.8 point drop in Full-Scale IQ at 10 years of age. Wasserman et al., in an examination of the effect of pre- and postnatal lead exposure in the former Yugoslavia found that an increase in post-natal blood lead levels by 50% (over pre-natal levels) was associated with a decrease in IQ by 2.82 points (the confidence interval was 0.52 – 4.91).[169] Canfield et al. found that an increase in lifetime average blood lead level of 1 µg/dL was associated with a 0.46-point decrease in IQ (-0.76 points to -0.15 points).[170] That confidence interval can then be applied to estimates of blood lead levels found using the EPA's IEUBK Model to estimate a range of IQ loss for children that are exposed to water-borne lead. That estimate would be between 0.86 and 5.93 points.

6. IQ and Earnings

While IQ as a metric has its own problems, it is useful as a proxy for intelligence or ability. There is literature suggesting that IQ loss (or a lower IQ at the baseline) lowers lifetime earnings. Barth et. al. (1984) found that a decrease in IQ by 1 point was associated with a decrease in lifetime earnings between 0.2% and 0.75%. Schwartz estimated in 1993, based on previous panel studies, that lead exposure equivalent to a one point drop in IQ would decrease lifetime earnings by 0.79%. In a later meta-analysis, Schwartz found an overall drop of IQ by 0.245 points per µg/dL increase in blood lead level.[171]

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[164]Lanphear et. al., "Environmental Exposures to Lead and Urban Children's Blood Lead Levels," *Environmental Research* 76, no. 2 (1998): 126.
[165]Deshommes et al., "Application of Lead Monitoring Results to Predict 0–7 Year Old Children's Exposure at the Tap" (2013).
[166] "Short Sheet: Overview of the IEUBK Model for Lead in Children."
[167]See Byers and Lord (1943) and Koller et. al. (2004) for examples of this.
[168]David C. Bellinger, Karen M. Stiles and Herbert L. Needleman, "Low-Level Lead Exposure, Intelligence and Academic Achievement: A Long-Term Follow-up Study," *Pediatrics* 90, no. 6 (1992).
[169]Wasserman et al., "The Yugoslavia Prospective Lead Study: Contributions of Prenatal and Postnatal Lead Exposure to Early Intelligence" (1999).
[170]Canfield et al., "Intellectual Impairment in Children with Blood Lead Concentrations below 10 Mg per Deciliter" (2003).
[171] Schwartz, "Low-Level Lead Exposure and Children's IQ: A Meta-Analysis and Search for a Threshold" (1994).

Taken together, those studies conclude that a reduction in blood lead level by 1 µg/dL would decrease earnings by $1,300 (1993 USD) per year. Nevin et. al. (2008) used a value of $16,809 per IQ point to estimate the value of reducing environmental lead around young children. Gould (2009) estimates that a point of IQ loss is equivalent to a reduction in lifetime earnings of $17,815 (2006 USD). Using Gould's estimate, the range of IQ drops presented above would result in lifetime earnings losses (in 2006 USD) between $15,320.90 and $105,642.92.

If that estimate of lost earnings is used in combination with the estimate of the number of children who are served by lead service lines, the overall educational benefit of replacing those lines can be estimated. That would be between $14,937,877,500 and $151,069,375,600 (2006 USD) in lifetime earnings.

7. Overall Public Health Estimate

When the estimates for the benefits for disease prevention and lead reduction are combined, the total is between $14,939,747,117 and $151,072,585,147. The low end and the high end of that range can be divided by the total amount of spending for the time period to reach our conclusion. The combined estimate of overall benefit from diseases prevented and improve educational outcomes is between **$142 and $1,438 per dollar spent on water infrastructure.**

VIII. Looking Forward

There are several steps that can be taken to leverage the findings of this report, including:

A. Encouraging Congress to:

- *Maintain Tax-Exempt Financing Options.* Research suggests that capping or eliminating the tax-exemption for bonds would have a significantly negative effect on infrastructure investment and increase financing costs for water infrastructure by as much as 15%.[172] Maintaining the tax-exemption is critical to continued infrastructure investment.
- *Promote Partnerships, Both Public-Public and Public-Private.* Although they are not currently in widespread use across the United States, public-private partnerships stand to benefit both the water structure owners, who may not have the capacity to handle their water infrastructure issues, and private investors who can receive stable long-term revenues. Public-public partnerships also allow owners to build capacity while accessing larger pots of funds and making their water infrastructure better.

B. Encouraging water structure owners to assess the state of their infrastructure and plan for upgrades.

As evidenced by interviews and the past research of the GAO, water infrastructure owners often have no strategic plan for improving their systems. Only by assessing the age and integrity of their current systems and identifying areas of need can owners enact a strategy for financing. These assessments are essential steps that must be taken before any sustainable financing plan can be formulated. Moreover, comprehensive system assessments are more likely to uncover potential health risks early, aiding municipalities in avoiding outbreaks of waterborne pathogens and carcinogens.

C. Request GAO further investigate the effectiveness of federal financing options.

Interviews suggest public water structure owners are not interested in utilizing federal options because of the 'strings attached' and research shows many localities simply lack the technical capacity to meet federal requirements. In September 2017 GAO released a report on federal water infrastructure and challenges agencies have faced in financing projects.[173] A further investigation could be conducted to understand what adjustments Congress and federal agencies could make to become more appealing options for water structure owners.

[172]National Association of Clean Water Agencies and Association of Metropolitan Water Agencies. "The Impacts of Altering Tax-Exempt Municipal Bond Financing on Public Drinking Water & Wastewater Systems."
[173]Government Accountability Office. "Drinking Water and Wastewater Infrastructure: Information on Identified Needs, Planning for Future Conditions and Coordination of Project Funding."

D. Conduct further research into:

- *Lead Infiltration into Pipes.* How much lead enters into drinking water is dependent on a variety of factors, including soil conditions, water acidity and agressiveness, time from treatment plant to faucet, and weather conditions. A more complex model could account for these factors in estimating how much lead enters into water over time. Another complication with modeling lead infiltration on a national, or even regional scale is that no one is certain how many lead pipes are currently in use. This lack of certainty will naturally hinder investigation into the scale of the harm generated by lead pipes.
- *Public Health Impacts of Water Infrastructure.* While this analysis was able to shed some light on the public health benefits of investing in water infrastructure, the analysis is intentionally conservative. Monetizing public health benefits is a burgeoning field and there is a potential to understand the benefits in a more holistic manner. Other potential health impacts, including certain particulates and more minor illnesses, could be included in future analyses. In addition, there is more research to be done on the exact connections between health and water infrastructure.
- *Comparing Water Structure Owners.* With the lack of consistency in metrics and comprehensive research, there is a gap when it comes to understanding how water structure owners compare and benchmark against other owners. There are a variety of conditions that affect how water structure owners operate. However, further research on methods of comparing owners will allow state and local policy-makers to form more context-dependent policies.

XI. Conclusion

Access to reliable, affordable and clean water in America is predicated upon water system owners making proactive investments in infrastructure. This report seeks to present a holistic view of the state of underinvestment in water infrastructure in America and the threat this poses to health and economic vitality.

By reviewing the literature on funding and financing mechanisms at all levels of government and private industry and interviewing water system owners, this report presents a comprehensive view of the many kinds of solutions that localities across the country are employing to meet their water needs. A key lesson from these distilled best practices is that local solutions have the potential to be the most effective. One essential thread found throughout the best practices is the importance of maintaining access to tax-exempt financing. Whether it is through bonds or public private partnerships, tax-exempt financing is essential to ensuring infrastructure investment continues.

Empirically, this report contributes to the literature by providing an analysis of the return on investment for water infrastructure which quantifies and considers the significant public health benefits of a well-maintained water system. Our findings suggest that the narrative on water infrastructure investment needs a change in perspective. Lawmakers should be aware that water infrastructure is fundamentally different than other types of infrastructure. It may not be as visible as other parts of the built environment, but it is foundational to the health of our communities. In this sense, every dollar invested in water infrastructure is an investment in a future that is both healthy and productive for all Americans.

IX. References

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