The Economics of Reliability

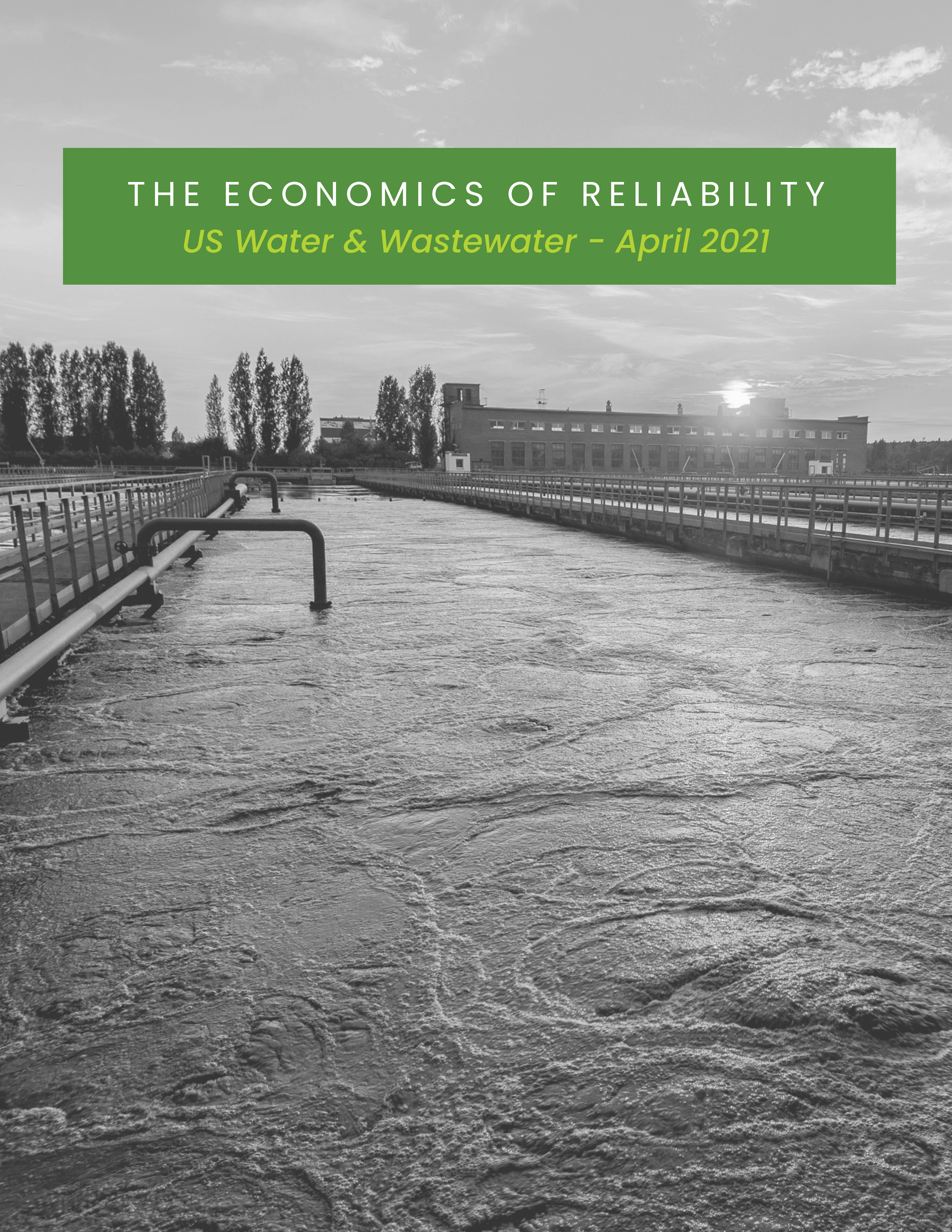
US Water & Wastewater

PINNACLE

DATA-DRIVEN RELIABILITY

THE ECONOMICS OF RELIABILITY

US Water & Wastewater - April 2021



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On average, 40% of an operator's O&M expenses are allocated to reliability-related activities.

LETTER FROM THE CEO

At the beginning of this year, an unprecedented freeze hit the southern part of the United States. The state of Texas, which has its own, self-contained energy grid, saw power outages that it had never experienced. At one point, nearly six million Texans were without power. The Electric Reliability Council of Texas (ERCOT) had managed the power system since 1970. Over those 50 years, the organization worked to ensure adequate power was available by forecasting power needs, regulating pricing, and monitoring the amount of generation available at any given time. The grid was designed to achieve reliability through the redundancy of building extra infrastructure to provide extra capacity if a unit went down. The great freeze exposed this strategy as inadequate. Redundancy only works when the pieces of a system don't affect one another or when one event can't affect all the pieces. The freeze slowed multiple power facilities which affected gas supplies, which then affected other facilities, causing a crisis to occur. This crisis identified a lack of optimization and a lack of calculation of system-wide risk.

For the past half century, private companies in commercial industries have worked constantly to improve reliability. Almost all large, complex processing facilities in the manufacturing, mining, chemicals, power generation, and refining industries have seen their reliability improve and their costs reduce. This was not achieved through redundancy. On the contrary, redundancy adds more cost per product made, not less. Most of these gains were made by commodity business arenas where competition built out new facilities and made enough product to fill demand. Once supply met demand, adding additional capacity to ensure reliability became costly. Instead, to be competitive, operators worked to get more out of existing facilities by optimizing their spend alongside their production.

In municipal arenas, the adoption of these strategies has been much slower to take hold. A project that builds more water capacity may be simple to understand and easy to fund, but optimization is hard to quantify and even more difficult to measure up front. Plus, with populations growing, there is a need to add capacity, resulting in these types of projects being prioritized.

This situation has also been prevalent in other industries. In the 1960s, the US refining industry was in a hyper-growth mode. The world was hungry for more fuel and we needed more refineries to produce it. From 1950 to 1980, the country added nearly 100 refineries, which peaked around 300 in 1980. However, improved auto efficiency and competition made the market much more difficult and over the course of the 1980s, the strategy began to change. By 2020, only 140 refineries were left in the country and they produced more refined product than the 300 did in 1980.

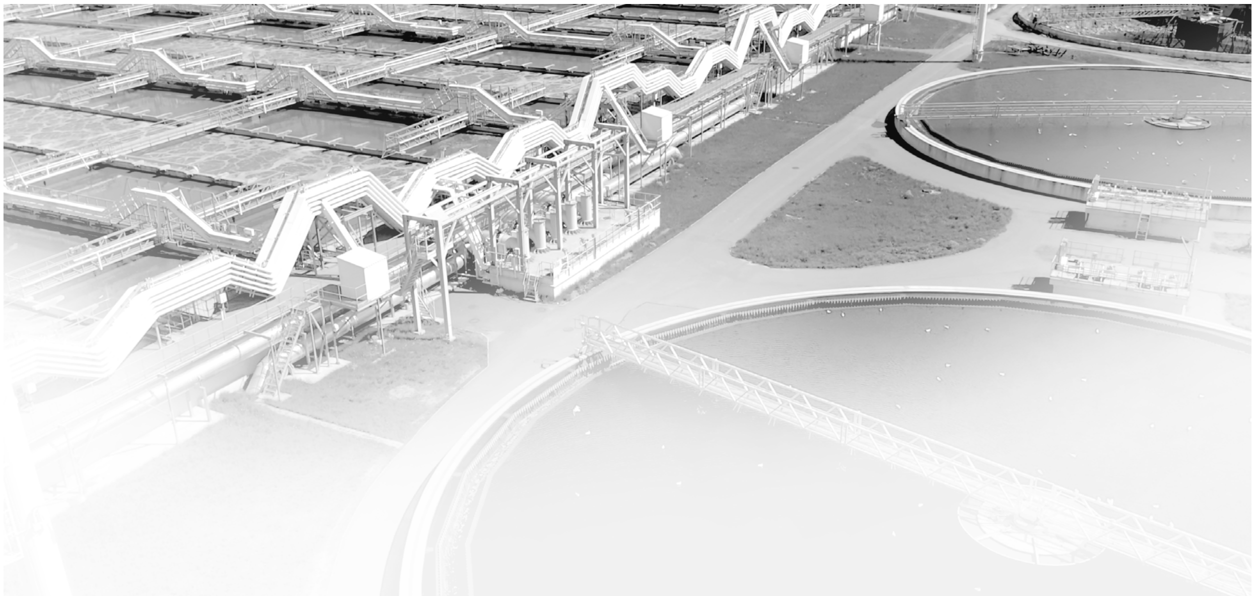
Water is our most basic need and therefore our most precious resource. Managing wastewater is equally important. We are often not aware of these because we have built enough capacity that we rarely run into shortages. However, when a natural disaster makes water unavailable or backs up our sewage, everything else stops. Governments make everything else a second priority until water services are returned.

As we completed the analyses shown in this report, I was surprised at the trends. The US's water facilities are spending more on operations and less on capital, meaning that we are not expanding the number of assets but are spending more to manage older assets. This is incongruent with a growing population. If these trends continue, we will be faced with a difficult choice in a few years: substantial water restrictions or massive investments in new assets that ratepayers will painfully bear.

The other option is to change the trend. One of the key insights from our analysis is that the water industry can optimize their operations by learning lessons from industries that were forced to improve efficiency over the past 40 years. If the lessons, ideas, and solutions that improved US refining are applied to the water industry, a new trend can emerge: lowered operating costs, improved throughput, and more efficient investment in improvements. In other words, for the same money ratepayers spend today, US water supply can be more reliable and produce more water for decades to come.

This report analyzes the reliability economics for the US water industry and provides insights into the future of our most valuable commodity. I look forward to talking with others about how we can make the next big leaps in water reliability.

Sincerely,
Ryan Sitton
Founder and Chief Executive Officer



INTRODUCTION

Water processing facilities, whether freshwater or wastewater, are crucial to modern society. They sustain life, protect public health, and lubricate our economic machinery. It is surprising, then, how often we fail to think about these facilities. We expect them to run without failure. On the rare occasion that we lose freshwater or sewage service, we get a harsh reminder of exactly how important the reliability of our water infrastructure is.

RELIABILITY – ITS DEFINITION AND IMPACT

What is reliability? In our analyses, we define reliability as the measure of how often something runs when you want it to. As we think about the economics of reliability, this draws into consideration how organizations make investments to maintain or improve reliability. In other words, are they being effective in their pursuit of reliability, or not?

The world of water has some important nuances that set it apart from other industrial facilities. Since water and wastewater facilities are almost always built as a part of a development, connected directly to homes or buildings, and owned by local governments, they have no competition. Unlike refineries or chemical plants, water utilities do not have pressure to be profitable to avoid layoffs. They do, however, have a different pressure: to keep water rates low for the citizens they serve.

As populations are growing and infrastructure is aging, the quest to maintain affordable water for residents is becoming a more urgent challenge. And since reliability is a requirement, the main question for city managers, utility operators, and other municipal stakeholders is this: How do I spend money in the most effective ways to ensure our water infrastructure, and therefore the supply of water, is reliable?

Historically, much of the strategy in water management has been redundancy. That is, building extra infrastructure to provide extra capacity. That way, if there is a problem with one facility, there is extra capacity to take its place. One problem with this solution is the cost. It costs more to build, and even more to maintain. Learning lessons from other industries that have been on this journey over the past few decades, water processing facilities are beginning to think differently. They are optimizing the reliability of their infrastructure first to lower operating costs and mitigate the need for new capital.

SUMMARY OF OUR REPORT

In this report, we analyze operational and financial data from 40 large municipal water and wastewater operators in the United States. The data comes directly from the operators themselves, often via annual reports or budget documents. We use this data to estimate what the US water and wastewater sector spends annually on reliability-related activities, which include the supplies and labor necessary for repair and maintenance work, along with the engineering work to develop new reliability-enhancing solutions, the cost of sustaining redundant assets, and other similar expenses.

We distilled three insights from our investigation:

1. Water and wastewater operators have a massive opportunity to capitalize on improvements in reliability spend
2. The water and wastewater sectors can apply lessons in other industries and can expect to target similar gains
3. Water and wastewater operators are under investing in assets today, and prevailing environmental and political dynamics will make it even harder to fill this investment gap in the future

Finally, we close with three data-driven conclusions:

- Operations and maintenance spending levels are growing disproportionately to the amount of water produced and to the spending on other portions of water processing. This is due to a lack of optimization of investment, and as facilities grow older, facilities are simply spending more but getting less out of that spend.
- There is a wide disparity in spend level on reliability across facilities. The root causes are difficult to disentangle, given some other large impacts on operations and maintenance (O&M) costs such as proximity to potable water sources. However, by comparing across similarly positioned facilities and overall industry trends, it appears that best-in-class performers spend approximately one third of the amount that industry laggards spend on reliability on a per gallon basis.
- In general, operators are underspending on water infrastructure in the short term. As such, spending on O&M is becoming a larger and larger portion of facility spend. This appears to be driven by a priority to keep overall costs low and by a slow transition to more optimized operations in some regions.

ANALYSIS METHODOLOGY

Our aim in this report is to use data to estimate the financial impact of ***reliability*** on large municipal water and wastewater operators. We have not included an assessment of industrial water operators.

RELIABILITY The property where a productive asset is in condition to serve its intended function.

The ***operators*** we study often manage the totality of the involved infrastructure – potable water sources treatment, storage, transmission, and distribution; wastewater collection; and wastewater treatment and disposal.

OPERATORS Companies, agencies, or institutions whose personnel directly oversee the day-to-day functions of complex process facilities and make the long-term financial and strategic decisions about the facilities' future.

One high-level challenge is around the availability of the data itself. While municipal operators do publish publicly available financial reports, we face three specific obstacles because water and wastewater financial reports:

1. Are not housed in a central repository. As a result, we must collect the data from the website of each entity we want to study.
2. Do not follow the same format, so we must take care to ensure we are collecting like-for-like data when pulling from the reports of different entities.
3. Do not always include all the data we require. As a result, we must sometimes file public records requests to capture everything we need.

Given these constraints, we chose to focus on large US municipal and regional water and wastewater districts. Specifically, we gathered and organized data from 40 such entities which supply water and wastewater services to all or part of 31 large US population centers. For example, we pull data from both King County (wastewater) and City of Seattle (water) to characterize the economics of this sector in Seattle, Washington. In some cases, the city supplies these services for its citizens. In other cases, a regional authority will serve many different population centers, e.g. Great Lakes Water Authority in Southeast Michigan.

In 2019, these 40 operators accounted for nearly 7 billion gallons per day in potable water volumes. According to the US Geological Survey, US public and private water suppliers provide 39 billion gallons of potable water daily.[1] In other words, our chosen portfolio of operators delivers nearly 20% of total potable water volumes across the United States. As a result, we have confidence that we can extrapolate our findings across the wider US municipal water and wastewater landscape.

The water and wastewater sectors are notoriously fragmented. For example, in some cases the city is responsible for collecting sewage, while a regional water authority may manage all the wastewater treatment plants. In other cases, a city water system may not deliver water to all citizens of the city. Some citizens may receive water service from a separate entity. As a result, our analysis is impacted by the various apples-to-oranges issues that exist across the portfolio of operators we study.

As we mentioned, we source data directly from the financial reports of water and wastewater operators. Some industry reports characterizing the performance of this sector rely on survey data.[2] Other reports rely on survey data to feed models, which can then forecast future outcomes.[3] A US federal government report relies on high level data from several federal offices and agencies to give a bird's eye view of ongoing developments.[4]

Our report, however, relies on granular operational and financial data directly from the municipal water and wastewater operators themselves. While this data can be tedious to gather and organize, we get some important advantages in how we can study this data:

- We see as deeply as their publicly reported financial statements allow. For example, in many cases on the expense side we can go beyond the all-in operations and maintenance (O&M) bucket, seeing a breakdown between personnel, materials and supplies, and fuel costs.
- We see variations between different geographic regions as we track the major population centers served by each reporting entity.
- We bridge low-level and high-level views and thus can better understand why the macro results look the way they do.

Specifically, we gather and organize the following information from large municipal water and wastewater operators:

- Water production and/or consumption volumes
- Treated wastewater volumes
- Operating revenues and operating costs at the level of reporting on the relevant financial statements
- Capital asset value, net of depreciation
- Cash spent to acquire capital assets

Some reporting entities break down their operating expenses in considerable detail. When we have sufficient detail, we categorize expenses by whether they are related to reliability or not. We label items like repair and maintenance, materials and supplies, engineering services, and third-party labor as being reliability related.

We purposefully paint with a broad brush here, looking beyond the traditional scope of inspections, preventive maintenance, and reactive maintenance. Given our experience with reliability programs, we know operators find the best outcomes when they view their reliability programs holistically. While component-level challenges are important, system-level constraints, opportunities, and analyses are most important when it comes to broad-based reliability improvement. Our experience working closely with operators motivates these beliefs, which is why we deliberately use a wide lens to consider the economics of reliability.

VALUE OF RELIABILITY

As we mentioned in the analysis methodology section, according to the US Geological Survey, US public and private water suppliers provide 39 billion gallons of potable water daily.[5] According to the US EPA, operators treat 34 billion gallons of wastewater daily.[6] We assume these figures account for activity during 2019. We further assume that per capita water and wastewater usage have remained constant from 2010 through 2019. We then rely on an estimate of the US population for this ten-year window.[7] Combining our flat per capita usage assumption with US population data, we are able to back-calculate an estimate of total potable water and treated wastewater volumes from 2010 through 2019.

After studying the financial reports for 40 large municipal and regional water and wastewater districts, we segmented O&M expenses into reliability costs, personnel costs, utility costs, and other costs. Figure 1 shows the relative size of these segments. We find that, on average, 40% of an operator's O&M expenses are allocated to reliability-related activities.

AVERAGE O&M SPEND BREAKDOWN

Water & Wastewater Operators

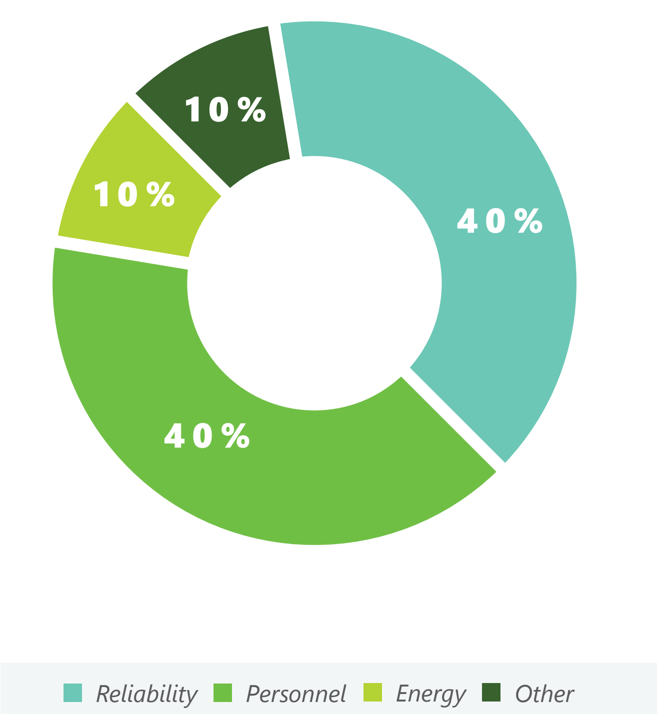


Figure 1. Average O&M Expense Breakdown for Water and Wastewater Operations.

In the reliability cost bucket, we include items like materials and supplies, equipment rentals, and contract and other third-party labor, all of which are used to sustain optimal facility operations. We deliberately take a wide view of reliability. In our experience, customers can invest more dollars in technology, with a greater than one-to-one offset in other buckets like materials and supplies or even labor, if they can eliminate enough low value tasks to require fewer contractors. We used the same wide lens in our Economics of Reliability Interim Report – Global Refining, where we analyzed the global petroleum refining industry using similar techniques.

The historical financial reports from large municipal and regional water and wastewater districts allow us to isolate their annual O&M spend from 2010 through 2019. Using our rule-of-thumb that nominally 40% of O&M spend is reliability-related, we can estimate annual reliability spend across this ten-year window. Figure 2 shows the trend where reliability spend has grown from $17.6 billion in 2010 to $24.7 billion in 2019.

ESTIMATED RELIABILITY SPEND
Water & Wastewater Markets

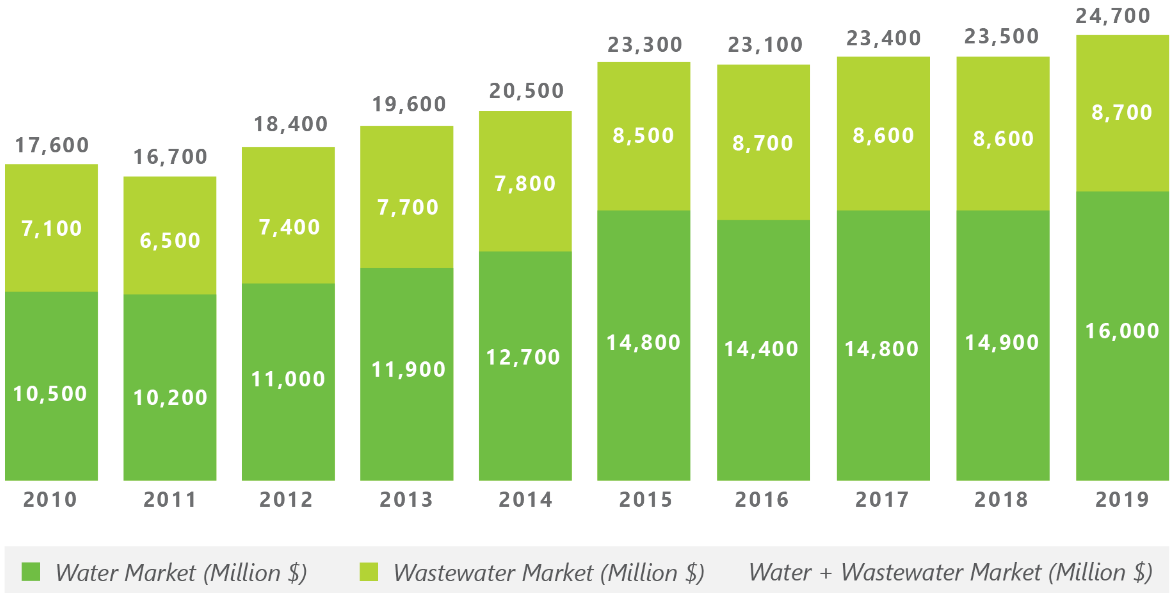


Figure 2. Estimated Reliability Spend in US Water and Wastewater Markets.

We can compare the size of reliability spend in US water and wastewater markets with what we previously found for the US petroleum refining industry.[8] Figure 3 shows this comparison for 2019, where we estimate US water and wastewater operators spent $16.0 and $8.6 billion in reliability-related activities, while US petroleum refiners spent $10.1 billion.

ESTIMATED RELIABILITY SPEND
US Water, Wastewater, and Petroleum Refining in 2019

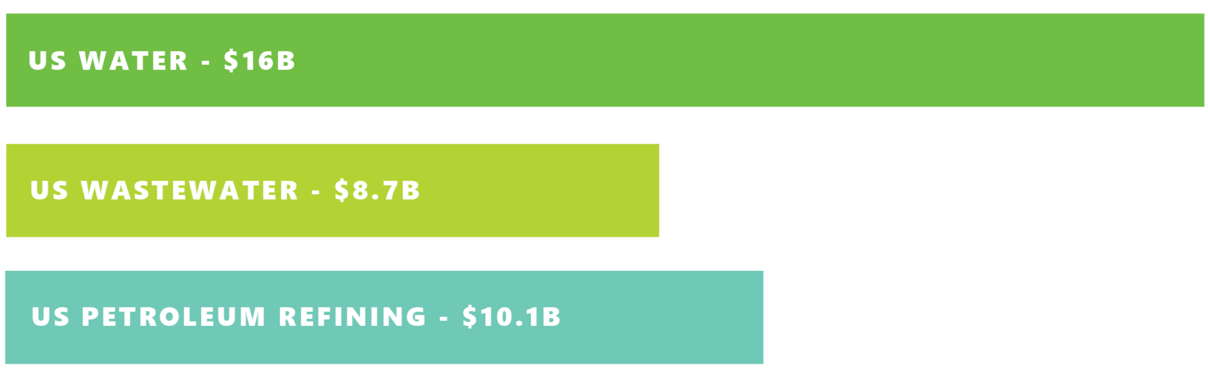


Figure 3. Comparison of Estimated Reliability Spend For US Water, Wastewater, & Petroleum Refining Markets.

We see that, compared with the size of the reliability market in US refining, the US water and wastewater reliability investments are nearly 60% larger and 15% smaller, respectively. Combined, the US water and wastewater reliability spend is nearly two and a half times the size of the US refining reliability market.

This result may surprise energy industry professionals. Refining is often considered a canonical market for reliability because of the high-profile spills, leaks, fires, and explosions that have driven the refining industry to adopt stricter process safety measures. Operators and service companies have invested considerable time and capital in pursuing cutting-edge improvements around operational excellence, sustainability, and reliability.

Water and wastewater markets have a disproportionately low public profile regarding reliability for a few reasons:

1. Water and wastewater systems fail in less visible ways than, for example, petroleum refineries. Refinery fires and explosions capture immediate attention. Water-related failures can be similarly catastrophic, but typically occur in less awe-striking fashion.
2. Water and wastewater systems are typically publicly owned and attract much less interest from private capital. With less private ownership of the infrastructure, and the corresponding decrease in acquisition and divestiture possibilities, the market steers fewer research resources toward deep dive investigations of past, present, and future asset performance. Finally, without these investigations, we have less insight into reliability than we do in industries like petroleum refining, petrochemical processing, and mining.
3. Water and wastewater systems are always on and cannot reduce their throughput. In the chemical world, some plants work on batch schedules, where time between batches offers a natural window for reliability and maintenance work. For petroleum refiners, operators can temporarily reduce their throughput to allow for more disruptive reliability and maintenance interventions. Water and wastewater operators, on the other hand, must operate without interruption. Demand for fresh drinking water is constant. Demand for sewage removal, treatment, and disposal is constant. In the world of water and wastewater, reliability more easily recedes into the background of an always-on operational posture.

So, while the public profile around the reliability of water is usually low, and upsets are not considered taboo, spending levels in water facilities are high relative to other industries simply due to the amount of water that is used. For example, the US uses approximately 337 million gallons of gasoline per day but uses around 350 billion gallons of water (over 1,000 times as much). Even though spending per gallon is notable lower, the total spend for water reliability is high.

US water and wastewater operators spent $16.0 and $8.6 billion in reliability-related activities, while US petroleum refiners spent $10.1 billion.

OBSERVATIONS ABOUT SECTOR PERFORMANCE

SIGNS OF INFRASTRUCTURE UNDER INVESTMENT

The country's largest municipal and regional water and wastewater operators are shifting their spend profile toward O&M and away from capital expenditures. Figure 4 shows the details. In 2010, these operators spent $1.78 per thousand gallons on O&M and $1.58 per thousand gallons on capital expenditures. In 2019, these spend levels grew to $2.19 for O&M and $1.84 for capital expenditures.

Another way to look at this trend is to note that in 2010, capital expenditures were 11% below O&M spend for this group of operators. By 2019, capital expenditures were 16% below O&M spend. The uplift in capital expenditures is not keeping pace with the growth in O&M spend.

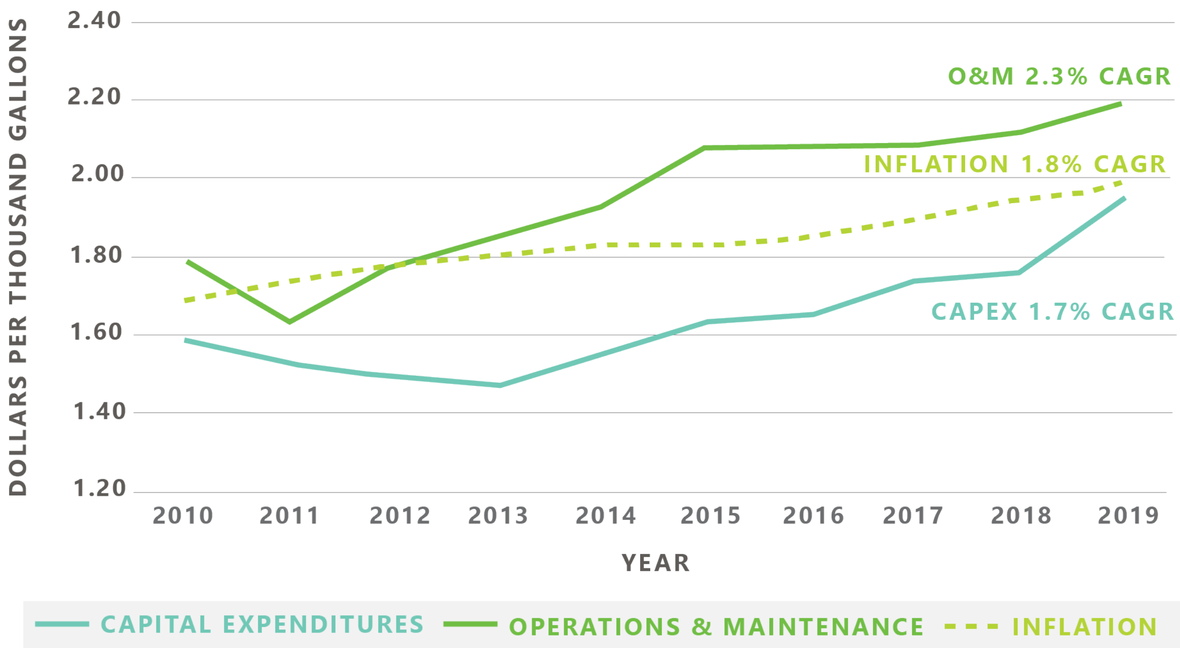
We get to the same outcome by looking at the ***compound annual growth rates (CAGRs)*** of these two categories. From 2010 through 2019, O&M had a 2.3% CAGR, while capital expenditures grew at 1.7%. While six-tenths of a percentage point may not seem like much, in this case it represents a nearly 40% gap between the two growth rates.

> **COMPOUND ANNUAL GROWTH RATES (CAGRs)** The net gain required for an investment to grow to its desired end state, assuming profits are reinvested at the end of each year.

Finally, we can compare these two growth rates against inflation. The dashed line in Figure 4 shows the trend in the ***consumer price index (CPI)***. The starting value in 2010 is arbitrarily chosen to be the average between operation & maintenance and capital expenditure spend levels. The dashed line follows the CPI forward in time. We see that capital expenditures have grown at nominally the rate of inflation, while O&M spend has raced ahead of inflation by about half of a percentage point annually.

> **CONSUMER PRICE INDEX (CPI)** The average change over time in prices paid by consumers for goods and services.

TRENDS
Operations & Maintenance and Capital Expenditures



IN 2010, CAPEX WAS 11% BELOW O&M SPEND

IN 2019, CAPEX WAS 16% BELOW O&M SPEND

Figure 4. Trends in operation & maintenance and capital expenditures for large US water and wastewater operators.

Figure 4 shows us that O&M spend is growing more quickly than capital expenditures. Unfortunately, the chart does not tell us precisely why. We can, though, infer a reliability impact here.

Capital expenditures are either new assets that an operator purchases or upgrades that an operator makes to existing assets. A natural tension exists between capital expenditures and the ongoing expenses that belong to the O&M bucket. As an operator ramps up its capital expenditure program, typically O&M expenses will flatten or even fall, because new or upgraded equipment is generally more efficient and costs less to maintain than older equipment. We also see the opposite phenomenon. If an operator throttles back on its capital expenditure program, ongoing repair and maintenance costs will increase. Rather than replacing older equipment with newer equipment, or upgrading older equipment to overcome its various limitations, the operator will need to spend more to keep the older equipment operational longer as it approaches the end of its useful life.

We can see direct evidence of declining capital investment in Figure 5. This chart compares the cash spent in acquiring capital assets with the value of the capital asset base net of depreciation. These fields both map to the left axis. The right axis shows the reinvestment rate, which equals the cash capital acquisition costs divided by the capital asset value. We see a decline in investment over the past decade. In 2010, water and wastewater operators built, upgraded, or acquired assets with a value equal to roughly 7.5% of their existing assets. By 2019, this reinvestment rate had fallen below 6.0%. Further, each of the reinvestment rates from 2010 through 2015 was higher than each of the reinvestment rates from 2016 through 2019.

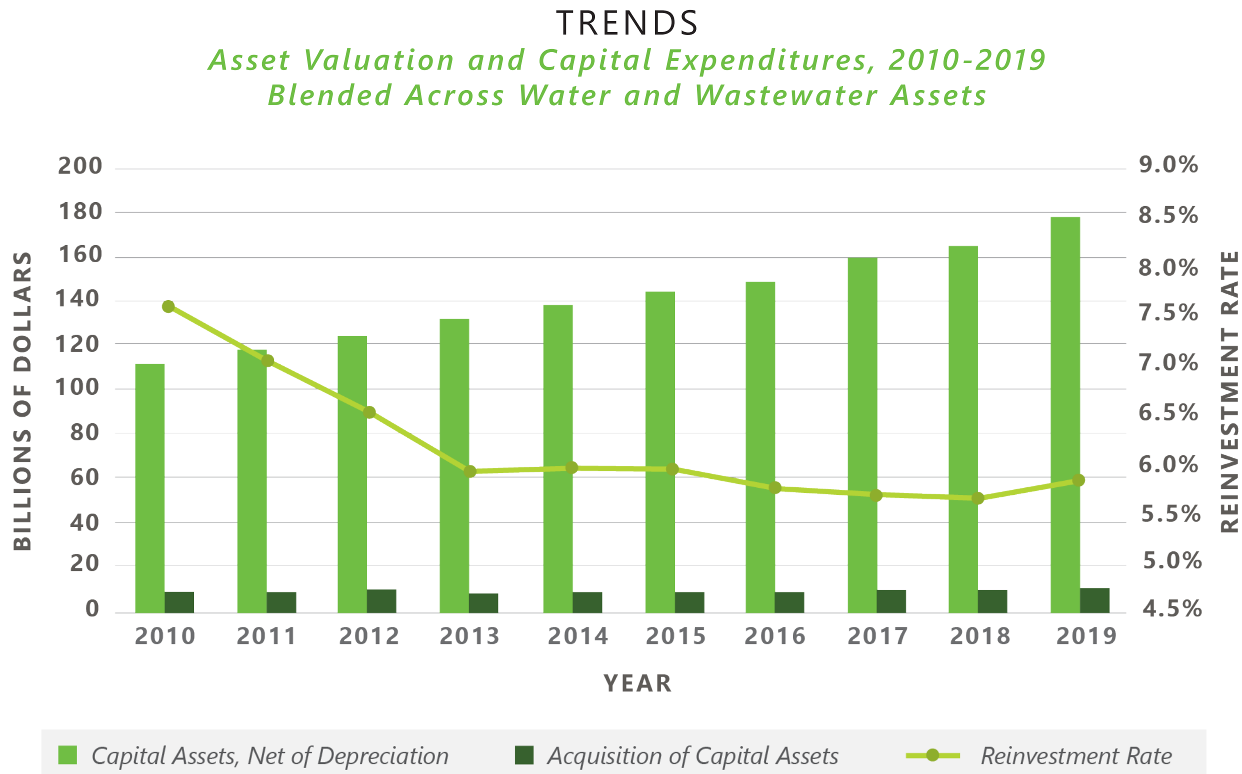


Figure 5. Trends in asset valuation and capital expenditures, 2010-2019.

Operators across the water and wastewater sectors are investing less in their assets when measured proportionally to their existing asset base. The root of the issue is aging infrastructure lives on top of cascading stresses from more extreme weather events, wider threats to public health, and increasing scarcity of fresh water. Even if infrastructure was in good shape on an aggregate basis, operators would face an uphill climb trying to alleviate these stresses. Add in aging infrastructure, and we see ballooning commitments in the O&M domain that starve what would be the budget for capital investments.

One possibility is that operators are spending less on capital because they are spending more on O&M. In other words, in trying to keep rates low to residents, they are spending on short term requirements for maintenance, but pushing off capital improvements, upgrades, or new facilities.

The results we see in Figure 4 and Figure 5 are consistent with observations in three recently released industry reports:

- In 2020, the American Society of Civil Engineers (ASCE) and the Value of Water Campaign published a report titled "The Economic Benefits of Investing in Water Infrastructure".[9] In the report, we see comparisons of actual spending on water infrastructure – drinking water, wastewater, and stormwater systems – with the spending levels required to return this infrastructure to good condition, in which it poses minimal risk of material failure. The report authors note that local, state, and federal spending on water infrastructure in 2019 totaled $48 billion, compared with investment needs of $129 billion. In other words, in 2019 alone the US suffered an $81 billion deficit in necessary water infrastructure spending. Actual spending only covered 37% of the total need.

- In March 2020, Black & Veatch surveyed 300 stakeholders in the North American water and wastewater industries. Nearly 80% of respondents listed "aging water and wastewater infrastructure" as the most challenging issue they face today.[10]
- In November 2019, the American Water Works Association surveyed over 3,000 water professionals about the state of the industry.[11] The challenge of "renewal and replacement of aging water and wastewater infrastructure" was reported as the most critical issue.

O&M EXPENSE PROFILES VARY DRAMATICALLY ACROSS THE US

The financial results of large municipal and regional operators reveal another interesting reality – O&M expenses can vary by a factor of five from the lowest cost operators to the highest cost operators. Figure 6 shows the data, specifically total operating costs per thousand gallons of treated water and wastewater. By total operating costs, we mean all of the O&M costs plus the depreciation and amortization charges. We see the lowest operating costs in the range of $1.50 per thousand gallons, while the highest operating costs are over $7.00 per thousand gallons. Likewise, we see large variations in the fluid volumes processed by these operators. The low end of the range we cover is just over 100 million gallons per day of combined water and wastewater flows, while the high end is over 2 billion gallons per day.

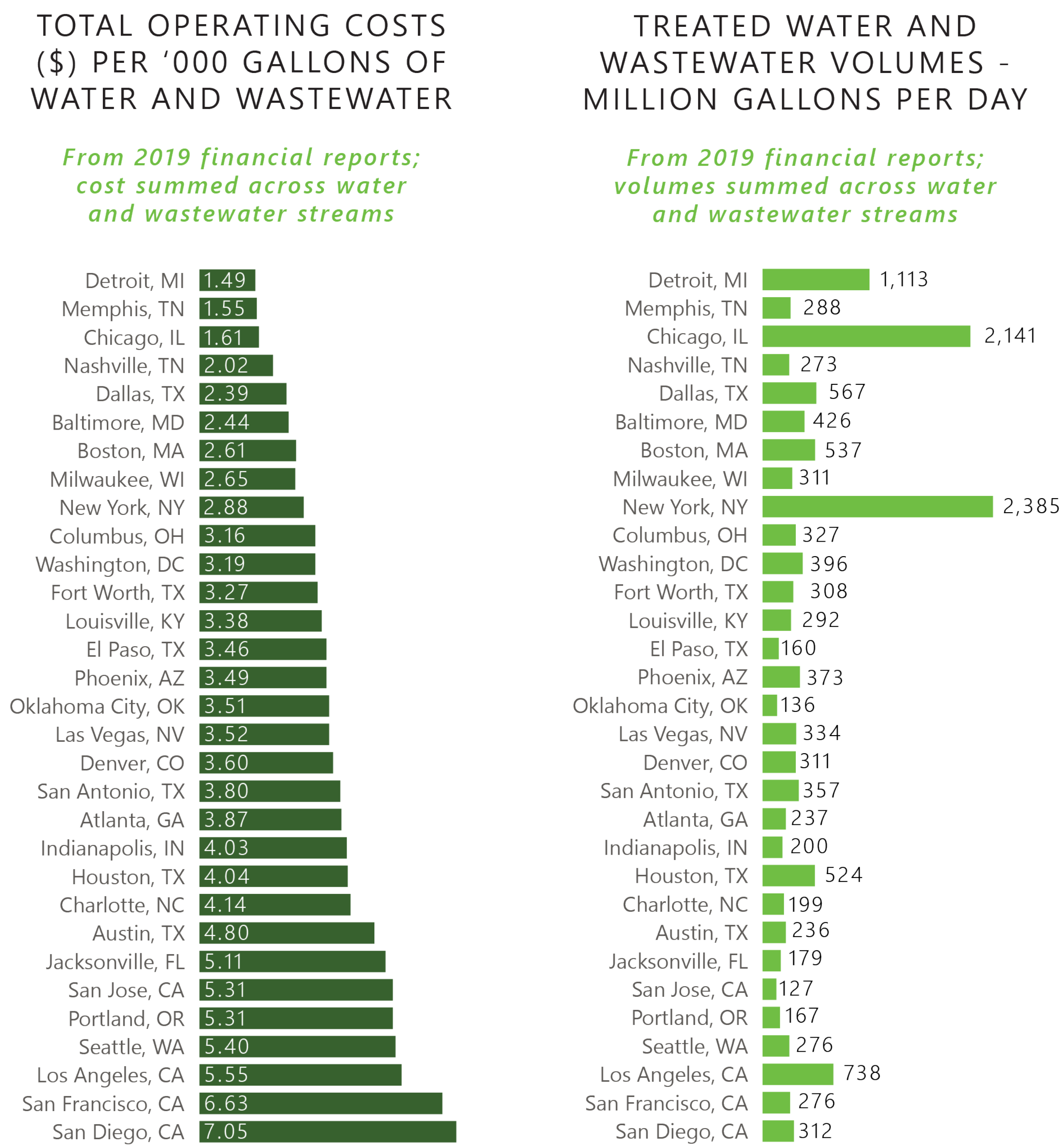


Figure 6. Operating cost and fluid volumes of large US water and wastewater operators.

It is worth revisiting our note about apples-to-oranges comparisons in the water and wastewater spaces.

Many factors explain the observed geographical variability in spend profiles. Some cities:

- Lack easy access to large volumes of clean water
- More thoroughly recycle and reuse wastewater, requiring more intense treatment methodologies
- Need to pump water across larger changes in elevation
- Are more dispersed and have to convey water and wastewater across longer distances.
- Choose to capture and treat their stormwater, instead of allowing uncontrolled runoff into local waterways.

Each of these challenges adds to the operating cost base necessary to run effective water and wastewater sourcing, treatment, delivery, and disposal programs.

Take the first two of these challenges – lack of easily available source water and more aggressive recycling and reuse approaches. These challenges go together. Cities that have more difficult sourcing potable water then find it necessary to pursue more exotic wastewater management programs. In this sense, some cities, many of which we find in the western US, face higher cost burdens on each end of the water life cycle. This compounding of core cost challenges helps explain why we can see such large disparities in operating costs between different regions of the US.

While apples-to-oranges effects are prevalent in the water and wastewater spaces, we can still infer a reliability effect in this data. No two operators face the same slate of challenges. As a result, we do not find a consistent, industry-wide push toward optimized reliability, in large part because of the difficulty of establishing sector-level benchmarks for the water and wastewater spaces.

We see the same phenomenon in refining, but from a different perspective. In refining, unlike in the water and wastewater space, operators do generally face a similar slate of challenges. Importantly, one such challenge reigns supreme – optimizing commercial performance. Refiners think deeply around how to procure the most advantageous crude streams as feedstock. They also think deeply around how to generate an attractive product portfolio, and how to reach the most lucrative markets for those products. Because the focus of refiners is so heavily steered toward commercial opportunities, refiners are inclined to under-explore the notion of optimized reliability programs. This under-exploration around reliability is also something we see across the water and wastewater community.

As we mentioned, Figure 6 shows that the highest cost water and wastewater operators have nominally five times the operating spend intensity of the lowest cost operators. In the world of refining, we generally see a factor of two between extremes on the total operating cost spectrum. In the western US, we have rapidly growing populations embedded in an arid climate who depend on imported water. Further, the western US has higher labor and energy costs than most other regions in the country. Combine these factors, and we can clearly see that western US water and wastewater operators are likely to feel more intense cost pressures than their counterparts in other regions.

With so much dispersion in water and wastewater spend profiles, it is even more difficult to define best-in-class reliability performance in these domains. The apples-to-oranges comparison between operators can mask or distract from the universal reliability challenge that exists across each and every heavy process industry. In this context, we are further convinced reliability challenges can more easily fly under the radar in the water and wastewater spaces, and operators have exciting opportunities in front of them in leveling up their facility-scale approaches to reliability.

OPERATING COSTS FOR WATER ARE ON PAR WITH WASTEWATER

When thinking of reliability, it is easy to lump water and wastewater operators together. The process fluid is the same. The customer base is the same. The regulatory constraints around revenue generation are the same. Should we, though, really expect the cost profile to be the same when comparing water to wastewater?

Figure 7 shows us that yes, operating costs are comparable between water operators and wastewater operators. Again, we must keep in mind that not all reporting entities break down their water costs versus their wastewater costs. Many entities reported lumped operating costs across all their water and wastewater process streams. Fortunately, the entities providing the data in Figure 7 did break out the financial realities of water versus wastewater, showing that these operators spend similar amounts on a unit basis regardless of which stream they manage.

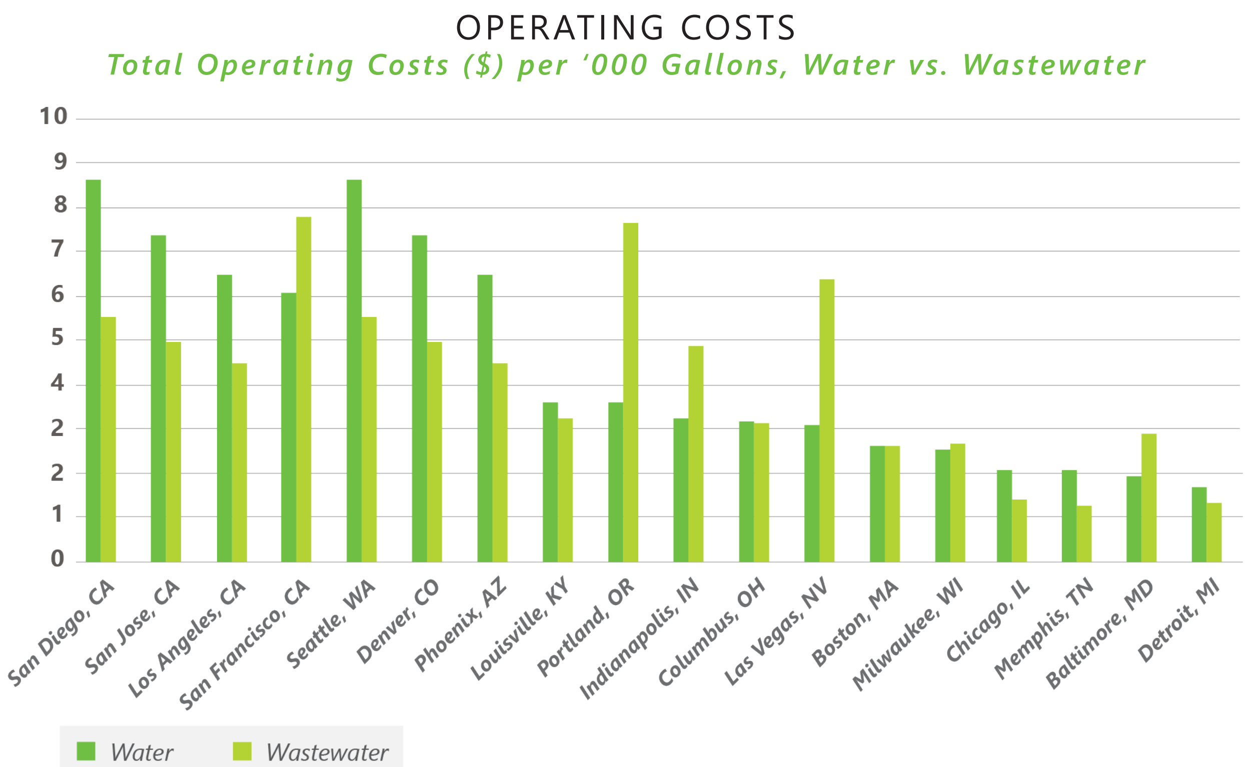


Figure 7. Total operating costs for water operators versus wastewater operators.

It is not just operating costs that are similar between the water and wastewater spaces. We also see parity in the asset base, again when normalized to the flow through each system. Figure 8 shows the details. As expected, as we compare Figure 7 and Figure 8, we see that operating costs tend to follow assets. In other words, operators that require more assets to process 1,000 gallons of water or wastewater also have higher operating expenses.

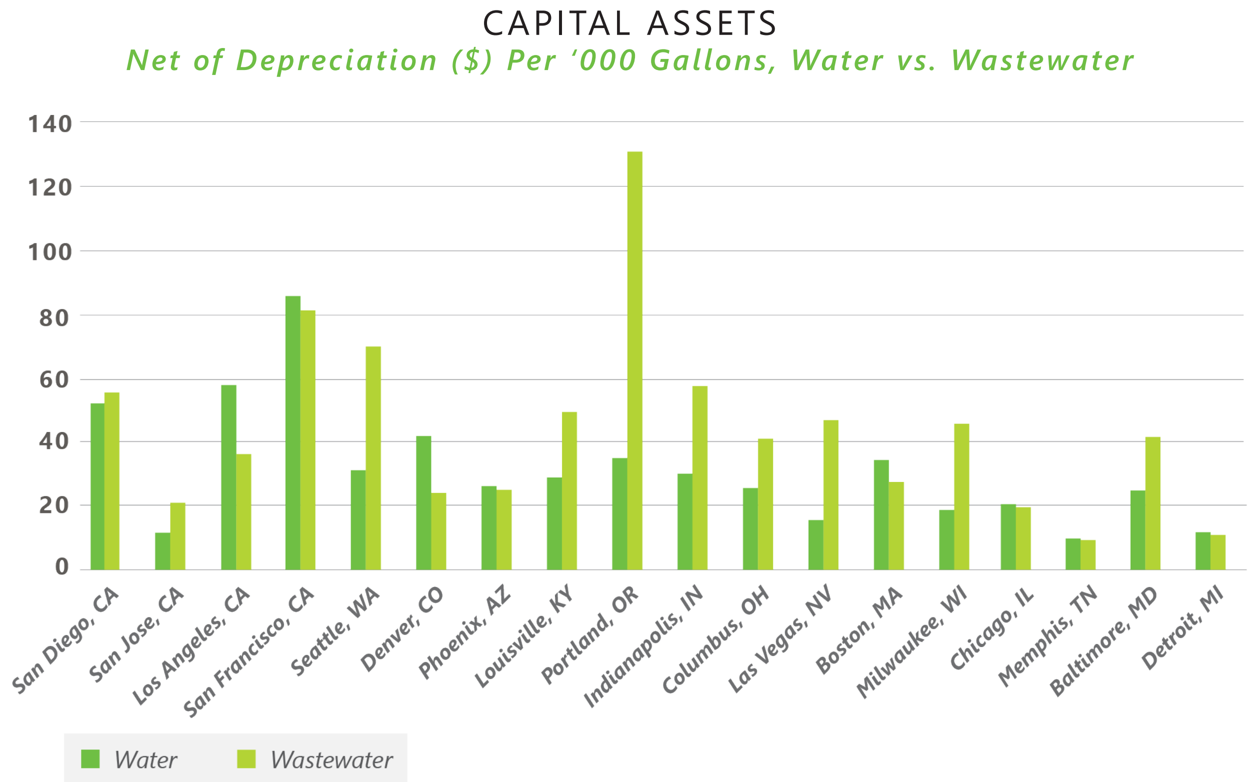


Figure 8. Capital assets, net of depreciation, per thousand gallons, water vs. wastewater.

We care about parity between water and wastewater costs because it gives us more confidence that lucrative reliability improvement opportunities exist in both spaces. Before we paint this sector with a broad brush around reliability, we need to ensure financial realities are approximately uniform. Figure 7 and Figure 8 tell us that water and wastewater operators rely on similarly valued asset bases and the same spend intensity to meet the needs of their customers. As reliability partners, then, we can be more confident that a thorough investigation will yield important opportunities across this whole sector, regardless of which part of the water life cycle is immediately in play.

INSIGHTS

In this section, we list four insights we uncovered in our investigation. Each insight has particular relevance to the role reliability will play in water and wastewater and build on the conclusions we describe in the previous section. We believe increasing awareness around these insights will motivate operators and their service partners to utilize today's cutting-edge approaches to reliability improvement, and to experiment with the emerging techniques and technologies that will drive the step change improvements we so desperately need.

1. Water and wastewater operators have a massive opportunity to capitalize on improvements in reliability spend

As we saw in Figure 3, US municipal water and wastewater operators spent \$16.0 and \$8.7 billion, respectively, on reliability-related activities in 2019. For comparison, US petroleum refiners spent \$10.1 billion in the same areas. In other words, US municipal water and wastewater operators spend about two and a half times what US refiners do on reliability.

Petroleum refining is a canonical industry when it comes to reliability. Refining failures are often conspicuous. Small leaks can turn into massive spills. Small fires or uncontrolled release of combustible materials can turn into extraordinary explosions. These kinds of catastrophes have pushed regulators and operators toward more aggressive management of reliability in the refining domain since failures in reliability can quickly cascade into failures in process safety. Also, in the refining world, consolidation means fewer corporate owners control larger fractions of the total asset base. The industry as a whole can move more quicky if a handful of large-scale players quickly pave the way for their smaller peers.

In the water and wastewater domains, failures are often less visible than they are in refining, but they are no less catastrophic. Water and wastewater operators manage infrastructure that forms the foundation of our modern standards of living. Public health hangs in the balance, which means operational failures have profound consequences. Combining the consequences of potential failure with the size and scale of the asset base, the country's municipal water and wastewater operators spend more than petroleum refiners on reliability-related activities. Further, when we consider the fragmentation across seemingly countless utilities spread throughout the country, ensuring reliability in the water and wastewater sector is a uniquely large, and quickly growing, challenge.

2. The water and wastewater sectors can apply lessons learned in other industries and can expect to target similar gains

In Section 3, we noted that high profile failures led the petroleum refining industry to adopt stricter process safety measures. Some progress came organically through the voluntary action of refiners. Other progress was motivated by more aggressive requirements from regulators. The broad-based push toward process safety improvement allowed refiners to work cooperatively to identify and implement best practices around reliability. Subsequently, operators in adjacent industries, like petrochemical processing, adopted modified versions of these best practices tailored toward their specific challenges.

Water and wastewater operators can take advantage of lessons learned across the complex process landscape. Data-driven risk analyses are available to optimize inspection and maintenance programs. Sophisticated failure models point to problems before they occur, allowing operators to target their limited resources in ways that will unlock the greatest performance across the whole system of assets. One reason these lessons have not already made their way to water and wastewater is because of industry fragmentation. Figure 1 showed us the lowest cost large municipal operators spend between $1.00 and $2.00 per thousand gallons on total operating costs, while the highest cost operators spend over $7.00 per thousand gallons. In other words, the highest cost operators spend five times the level of the lowest cost operators. That spread of five times is considerably larger than we see in US petroleum refining, for example, where the spread is closer to two times.

Such a large range of costs confirms what industry observers know, namely that operators have a plethora of region-specific challenges that dominate their budgets. These region-specific challenges obscure the reliability improvement opportunities that exist across the sector. Today's approaches are too reactive and too focused at the level of individual components. At Pinnacle, we have seen step change improvements in reliability outcomes by zooming out, gathering and organizing all the relevant data, and analyzing performance at the system level. These opportunities exist across the water and wastewater sectors, though they are obscured by the more visible challenges that exist for some operators relative to others.

3. Water and wastewater operators are under investing in assets today, and prevailing environmental and political dynamics will make it even harder to fill this investment gap in the future

The challenges around aging water and wastewater infrastructure have been well documented. This deteriorating asset base is forcing increased spend on the O&M side, as operators contend with more frequent breakdowns and more expensive on-the-fly refurbishment projects.

The data tells this story in two ways. First, we saw in Figure 4 that O&M spend levels for large municipal water and wastewater operators are growing more quickly than capital expenditure levels. Second, Figure 5 showed us that in the past five years, operators are spending less to replenish their asset base than they had been in the five years prior. These dual trends – increased O&M spend on the heels of reduced capital reinvestment – are consistent with the observations around aging infrastructure made by other industry stakeholders.

Further, the water and wastewater industries face well-known challenges from the changing climate to various public health threats. In response, the nation's regulatory apparatus will continue to push for tighter quality tolerances and ensure operators are able to capably handle larger flows from more extreme weather events. The ubiquitous pressure from rate payers to keep service charges as low as possible will continue. This mix of environmental and political challenges will amplify the stress placed on aging assets, as operators will need to optimize today's working systems to free the capital needed to invest in tomorrow's infrastructure.

The focus on reliability will only grow stronger. New capital investments will take time to plan and execute. In the meantime, operators will press existing assets into longer service lives, asking these assets to perform across larger flow volumes. Comprehensive, data-driven approaches to system-wide reliability are critical to ensuring operators can meet even greater challenges across the environmental and political domains.

CONCLUSIONS

In the analysis methodology section, we explained our unique approach to investigating the water and wastewater sectors using a data-driven methodology. As opposed to other stakeholders that have relied on survey data or forecasting models, we have relied on publicly reported historical operational and financial results from the utilities themselves. Specifically, we gathered data from 40 of the largest US municipal water and wastewater operators. Much of this data is audited before the utilities publish it. We can thus see a clear, unbiased picture of past performance, which helps understand how the sector might evolve in the future.

Our first analytical step was to estimate what US municipal water and wastewater operators spend on reliability-related activities. The results are shown in the value of reliability in the water and industries section. Based on the results from the large utilities we studied, we estimate 40% of total operating and maintenance spend has a material impact on reliability. Assuming the per volume spend patterns of large operators are in line with the utility sector on the whole, we estimate municipal water operators spent $16.0 billion on reliability-related activities in 2019. We estimate municipal wastewater operators spend $8.7 billion on these same activities in 2019. For context, this $24.7 billion in combined municipal water and wastewater spend is over twice the $10.1 billion we estimate that US petroleum refiners spend on reliability.

With some perspective around the total reliability spend profile, we distilled three observations from our newly compiled database:

1. Operations and maintenance spending levels are growing disproportionately to the amount of water produced and to the spending on other portions of water processing. This is due to a lack of optimization of investment, and as facilities grow older, facilities are simply spending more but getting less out of that spend.
2. There is a wide disparity in spend level on reliability across facilities. The root causes are difficult to disentangle, given some other large impacts on O&M costs such as proximity to potable water sources. However, by comparing across similarly positioned facilities and overall industry trends, it appears that best-in-class performers spend approximately one third of the amount that industry laggards spend on reliability on a per gallon basis.
3. In general, operators are underspending on water infrastructure in the short term. As such, spending on O&M is becoming a larger and larger portion of facility spend. This appears to be driven by a priority to keep overall costs low and by a slow transition to more optimized operations in some regions.

Reliability spend in the US has grown from $17.6 billion in 2010 to $24.7 billion in 2019.

GLOSSARY

Compound Annual Growth Rates (CAGR)	The net gain required for an investment to grow to its desired end state, assuming profits are reinvested at the end of each year.
Consumer Price Index	The average change over time in prices paid by consumers for goods and services.
Operators	Companies, agencies, or institutions whose personnel directly oversee the day-to-day functions of complex process facilities and make the long-term financial and strategic decisions about the facility future.
Reliability	The property where a productive asset is in condition to serve its intended function.

We see the lowest operating costs in the range of $1.50 per thousand gallons, while the highest operating costs are over $7.00 per thousand gallons.

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As the world continues to recover from one of the worst economic downturns in history, more than 85% of the world's industries are still experiencing difficult markets. With one third of the world's economy directly affected by the reliability of operations, reliability can make the difference between being an industry leader and laggard.

In this interim report, Pinnacle analysts dive into the impact that reliability has on the water and wastewater industries. Throughout this report, we analyze operational and financial data from 40 large municipal water and wastewater operators and identify the key trends that are driving reliability in these crucial industries.

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