# Draining:

## The Economic Impact of America's Hidden Water Crisis

DIGDEEP

# Draining: The Economic Impact of America's Hidden Water Crisis

*a study*

*digdeep.org*

## THE GIST

# If you don’t read anything else, read this:

More than 2.2 million Americans live within the water access gap, without the taps and toilets that the rest of us take for granted. That gap has a very real price tag; **every year the water access gap remains open, the US economy loses $8.58 billion**. Each household without access to running water or basic plumbing costs the US economy $15,800 per year in health care costs, time spent collecting and paying for bottled water, loss of time at work or at school, and premature death. Low-income families and their communities bear most of these costs. Every year, the water access gap causes 219,000 cases of waterborne illness and 71,000 cases of mental illness; it costs us 68.7 million work hours and an estimated 610 lives.

Fortunately, that's not the end of the story. **As this report shows, the economic benefits of closing the water access gap outweigh the costs by nearly 5 to 1**. For every public or private dollar invested in expanding access to running water and flush toilets, the economy gains $4.65 in net societal return. That's $1.65 in direct benefits, such as lowered health care costs and more time to work or study, and $3 in implicit benefits by reducing premature loss of life. Closing the water access gap will transform lives by eliminating 36,400 cases of diabetes a year and helping families save the $1,350 they spend on bottled water to drink, cook, and bathe (to name just a few examples). All told, closing the water access gap could create nearly $200 billion of economic value over the next 50 years.

In the summer of 2015, I visited Brenda J. at her house in Smith Lake, New Mexico. I arrived on a truck carrying 3,500 gallons of drinking water, a lifeline for Brenda and hundreds of other Navajo families living in an area too remote to be reached by water lines. Brenda filled a heavy stock pot with water and hurried back into the kitchen to make tamales that she would later sell in town.

Brenda explained to me that her husband had injured his foot at work the month before, and without running water at home to clean the wound, it became dangerously infected. He was taken to the hospital in Gallup, nearly 50 miles away, treated, and discharged. Unfortunately, no clean water meant Brenda couldn't make tamales; no tamales meant no gas money; and no gas money meant she couldn't bring her husband home. He had been sleeping on the streets as Brenda waited for the water truck to appear, and his lost work hours were a crippling hit to their family's in come. Without access to clean, running water, something as simple as a minor work injury threatened Brenda's family with economic ruin.

Running water and sanitation are essential for life, health, and economic prosperity. These basic human rights, however, remain out of reach for more than 2.2 million people in the United States, including communities of color, lower-income people in rural areas, and tribal communities. The water access gap costs the US economy billions of dollars a year, a price paid first and foremost by impacted families, already some of the most economically vulnerable in the country. Fortunately, we now know that the economic benefits of closing the water access gap outweigh the costs by nearly 5 to 1 and have the potential to create economic prosperity for generations to come.

Our 2019 report *Closing the Water Access Gap in the United States: A National Action Plan* used quantitative and qualitative data to uncover the significant gaps in access to water and sanitation that persist in the comparatively high-income US. We found detrimental impacts to people's health, employment, leisure time, and general well-being, yet at the time we couldn't measure the magnitude of those impacts or the extent to which they led to economic harm.

This report details how the benefits of extending water and sanitation access to every home in the United States outweigh the costs, creating a powerful economic argument for accelerating solutions. To that end, it also updates key recommendations for action from our earlier work in *Closing the Water Access Gap in the United States*. This report is the collective effort of many from within the burgeoning domestic WaSH (water, sanitation, and hygiene) sector. It is for anyone seeking a more comprehensive understanding of the impact the water access gap has on individuals, their communities, and the nation at large. We hope a clearer accounting of these costs and benefits are especially helpful to those setting state and national priorities, appropriating funds, and directing the work of agencies.

The last time I visited Brenda was to inspect her off-grid water system installed by DigDeep's Navajo Water Project. She took me into her bathroom and asked me to flush her toilet. When I did, she lit up. Someday, millions of Americans without access to water will finally turn on their taps or flush their toilets with the same look of joy I saw on Brenda's face. We must close the water access gap. As this report demonstrates, we can't afford not to.

**George McGraw**
Founder & CEO, DigDeep

# ACKNOWLEDGEMENTS

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# THE HEADLINES

## 5 to 1

Extending water and sanitation access to every American will create economic prosperity; the economic benefits of closing the water access gap outweigh the costs by nearly **5 to 1**.

## $4.65

That means for every dollar invested in expanding access to taps and toilets for the millions of people without them, the economy gains **$4.65: $1.65** in direct benefits such as lowered health care costs and more time to work or study, and **$3** in implicit benefits by reducing premature loss of life.

## $15,800

Each household without access to water and sanitation costs the US economy **$15,800 per year**, because of health care costs, time spent collecting and paying for bottled water, loss of time at work or at school, and premature death.

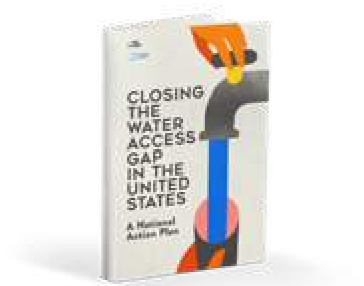
## $8.58 billion

That means every year the US economy loses **$8.58 billion** because millions of people still don't have access to running water or flush toilets at home.

## $366,400

Closing the water access gap will create **$366,400** in direct and implicit economic benefits per household on average—that's a total of nearly **$200 billion** in potential economic benefits waiting to be captured.

# INTRODUCTION




**CLOSING THE WATER GAP**

This report builds on *Closing the Water Access Gap in the United States: A National Action Plan*, a report published by DigDeep and the US Water Alliance in 2019 that used multi-faceted quantitative and qualitative analysis to estimate the number of people in the US living without access to water and sanitation and described the historical drivers of the challenge and potential solutions.

The United States is the most prosperous democracy on Earth, so it's shocking to learn that more than 2.2 million people in the US still live without running water and basic plumbing in their homes, and tens of millions more without adequate sanitation. The water access gap impacts entire communities across all 50 states, DC, and Puerto Rico, and race is the strongest predictor of whether you and your family will have a tap or toilet at home. Indigenous households are 19 times more likely than white households to live without basic plumbing; Black and Latino households are twice as likely.[1] In many parts of the US, the problem is getting worse—not better.[2,3,4]

DigDeep staff have witnessed the economic harms caused by the water access gap firsthand. Native children in the Southwest spend hours hauling water instead of studying, lowering the likelihood that they will graduate high school, attend college, and meet their true economic potential. Families in Appalachia are forced to flush sewage into nearby streams, causing higher rates of waterborne illness and racking up expensive medical bills. Families in Texas border *colonias* sacrifice valuable work hours to haul water, and many spend a significant amount of their monthly income on bottled water. Tragically, many people in the US without access to water and sanitation die prematurely each year, impacting their families' economic and emotional well-being for generations. All these unacceptable scenarios cost real money, and each is completely avoidable.

This report not only calculates the staggering cost of America's water access gap in real dollars, but, more importantly, shows how much we stand to gain by fixing it. Meeting this basic need for every American would create tremendous prosperity, starting within the communities that need it most. In fact, we found that the economic benefits of closing the water access gap outweigh the costs by nearly 5 to 1.

A hundred years ago, waterborne illnesses such as cholera were a leading cause of death in the United States. Recognizing the threat to public health, the federal government made historic investments in modern systems that extended safe and reliable drinking and wastewater services to nearly every American.[5] The United States aggressively funded water infrastructure through the late twentieth century, starting in the mid-1930s with the New Deal, creating economic prosperity by literally laying the groundwork for public health, industry, and tourism. But waterborne illness, the stress and expense of hauling water, the anxiety of life without a tap or a toilet … these things didn't completely disappear as they should have.

That's because many communities—including tribes, communities of color, immigrant communities, and some rural areas—did not receive equitable investment in water and wastewater infrastructure from the start.[6] That initial lack of investment created a hidden water and sanitation crisis that continues to threaten the health and well-being of millions of people today. In recent decades, federal funding for water and wastewater has declined precipitously, reducing the support available for communities to build and maintain water and wastewater systems.[7] As a result, communities that did not benefit from past investments have struggled to catch up, while once-functioning systems have begun to fall into disrepair or even stopped working completely, a process accelerated by climate change.[8 9 10]

The recent passage of the bipartisan Infrastructure Investment and Jobs Act (IIJA) provides an historic opportunity to begin repairing our nation's ailing water and wastewater systems. Eliminating the water access gap, however, is not an explicit goal of that legislation. While new federal spending will likely result in increased access to water and sanitation for some, eliminating the water access gap completely will require more targeted investment as outlined in the Action Plan below. Those dollars are urgently needed, and as we demonstrate here, would generate a powerful economic return.

In this report, we estimate the economic harms attributable to households lacking a reliable water source and/or indoor plumbing as identified by the US Census. We then estimate the total investment required to bring running water and sanitation to those homes. By combining the two estimates, we calculate the return on investment achieved by closing the water access gap for good. Each of our estimates is deliberately conservative, helping us demonstrate that the benefits of closing the water access gap outweigh the expected costs and creating a powerful economic argument for accelerating solutions. Finally, we bring depth and texture to these numbers by incorporating real stories from Americans who still lack basic access to drinking water and sanitation.

This report is the first of its kind for the US and builds on our previous research with the US Water Alliance for *Closing the Water Access Gap in the United States: A National Action Plan*. Although other studies have calculated the cost to replace or repair our nation's water infrastructure more broadly,[16 17] this is the first analysis to estimate the specific costs and benefits of extending basic water and sanitation access to every American.

This report is organized into four sections:

- **Key Takeaways on the Economic Impact of Water and Sanitation Access** outlines five key findings from the report and their implications.
- **Economic Harms Caused by a Lack of Access to Water and Sanitation** describes the various economic burdens placed by the water access gap on individual households and on society at large.
- **The Cost to Close the Water Access Gap and the Return on Investment** estimates the cost and the potential return on investment from closing the water access gap for good.

**WHAT IS THE WATER ACCESS GAP?**

The "water access gap" is the disparity in access to water and sanitation between the vast majority of Americans and those communities that still lack access. More than 2.2 million people in the US lack basic access to drinking water and sanitation. By that we mean:

- a tap, toilet, and shower in the home;
- reliable hot and cold running water; and
- a system for removing and treating wastewater.

Tens of millions more face affordability challenges or rely on water or wastewater systems that don't meet basic safety standards. In some cases, these factors may prevent them from accessing a tap or toilet, resulting in a *de facto* lack of access.

**THE 2021 BIPARTISAN INFRASTRUCTURE LAW**

The federal share of spending on water and wastewater infrastructure has fallen for decades, but that may be changing. The bipartisan Infrastructure Investment and Jobs Act (IIJA) of 2021 authrized a total of $550 billion in new infrastructure spending through 2026, including $55 billion for water and wastewater. This constitutes the single largest water infrastructure investment in history, but it is only a first step. Long-term underinvestment has led to an $81 billion gap in funding for critical water-related infrastructure,[11] and the Environmental Protection Agency, American Water Works Association, and others estimate the cost of repairing and expanding the US water infrastructure to be between $750 billion and $1 trillion over the next 20 to 25 years.[12 13]

While IIJA funding is desperately needed, the legislation was not designed to eliminate the water access gap completely. Some IIJA funding will be used to provide first-time access to water and wastewater services;[14] however, most of the funding is focused on upgrading and repairing existing systems through loan and grant programs, replacing lead service lines, removing new contaminants (such as PFAs), and protecting environmental resources such as rivers, lakes, and estuaries.[15] A smaller, more flexible, more targeted investment is still needed to close the water access gap for good. As this report demonstrates, that investment will generate a powerful economic return.

- **Where We Go from Here: An Action Plan** lays out four recommendations for achieving universal water and sanitation access in our lifetimes.

Americans without access to water and sanitation have shown extraordinary tenacity and inventiveness in the face of an almost unimaginable challenge, but they shouldn't have to solve this problem on their own. The United States is the most prosperous democracy on Earth, with the opportunity, the resources, and the responsibility to close our water access gap once and for all. Not only will this make millions of people happier and healthier; it will create real economic prosperity for our nation, for marginalized communities, and for the families who need it most.

**PART ONE**

## Key Takeaways on the Economic Impact of Water and Sanitation Access

Outlines five key findings from the report and their implications

**PART TWO**

## Economic Harms Caused by a Lack of Access to Water and Sanitation

Describes the various economic burdens placed by the water access gap on individual households and on society at large

**PART THREE**

## The Cost to Close the Water Access Gap and the Return on Investment

Estimates the cost and potential return on investment from closing the water access gap for good

**PART FOUR**

## Where We Go from Here: An Action Plan

Lays out four recommendations for achieving universal water and sanitation access in our lifetimes

# KEY TERMS & METHODOLOGY

## KEY TERMS

- **Cultural Continuity** - the spread of cultural heritage from one generation to another. Often the heritage assets of a culture (for example, language, craft, or practice) have a direct or implicit economic value.

- **Direct Economic Benefit** - saved or recovered returns to society due to preventing a Direct Economic Cost (see below).

- **Direct Economic Cost** - quantifiable societal loss directly and negatively impacting a stakeholder's earnings, revenues, or costs, measured in dollars. In this report, direct economic costs occur due to lacking water access and may include decreased household earnings, higher health care costs, lower GDP, decreased federal government tax revenues, decreased state government tax revenues, and lower business earnings. Direct economic costs are financially recoverable for stakeholders.

- **Economic Burden / Economic Harm** - negative impact resulting in a societal loss to any stakeholder(s), including lower revenues/earnings, loss of production, higher costs, or loss of use.

- **Economic Value** - the worth of a good or service determined by the benefit it provides to an economic stakeholder, often quantified and measured in dollars.

- **Equitable Water Access** - in the US, this refers to safe, acceptable, accessible, affordable, and non-discriminatory access to in-home water and wastewater services for all people.

- **Implicit Economic Benefit** - saved or recovered Implicit Economic Costs (see below).

- **Implicit Economic Cost** - (as distinct from Direct Economic Cost) an economic cost calculated based on the inferred, but not financial, value of an impact. In this report, implicit economic costs mostly refer to estimates of the additional valuation of premature loss of life above and beyond lost individual earnings. Implicit economic costs are not financially recoverable for stakeholders, but still meaningful in a cost-benefit analysis.

- **Indoor Plumbing** - the presence of hot and cold running water, a shower or bath, and a flush toilet inside the home. Until recently, the Census Bureau used the term "complete plumbing" to refer to these components. In 2016, the Census Bureau removed toilets from its definition of complete plumbing. Since this study uses 2019 Census estimates, US residents without toilets are not counted here.

- **Lost Productivity Impacts to GDP** - additional losses to US Gross Domestic Product (GDP) from missed economic activity caused by an initial loss in individual or household earnings that accrue over time.

- **Net Societal Benefit / Net Societal Return** - a calculation in the cost-benefit analysis demonstrating the economic return relative to the upfront costs of a new policy. In this report, net societal benefit or return is most often expressed as "dollars returned per dollars invested." A net societal return greater than $1 per dollar invested is "societally beneficial," providing greater societal benefit than the costs of implementing the policy.

- **Stakeholder** - any entity with standing affected by the impacts or policies evaluated, including households/individuals, governments, and businesses.
- **Sanitation** - as used in this report, sanitation encompasses the conveyance, storage, treatment, and disposal of human waste and other services required to maintain hygienic conditions. This must include toilets, pipes that remove wastewater from the home, and treatment measures.
- **Value of Health Tool** - an economic modeling spreadsheet calculator, developed by Altarum Institute, whose components were used in this study to predict and aggregate the financial and health effects of investments in social determinants of health—in this case, access to water and sanitation.
- **Value of Statistical Life (VSL)** - the valuation of a premature death (life lost) as measured as an implicit economic cost. Researchers and government agencies frequently use VSL to calculate the economic harm of a death above and beyond lost future earnings. This approach does not seek to put a dollar value on the life itself, but rather calculates an individual's willingness to pay for reductions to their risk of death in daily life and divides that amount by the relative risk reduction, typically resulting in a number somewhere between $5 million and $15 million per life.[18 19]
- **Water Access Gap** - refers to the disparity in basic access to water and sanitation services between most people in the US and the communities that still lack access.
- **WaSH** - an acronym referring to Water, Sanitation, and Hygiene as they relate to public health.
- **Wastewater** - untreated human waste, sewage, or sludge.

# METHODOLOGY

This report is informed by a multi-faceted quantitative and qualitative analysis conducted by Altarum Institute and DigDeep. Every finding not otherwise cited came directly from the original research conducted for this report. A detailed explanation of data analysis methods and computation is available in the Appendix.

This report includes the following components:

- **Key Advisors:** DigDeep assembled a cabinet of key advisors to assist in study design, provide expert feedback on the development of economic models, and to review the results contained within this report throughout their development. Cabinet members included representatives from DigDeep, Altarum Institute, Robert Wood Johnson Foundation, American Heart Association, and the International Association of Plumbing & Mechanical Officials. Key advisors met quarterly during the 18-month study period and were individually consulted.

- **Study Design:** DigDeep and Altarum Institute designed this study using existing global models for estimating the economic benefits of WaSH and by analyzing Office of Management and Budget (OMB) guidelines for economic analysis. The study uses Altarum Institute's Value of Health Tool (VOH), which leverages available data to predict the financial impacts of investments in social determinants of health, such as access to running water and sanitation. The VOH can assess the potential cost and future savings associated with various policies that would accrue to the federal government, states, and society at large based on an intervention's predicted impact on mortality, morbidity, future earnings and health care costs, and noneconomic impacts such as educational attainment. Some government research and datasets were accessed via the Congressional Research Service (CRS) with the help of several Members of Congress.

- **Burden Analysis:** We used a three-part analysis to produce the findings in this report. First, we conservatively estimated the economic losses due to a lack of water access attributable to the 539,000 US households lacking complete plumbing. We compiled a list of all expected economic impacts, pared that list down to impacts that were both measurable and meaningful in size, [20] and constructed models based on our target population, thus finding the economic harms caused by current gaps in infrastructure. Both direct and implicit economic costs were calculated.

- **Cost Analysis:** We built on those burden estimates by constructing a model to predict the total infrastructure cost required to bring running water and sanitation to that same population. Our model estimated the total cost of installing, replacing, or repairing household water and wastewater infrastructure by incorporating survey data, geographic data, prior literature, and expert opinion to create an estimate of: 1) upfront installation costs, 2) long-term operations and maintenance, 3) ongoing costs of water and sewer services, and 4) the expected longevity of the new infrastructure. We did this while estimating the fraction of households (by county) that are in urban versus rural areas, require new installation versus repair of existing infrastructure, require new water-only, wastewater-only, or both types of services, and the expected period for which each household would benefit from their improved access.

- **Return on Investment (ROI):** Finally, by combining the burden and cost estimates, we calculated the net societal return achieved by closing the nation's water access gap.

- **Synthesis and Key Takeaways:** This report summarizes our quantitative findings and five key takeaways, which represent broader learnings extrapolated from the economic analysis.

- **Adding Context and Real-World Examples:** We included personal stories from real people impacted by a lack of access to water and sanitation to give depth and texture to the data. We collected these stories through conversations between impacted individuals and researchers, by consulting project partners and field staff, and by reviewing press interviews and previous research.

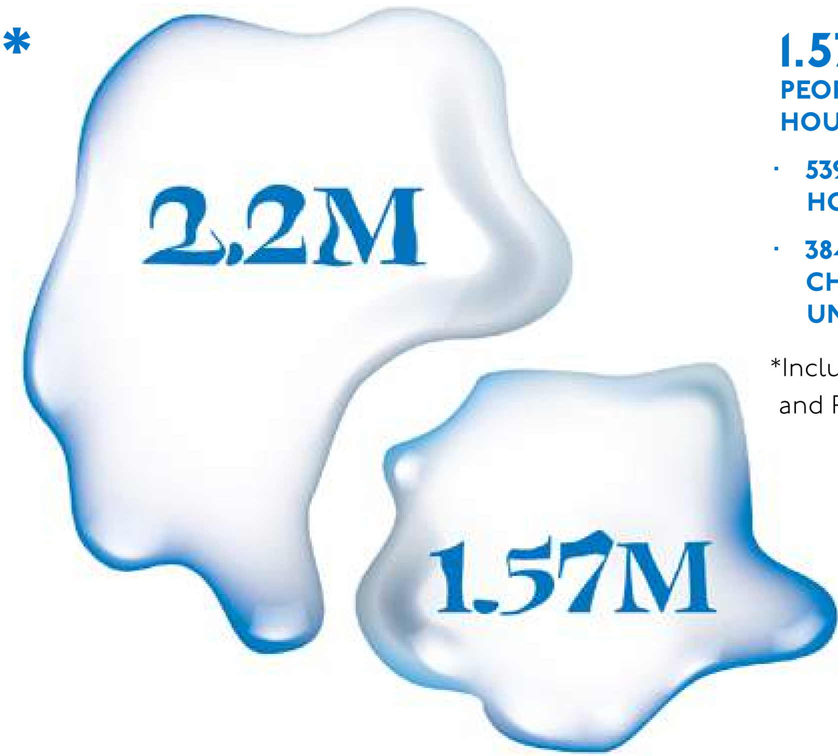
- **Advisory Council:** We invited every organization in DigDeep's US WaSH Sector Database to provide feedback on study design. Twenty-nine experts contributed to this study either as advisors or by providing detailed feedback on a written draft of the report. Their names are listed above in the Acknowledgements section.

Our previous research in *Closing the Water Access Gap in the United States* estimated the size of the water access gap to be at least 2.2 million people across the US and Puerto Rico, including about 533,000

# WHO IS COUNTED?

**THE FULL US WATER GAP IS:**

**2.2M* PEOPLE**




**THE STUDY POPULATION IS**

**1.57M* PEOPLE IN HOUSING**

- **539,000 HOUSEHOLDS**
- **384,000 CHILDREN UNDER 18**

*Includes US, DC, and Puerto Rico

people experiencing homelessness. While the primary dataset used in both reports is the same, there are some important differences in population between this report and that one.

This report focuses only on the 539,000 households in the 50 US states, District of Columbia, and Puerto Rico that lack running water and indoor plumbing—a total of about 1.57 million people. We do not include people experiencing homelessness, because the benefits of improved access to water and sanitation are too difficult to isolate. This report also updates the data used in the *Closing the Water Gap* report from 2014 to 2019 estimates. Tragically, the size of the water access gap has persisted over recent years, with the number of impacted households in the US remaining constant, and even increasing slightly, since 2016.[21] Slowly deteriorating infrastructure, a lack of sufficient funding for repairs and maintenance, and continued barriers to access for those living in rural parts of the US all contribute to this problem.

#### DEFINING EQUITABLE WATER AND SANITATION ACCESS

The goal of this report is to quantify the economic value of efforts that advance equitable access to water and sanitation, by which we mean services that are safe, acceptable, accessible, affordable, and non-discriminatory.

Our definition of equitable water access is grounded in the Human Right to Water and Sanitation recognized in international law, tailored to conditions in the United States.[23] Access to running water and indoor plumbing in the home is an achievable goal that is context-appropriate for a high-income country such as the US.

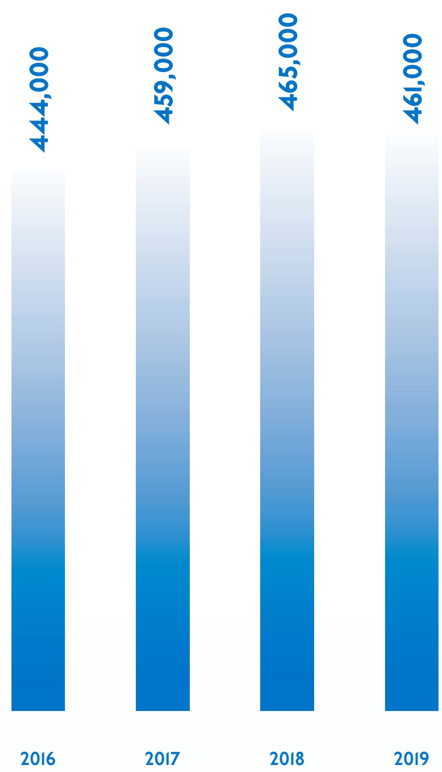
#### SDG 6

In 2015, the United Nations (UN) unanimously adopted the Agenda for Sustainable Development, a platform to end poverty, reduce inequalities, and address environmental crises. UN members, including the United States, committed to meeting 17 Sustainable Development Goals (SDGs) by 2030.

SDG 6 calls for safe, sufficient, sustainably managed water and sanitation services for every person. This report provides additional insight on the work that must still be done to meet SDG 6 in the United States.

Our primary data source on this population is the US Census Bureau's American Community Survey (ACS). The ACS estimates the number of occupied housing units without running water or indoor plumbing, meaning that one or more of the following components is missing: hot and cold running water, a working sink, and a bathtub or shower.[24 25] The ACS is the only national dataset on water access, but it has limitations.[26] Most notably, since 2016, the survey no longer estimates the number of households without working toilets.[27] Households without access to sanitation are included in our definition of the water access gap. Many households that lack indoor plumbing often also lack toilets or reliable wastewater services, so we averaged the price of extending both water and wastewater services through our cost modeling described in Section Three.

## NUMBER OF US OCCUPIED HOUSEHOLDS WITHOUT ACCESS TO COMPLETE PLUMBING, 2016-2020[22]

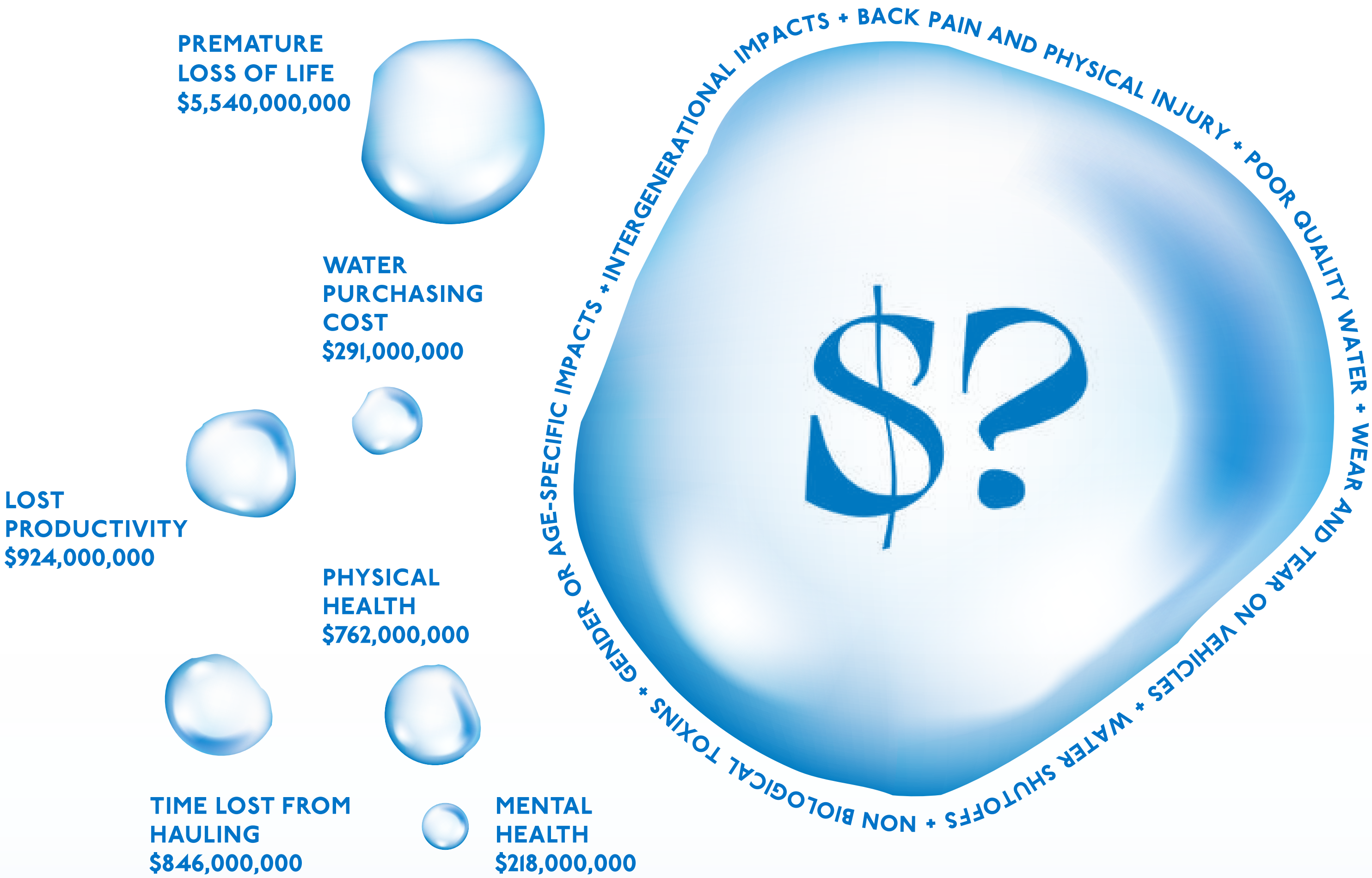


# WHAT'S NOT INCLUDED IN THIS ESTIMATE?

The procedures used in this analysis almost certainly underestimate both the size of the population without access to running water and sanitation and the economic impact of the problem. That's by design. By using conservative estimates throughout our analysis, we hope to make the most persuasive economic argument possible. Even when using conservative estimates, our research shows that the benefits of extending water and sanitation access to every home in the United States outweigh the costs by nearly 5 to 1, creating a powerful argument for accelerating solutions.

## *FACTORS WE COULD QUANTIFY*

## *FACTORS WE COULDN'T QUANTIFY*



### WATER AFFORDABILITY AND ACCESS

The cost of water and wastewater services has risen steadily in recent years, sometimes making them unaffordable, particularly for low-income households and people of color.[32] In a typical year, approximately 15 million people in the US experience water shutoffs for nonpayment.[33] Researchers estimate that if water bills continue to rise at their current rate, 36% of US households could be unable to afford their water bills in five years.[34]

When water service is unaffordable or shut off completely, people may be forced to haul water. As a result, these households fall into the water access gap, where they experience the same economic harms outlined in this study. Unfortunately, these cases are not captured in our population, because those households still have "complete plumbing" by Census definition, and limited data available on the impact of utility fees and shutoffs are often fragmented, contradictory, or incomplete.[35]

Our analysis is conservative in the following ways:

First, as explained above, our study population counts only residents of a permanent home; it does not include persons experiencing homelessness, because those cases likely include a broader set of housing deficits that cannot be fixed solely through new water infrastructure spending. The population does not include households solely without a toilet (removed from the ACS in 2016), and households without a safe and reliable wastewater solution.[28]

Second, we focus only on households without physical water infrastructure; we do not include households with concerns around water quality or affordability. In some cases, an individual may have "complete plumbing" but quality issues, price, or utility shutoffs force them to haul water from outside of the home. Water quality and affordability are both growing concerns nationwide.[29] The number of impacted households may number in the tens of millions, but datasets on those impacts are too unreliable to confidently include in this model, and the solutions to those challenges are distinct from the infrastructure costs modeled in this report.[30 31]

Third, we do not quantify intergenerational impacts. Because the water access gap harms a person's physical and mental health, lifespan, and earnings, the children of that person living in the same household may suffer intergenerational impacts related to educational achievement, debt, and other compounding factors that reduce their future income and the income of further generations.[36] Because race is the single strongest predictor of whether a family has access to water and sanitation, these intergenerational impacts likely disproportionately affect communities of color.

This analysis only includes economic harms for which there were sufficient data from a reliable source. We do not include economic harms that we cannot confidently quantify, such as:

- Back pain and physical injury from water hauling
- Wear and tear on vehicles from water hauling
- Exposure to non-biological toxins (e.g., arsenic, PFAs) from unsafe water sources
- Environmental contamination from unsafely managed wastewater
- The increased risk of communicable diseases such as Covid-19 and other health impacts from reduced access to bathing and hand washing
- Gender- or age-specific harms, such as additional time losses or health impacts

related to menstrual care, or those experienced specifically by pregnant persons, newborns, or older adults

Similarly, we do not include economic benefits of new infrastructure investments that we cannot confidently quantify, such as:

- Additional revenue generated by education, water security, water treatment, property values, tourism, or jobs created for new infrastructure projects
- Additional economic benefits that likely result from broader water infrastructure investments estimated by other authors[37]
- Impacts without a quantifiable economic benefit, such as cultural continuity

## INTERNATIONAL PRECEDENT

Our modeling is based on decades of published research on the economic benefits of universalizing water and sanitation access, which has been extensively studied in other, predominantly low-income countries by the World Health Organization (WHO) and others.[46] Those studies have found the total global economic return on investment (excluding North America and other high-income countries) to be roughly consistent with our analysis here.[47 48] Similar to the WHO's work, we focused our analysis on measurable economic impacts for which published research was available.[49]

### WATER ACCESS AND COVID-19

Families without a reliable water supply are often unable to maintain basic personal hygiene, including hand washing—the first line of defense against Covid-19.[38 39] During the pandemic, some families within the water access gap were also forced to break social distancing and go to crowded places to buy or haul water. This was especially true in rural, Indigenous communities, where access rates are lower.[40 41]

According to the Centers for Disease Control (CDC), American Indians and Alaska Natives were at least 3.5 times more likely than white persons to contract Covid-19 during the first wave of the disease.[42 43] Researchers have cited lack of access to running water as one of the main factors contributing to this elevated infection rate.[44 45] While it is likely that these cases of Covid-19 had a negative economic impact, that impact has not yet been quantified by researchers, and was not included in this analysis.

### WATER ACCESS AND CULTURAL CONTINUITY

Despite harsh conditions, Tina B. returned to her family's ancestral land on the Navajo Nation in 2017, relocating from a nearby trailer park in Thoreau, New Mexico. She wanted her children to have more open space to run around outside and a deeper connection to their cultural heritage. That meant living without access to running water. When they arrived, Tina and her five children had to haul water from her mother's home a mile away, where they also traveled to use the bathroom.

Cultural continuity is the spread of cultural heritage from one generation to another. When a lack of investment gradually destroys the economies that support those cultural traditions, the traditions themselves may be weakened or even destroyed, having a powerful impact on a community's economic well-being. For example, many Indigenous people are forced to abandon their ancestral homeland, language, and ways of life in search of a better standard of living. In some cases, preserving cultural continuity is the reason a family may live without services. Unfortunately, the economic impacts of disruptions to cultural continuity are too difficult to measure and were not included in this analysis.

SECTION ONE

# Key Takeaways on the Economic Impact of Water and Sanitation Access

**This section outlines five key takeaways from the report and their implications. These key takeaways blend our quantitative estimates with broader, qualitative findings that flow from the economic analysis within this report.**

# KEY TAKEAWAYS

1. Closing the water access gap will create economic prosperity.

2. The market won't close the water access gap on its own.

3. Quantifying economic benefits empowers us to rethink the ways we fund water and wastewater systems.

4. The water access gap negatively impacts every part of the economy.

5. Water access is a social, economic, and environmental justice issue.

1. **Closing the water access gap will create economic prosperity.** The economic benefits of closing the water access gap outweigh the costs by nearly 5 to 1. Our analysis shows that for every dollar invested in expanding access to running water and flush toilets for the millions of people in the US without them, the economy would gain at least $4.65, including $1.65 in direct benefits, such as lowered health care costs and more time to work or study, and $3 in implicit benefits by reducing premature loss of life.

   For the 539,000 US households currently in the water access gap, the direct and implicit economic benefits are significant—accruing to $366,400 per household over the lifespan of their new water and wastewater service (up to 50 years). That's a total of nearly $200 billion in potential economic benefits waiting to be captured.[50]

   Meeting this basic need for every American will have significant, positive impacts on communities struggling with a host of seemingly intractable issues, including regional economic decline, local government fiscal shortfalls, and loss of financial opportunities. While solving those challenges will require much broader investment over time, simply meeting the most basic water access and sanitation needs will immediately reduce the economic impacts related to physical health, mental health, and lost time and productivity, producing significant benefits.

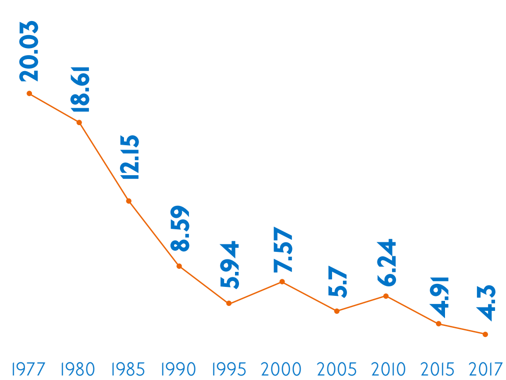
2. **The market won't close the water access gap on its own.** If the return on investment is so high, why hasn't the market already solved this problem? The answer is simple: The benefits of improved access to water and sanitation accrue to too many stakeholders, including households, their communities, the federal government, state and local governments, and even private businesses. In economics, this is called a "wrong pockets" problem: Because no single investor recoups the entire expected societal return of access to water, we face a market failure resulting in an underinvestment in critical infrastructure.

   Until the recent passage of the IIJA, the federal government has had a small and diminishing role in overall water infrastructure spending. This report, however, shows that new investment in water and wastewater systems has the potential to produce significant societal benefits. Because of the distributed nature of those benefits, the federal government must reclaim the central role in leading new investments in water and wastewater projects.

**DECREASING FEDERAL SHARE OF WATER INFRASTRUCTURE SPENDING**[51 52]

**Federal Spending on Water Utilities (1977-2017)**

Billions of dollars




We met Lena B. in 2015. She and her family were living on the Navajo reservation in Prewitt, New Mexico, in an area without running water. Every day, she walked a quarter of a mile to collect 10 gallons of water in buckets from a livestock windmill—water that was never intended for human consumption. Her family used that water for cooking, drinking, cleaning the house, and washing their clothing. They were frequently sick with diarrhea and vomiting from the water, which had high levels of coliform bacteria and nitrates and had tested positive for high levels of uranium in the past. It wasn't a safe choice, but it was the only choice they had.[59]

3. **Quantifying economic benefits empowers us to rethink the ways we fund water and wastewater systems.** By demonstrating that investments in water and sanitation access yield a 5-to-1 return, this report creates a new way of thinking about the value of those systems. Currently, the success of a water or wastewater system is largely judged by its ability to support itself through rate payment (a determining factor in accessing government loans and grants, for example). Financial self-sufficiency is enshrined in nearly every law, policy, and funding program for water and wastewater systems, yet remains out of reach for many due to economic, environmental, and technical challenges. This is particularly true for communities that did not benefit from government investment in water infrastructure during the twentieth century.[53]

   This research, however, demonstrates that investing in water and sanitation systems is economically advantageous overall, because it lowers the disease burden, increases economic productivity, and eliminates opportunity costs. This is true even when a system cannot sustain itself through rate payment. Policymakers can use this economic analysis to justify increasing infrastructure investments, funding operations and maintenance costs, and implementing policies that keep households from losing access due to factors like affordability or climate change.

4. **The water access gap negatively impacts every part of the economy.** Our research demonstrates that not having access to water and sanitation quantifiably impacts every aspect of a person's life, including harms to physical health and increased disease risk; increased stress and anxiety; time lost from work or school to collect water; money spent on packaged water; household productivity losses; and even death. Beyond the pain and stress of this daily struggle, each of these factors has an impact on a family's economic vitality. We estimate that households inside the water gap lose on average $15,800 a year, simply because they lack access to basic services. Low-income families suffer the most; for many, that's more than their total annual household income.[54]

   But while the economic burden of the water access gap falls most heavily on households without basic services, the harm doesn't stop there. A lack of access to water ripples out into the broader community and the nation at large. Federal, state, and local governments carry increased health care costs and lost future tax revenues, and private businesses accumulate losses via labor market impacts and decreased economic activity. Every part of the economy is impacted.

We can use diabetes to illustrate this point. Using available data, we estimate that the water access gap is responsible for 36,400 cases of diabetes per year. Research shows that a person without access to safe, reliable drinking water is more likely to rely on sugary beverages, which may be cheaper, more readily available, or more aggressively marketed than packaged water. As a result, they may consume a greater number of calories and added sugars, increasing the risk of diabetes, obesity, and associated adverse health outcomes.[55] Managing diabetes leads to increased health care costs for an individual, their household, and for society at large.[56] People with poorly managed diabetes also tend to incur higher productivity losses due to missed work days.[57] Their increased risk of premature loss of life due to complications from their illness may cause them to earn less, pay less in taxes, and invest less in their local economy over their lifetime, negatively impacting GDP.[58] It may also mean that their children suffer from intergenerational impacts related to educational achievement, debt, and other compounding factors.

In rural McDowell County, West Virginia, many people haul water home in milk jugs from mine shafts or mountain springs. The water can cause rashes, illness, and even death. Some residents have cut their daily water use to just five gallons, while others wait for rain so that they can shower under their gutters. Tori S., like many of her neighbors, goes into the woods to collect water from a mineshaft for herself and her daughter Iris Rose. "Last summer, I had to fill up buckets and heat up buckets and then put them in the bathtub and try to sponge bathe her, because I can't have my kid going for three weeks without a bath. You definitely ration it. You try to hold off taking a bath or flushing the toilet a few times, every way possible to just save yourself a trip."[60]

5. **Water access is a social, economic, and environmental justice issue.** Access to water and sanitation is a basic human right recognized by the United Nations (UN) and a key social, economic, and environmental justice issue.[61] Closing the water access gap will advance equity and right historical wrongs that go back nearly 100 years, when the US government started making enormous investments in modern water infrastructure that excluded many tribes, communities of color, immigrant communities, and rural areas.[62 63] While some Americans take their water and sanitation services for granted, these communities have suffered the economic consequences of not having safe, reliable water service for generations.

   Recent research has suggested that a lack of access to water and sanitation may correlate with other forms of poverty.[64,65] Race is also at play. Indigenous households are 19 times more likely than white households to live without basic plumbing; Black and Latino households are twice as likely.[66] And because federal funding for water infrastructure has declined precipitously over the last four decades, impacted communities have struggled to catch up to the rest of the country. Investments in basic water infrastructure would not only reduce racial and economic disparities by immediately lessening the burdens associated with physical health, mental health, and lost time and productivity, but they may also help close the gap in long-standing environmental and public capital inequities seen in many of these communities by attracting other types of investment.

# "People think that water is just something. No, it's everything. If you don't have it, you're at a total loss."

– Tina, McDowell County, West Virginia

SECTION TWO

# Economic Harms Caused by a Lack of Access to Water and Sanitation

**This section describes the various economic burdens placed by the water access gap on individual households and on society at large.**

The economic findings summarized in this report are the product of research led by Altarum Institute. This report quantifies the health, well-being, labor market, and other economic impacts of the US water access gap and the potential net societal return of closing it.

In April 2020, Larry W. and his mother Mary Ann contracted Covid-19. Larry was a disabled Army veteran who served in Operation Desert Storm. His mother lived in Arizona, in a remote corner of the Navajo Reservation. Larry often visited his mother to haul firewood and drinking water. Without running water, he couldn't wash his hands at home and he was forced to break social isolation to haul water, gathering in public spaces at the height of the pandemic. In mid-March 2020, during the first wave of cases, Larry contracted Covid-19 and likely brought it to his mother without knowing it. They both died.[67] Infection and mortality rates for Covid-19 on the Navajo Nation were the highest in the country during the first wave of the pandemic, a tragic reality many public health officials attributed to the fact that nearly a third of homes on the reservation lack running water.[68]

Like Larry and Mary Ann, more than 2.2 million people in the US lack basic access to drinking water, water for cleaning and bathing, facilities like showers and toilets, and safe means to dispose of wastewater. Families in the water access gap are forced to improvise. Some drastically limit their daily water use; others bathe in local surface water sources such as lakes and streams, or collect their drinking water from those sources, sickening themselves and their families.[69][70] Many spend a high percentage of their household income purchasing bottled water or substituting drinking water with other sugar-sweetened beverages. In the worst cases, people die.

The water access gap has a very real price tag. Previous research has demonstrated that living without access to water and sanitation means an increased risk of gastrointestinal and other diseases, decreased life expectancy, harms to overall health and well-being, poorer mental health outcomes, increased health care costs, and lower expected employment and earnings. Each of these burdens has a cost we can isolate and define.

Based on our analysis, the economic harm caused by the water access gap for the 539,000 households (1.57 million people) lacking complete water infrastructure conservatively amounts to a total loss of $8.58 billion, or more than $15,800 per household, per year, when direct and implicit economic costs are combined.

## THE US WATER ACCESS GAP COSTS

# $8.58 billion

## EVERY YEAR

*These estimates include only costs attributable to the 1.57 million people within the study population.

### PHYSICAL HEALTH

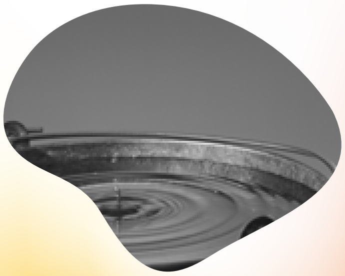
## $762 million

**219,000** cases of water-borne illness per year; **36,400** new cases of diabetes per year; people without running water are **30 times** more likely to contract a related disease

### MENTAL HEALTH

## $218 million

**71,000** additional cases of mental health conditions per year; **$183 million** in additional medical bills per year; **$35 million** in lost annual earnings due to depression



### TIME LOST FROM HAULING WATER

## $846 million

**68.7 million** work hours lost per year (232 work hours lost per adult); **11.5 million** school hours lost per year (170 school hours lost per child)

### WATER PURCHASING COSTS

## $291 million

**$1,350** spent on bottled water per family, per year

### LOST PRODUCTIVITY IMPACTS TO GDP

## $924 million

Nearly **$1 billion** in knock-on losses to GDP per year; more than two-thirds of which comes from time adults spend hauling water

### PREMATURE LOSS OF LIFE (IMPLICIT COSTS)

## $5.54 billion

**610** premature deaths per year

# PHYSICAL HEALTH IMPACTS: $762 MILLION

Families living in the water access gap face difficult health challenges every day because they don't have the taps or toilets many Americans take for granted.

On the Navajo Nation in rural New Mexico, Velma M. used to haul water several times a week, including from a nearby livestock pond. She hauled water for her late husband Silas, a disabled veteran with persistent health issues related to Agent Orange exposure in Vietnam. Because Velma struggled to keep him clean, Silas' bedsores frequently became infected, and he had to be transported to the hospital. Velma sometimes fell from carrying the heavy water buckets, injuring herself. She used her husband's wheelchair to haul the water when she was too weak or tired to carry containers. Fortunately, Velma received an off-grid water system in 2018, a day so joyful and life-changing that she compares it to the birth of her son.[71]

Our literature review found increased risk associated with lack of water access for four types of waterborne disease: diarrheal disease, lower respiratory disease, skin disorders, and obesity/diabetes. These specific health risks are deeply connected to the coping mechanisms of families without access to water and sanitation, such as collecting water from a nearby stream, or relying more heavily on sugar-sweetened beverages.

An estimated 219,000 cases of waterborne illnesses could be prevented each year if we closed the water access gap. On average, each case of a preventable waterborne disease costs a household $723 a year in medical costs (emergency department visits, outpatient visits, hospital admissions, and prescription drug costs), plus additional economic losses due to missed work or school days. Families in the water access gap are 30 times more likely to contract one of these illnesses than those living in houses with basic services.

A person without access to drinking water is more likely to rely on sugary beverages, causing them to consume a greater number of calories and added sugars, increasing their risk of diabetes, obesity, and the associated adverse health outcomes. We estimate that the water access gap causes 36,400 new cases of diabetes each year, each case costing an additional $10,100 in medical spending annually. That's a total of $368 million in diabetes-related medical bills for impacted households.

## EVERY YEAR

**219,000** cases of waterborne illness

**36,400** new cases of diabetes

**723 MILLION** extra dollars spent on health care

People without running water are **30 TIMES** more likely to contract a related disease

## *GAPS IN WATER AND SANITATION ACCESS*

Families without access to water and sewer lines or on-site solutions (such as functioning wells and septic systems) are forced to compensate by relying on unsafe sources—which can have a detrimental impact on their health and economic well-being.[72][73] Here are some common coping mechanisms:

### WATER

#### Drastically restricting daily water use

Families ration their water and often use the same water for multiple activities, including cooking, cleaning, and bathing.

#### Limiting daily bathing activities

Restricting water use means less frequent bathing and hand washing, contributing to more frequent cases of disease and infection.

#### Cleaning and bathing in local surface water

There are documented cases of families in Appalachia waiting for rain to bathe underneath gutter downspouts.

### SANITATION

#### Relying on a failing septic tank

At least **22 million** households rely on failing septic systems; in some areas over half of systems are failing and households bear the burden of fines and high replacement costs.[74]

#### "Straight-piping" waste into the ground or nearby streams

Straight pipes discharge raw sewage from homes into yards, trenches, and other nearby surfaces and are documented in **15 states**.

#### Using a cesspool to drain waste into the ground

Cesspools are a solution some households use that discharge wastewater into underground holes with or without a structure (such as a concrete cylinder) that allow wastewater to flow out an open bottom and/or perforated sides; cesspools are common in Hawaii and currently documented in four other states, but likely more extensively used.

## *GAPS IN WATER AND SANITATION ACCESS*

**Families without access to water and sewer lines or on-site solutions (such as functioning wells and septic systems) are forced to compensate by relying on unsafe sources—which can have a detrimental impact on their health and economic well-being.[72] [73] Here are some common coping mechanisms:**

### Collecting drinking water from the local environment

Families who cannot afford packaged water often haul drinking water from the most readily available sources, including mineshafts, streams, or ponds, which may be contaminated.

### Purchasing and hauling bottled water back home

We conservatively estimate that families without access spend an additional **$1,350 per year** on packaged water, not including the time spent hauling water, physical impacts, or the cost of fuel and wear and tear on vehicles.

### Substituting daily drinking water with sugar-sweetened beverages

A person without access to drinking water is more likely to rely on sugary beverages, increasing the risk of diabetes, obesity, and associated adverse health outcomes; we estimate that the water access gap causes an estimated **36,400 new cases** of diabetes each year.

### Relying on a failing septic tank

Many outhouses are not properly installed or installed in areas where the soil type is not conducive for outhouses, where the water table or bedrock are too shallow, and/or the wastewater is not properly contained; failing outhouses are still common on Navajo Nation and in *colonias*.

### Using a bucket latrine in place of a toilet

Bucket latrines are large buckets with a seat attached that are used as toilets, with a high risk of exposure to fecal-borne pathogens, gasoline, disinfectants, and other toxins; in some Alaska communities, the number of households without piped services relying on “honey buckets” increased from 2016 to 2017.[75]

### Defecating in the open

Families without access to any toilet or sanitation service defecate in the open; in the US, this condition is primarily experienced by the hundreds of thousands of people experiencing homelessness.

# MENTAL HEALTH IMPACTS: $218 MILLION

Families in the water access gap must make stressful decisions about how to ration their water and must constantly find, purchase, or collect water outside of the home. Numerous studies have identified a link between lacking reliable water access and mental health outcomes, primarily driven by increased stress and anxiety that come with the uncertainty of an insecure water supply.[76]

In Keystone, West Virginia, a town of fewer than 250 people, access to safe water is far from reliable, since infrastructure has been falling into disrepair for decades. Like many of her neighbors, Tori S. must venture frequently into the woods to collect water. Her most reliable source is an abandoned mine shaft that she visits to fill a plastic tank in the back of her truck. Several years ago, Tori experienced additional stress and anxiety when hauling water to feed and bathe her newborn daughter, Iris Rose. Tori worried that drinking contaminated water might taint her breast milk, and her anxiety only increased when she couldn't find the sought-after information in the parenting books available at her local library.[77]

We estimate that the water access gap is responsible for 71,500 cases of mental health conditions each year, including depression, anxiety disorders, and others. These additional cases cost more than $183 million to treat each year, or a whopping $2,560 per person in combined medical spending and lost productivity. People suffering water access-related depression lose more than $35 million in annual earnings. These health care costs are borne by individuals and households, private insurance payers, and government payers (Medicare and Medicaid), who spend this excess money on outpatient visits, prescription drugs, hospitalizations, and other health care costs that we estimated using aggregate cost-per-case data.

## EVERY YEAR

**71,000**
additional cases of mental health conditions

**$183 MILLION**
in additional medical bills

**$35 MILLION**
in lost annual earnings due to depression

# TIME LOST FROM HAULING WATER IMPACTS: $846 MILLION

Many people living in the water access gap must haul water for drinking, bathing, cooking, and cleaning. While the source of water and method of hauling vary greatly (e.g., some collect water from streams, while others purchase water from a store), the estimated time lost to water hauling can significantly impact how a person spends their day. For adults, water hauling comes at the expense of paid work, household chores, childcare, and even leisure. School-age children lose time from school, homework, or play.

About two dozen families in Cochran, a small *colonia* subdivision located just southeast of El Paso, must choose between buying bottled water, purchasing non-potable water at an astronomical $250 per load (they may require two to three loads per month during the summer), or hauling water from nearby wells, many of which are unregulated and may be contaminated. [78] Hauling is an expensive—and often dangerous—effort for the average household in Cochran, which makes just $28,000 a year. One resident lamented the way water hauling takes precious family time: "God willing that we actually get running water, because, you know, that's a lot of time that we miss away from our family. Either me, or my dad. My brother has his little ones ask 'Dad, where are you going?' They already know the time frame that it takes, you know, missing time away from home. That's very time-consuming and stressful."[79]

Assuming that 25% of individuals within a household lacking complete plumbing spend 30 minutes a day collecting water outside the home, we estimate that working-age adults lose 68.7 million hours each year—an average of 232 hours per adult. [80] The lost economic value of these hours equals nearly $713 million (or $2,405 per adult) each year, when calculated using an average prevailing hourly wage.[81]

We also estimated the economic impact on school-age children who must haul water. Although children don't generally earn wages, we used recent research that projects the discounted future earnings potential lost due to time missed in school and other educational activities, such as homework. [82] We estimate that the 66,725 school-age children living within the water access gap spend, on average, 170 hours a year collecting water outside the home—or 11.4 million hours per year total valued at $11.43 per hour. [83] That comes out to $133 million in total annual economic losses (or $1,993 per child) caused by time lost hauling water from outside the home.

**EVERY YEAR**

**68.7 MILLION**
work hours lost
(232 hours per adult)

**11.5 MILLION**
school hours lost
(170 hours per child)


DRINKING
WATER

# DIRECT WATER PURCHASE COSTS: $291 MILLION

Bottled water is one of the primary sources of drinking water for families without a tap at home, and those costs add up quickly.

In McDowell County, West Virginia, bottled water is the most requested item at Five Loaves, Two Fishes Foodbank. Because of its cost and long shelf life, it's also one of the most difficult items for the foodbank to secure as a donation. McDowell, once one of the wealthiest counties in the country, is now among the poorest. Its municipal water system, originally built by coal companies, has fallen into disrepair, and many people don't have reliable running water. Residents drive long distances to buy bottled water; some even haul water home in milk jugs from mountain springs and bathe under gutters when it rains. [84] "We've just learned to live with it," said Linda M., who runs the foodbank.[85]

Our estimate assumes that 40% of households lacking complete plumbing facilities purchase bottled water as their primary drinking water source, at a conservative cost of $0.50 per gallon. [86] (This cost, while likely appropriate for purchases of water in bulk, may underestimate the typical average family cost.)[87] As a result, we estimated that each family purchasing bottled water as their main source for drinking spends $1,350 a year, which reflects only the cost of the water itself and does not include time spent hauling water, fuel, or vehicle wear and tear.


**EVERY YEAR**

families spend

**$1,350**

on bottled water

# LOST PRODUCTIVITY IMPACTS TO GDP: $924 MILLION

Whenever an individual or household experiences a loss in earnings (for example, due to illness or water hauling), it has a knock-on effect impacting the US Gross Domestic Product (GDP).

Brenda J's family lost nearly all their household income for several weeks when her husband injured his foot at work. Without running water at home to clean the wound, it became dangerously infected, and he was hospitalized. His lost work hours were a crippling hit to the family's income, meaning Brenda couldn't buy food and gas. In her small town in rural New Mexico, a percentage of Brenda's economic distress was passed on to local business owners, government (as lost sales tax revenue), and eventually the broader economy.

When a dollar is earned by an individual, a portion of that dollar is typically spent in the real economy on goods and services, leading to additional income for other economic entities, which in turn spend a portion of those dollars themselves. [88] Lost earnings and productivity due to disease, mental health conditions, and lost time from hauling water all decrease individual earnings and therefore spending within the local economy, causing a knock-on effect to GDP that accrues over time. We estimate that the water access gap costs $924 million in lost economic growth per year. Of that nearly $1 billion hit to GDP, $65 million comes from lost productivity due to illness, $148 million from lost productivity due to premature loss of life, $33 million from the mental health impacts on labor force outcomes, and $678 million from the time costs for adults hauling water. This estimate only includes losses directly attributable to the water access gap.

## EVERY YEAR

Nearly

**$1 BILLION**

in knock-on impacts to GDP; more than two-thirds of which come from time adults spend hauling water

# IMPLICIT VALUE OF PREMATURE LOSS OF LIFE: $5.54 BILLION

The final economic component in our cost analysis is the implicit value of the lives lost prematurely due to the physical illnesses described above.

Sandra W.'s grandmother Mary lived in Crystal, New Mexico, in a home without running water. During the summers, Sandra's kids would stay with their grandmother, helping her haul water in barrels, milk jugs, and any other containers they could find. Sometimes they had to drive all the way to Navajo, New Mexico, to fill up at a family member's house. Because hauling water was so labor-intensive, Sandra remembers that Mary drank a lot of sugar-sweetened juice and soda.[89]

At some point, Mary developed a sore on her foot. She kept up her routine, even though a lack of clean, running water made it difficult to keep the wound clean. Eventually, the sore became so severely infected that Mary was flown to Albuquerque to receive treatment at a hospital, where she was diagnosed with diabetes. Although the sore eventually healed, Mary passed away due to complications from diabetes shortly after her diagnosis. Several of Mary's grandkids have since developed diabetes themselves.[90]

It's relatively easy to quantify the health care and productivity losses due to preventable disease, but these costs fail to account for the true value of human life beyond a person's economic output. While the concept of putting a dollar value on a lost life can be both difficult and uncomfortable, a Value of Statistical Life (VSL) approach is frequently used in evaluations of environmental or public safety issues by the federal government and is critical to understanding the true cost of the water access gap.[91]

Tragically, we estimate that 610 people die prematurely each year in the US from waterborne diseases and diabetes contracted because of a lack of access to running water.[92] That's the equivalent of two passenger planes falling from the sky… simply because some people living in the wealthiest democracy on Earth can't turn on a tap or flush a toilet. We use EPA's current guidance to estimate the total implicit value of life at $9.3 million per individual—resulting in an economic loss of $5.54 billion annually.[93 94]

# NON-QUANTIFIED IMPACTS

Our analysis does not account for certain potential harms for which economic costs cannot be quantified, because necessary data are not available. Those elements are outlined under the heading What's Not Included in This Estimate? in the Methodology section above. As a result, this analysis conservatively underestimates the economic burden caused by the water access gap.

**EVERY YEAR**

**610**
premature deaths


igloo

# "The communities where this is going on are low-income people that work hard for their money and still have to work extra to get clean water. Do we deserve to live like this? Are we pretty much trash? We deserve clean water."

**Mayra C.**
**East Orosi, California**

There is no water system in Mayra's neighborhood, even though water lines are just a few blocks away. She uses expensive bottled water for herself and her three kids.[95]

SECTION THREE

# Economic Benefits of Closing the Water Access Gap

**This section estimates the cost to close the water access gap for good and the potential return on investment.**

We've seen the terrible harms that the water access gap inflicts across society, especially on low-income families and communities of color. Fortunately, the story doesn't end there. The good news is how much we stand to gain by extending water and sanitation access to all US households.

Our model shows that the benefits of closing the water access gap outweigh the costs by nearly 5 to 1. For every dollar invested in expanding access to running water and flush toilets for the millions of Americans without them, the economy would gain $4.65 in net societal return, including $1.65 in direct benefits such as lowered health care costs and more time to work or study, and $3 in implicit benefits by reducing premature loss of life. Those economic benefits (both direct and implicit) accrue to $366,400 per household on average over the lifespan of their new water and wastewater service. That's a total of nearly $200 billion waiting to be captured.

To calculate the return on investment, we first estimated the cost of closing the water access gap. Our estimate should be seen as a conservative jumping-off point. This is the first estimate of its kind; estimates of the investment required to universalize access to water and sanitation in the United States are surprisingly lacking in current literature, perhaps because there is no complete national dataset on household infrastructure needs to leverage.[96] To compensate for this uncertainty, we provide very clear assumptions and use clear and conservative data values as model inputs.

**5-TO-1**
Return on Investment

**$42.5 BILLION**
to close the water gap

**$366,400**
on average per household in economic benefits

**$200 BILLION**
in value returned to US economy

# ESTIMATING INFRASTRUCTURE COSTS AND RETURN ON INVESTMENT

We used survey data, geographic data, prior literature, and expert opinion to estimate the upfront cost of installing new water and/or wastewater infrastructure, long-term operations and maintenance costs, the ongoing costs of water and sewer services, and their expected longevity. We did this while estimating the fraction of households (by county) that are in urban versus rural areas; require new installation versus repair of existing infrastructure; require new water service only, wastewater service only, or both types of services; and the expected period for which each household would benefit from their improved access.

Several steps were involved in this analysis:

**First, we estimated the total number of households lacking access to basic water service and their location.** ACS data estimates that 539,000 occupied households lacked access to complete plumbing in the 50 US states, District of Columbia, and Puerto Rico in 2020. Then we estimated the fraction of households in urban versus rural areas to help determine whether they were likely within an existing water system service region and could be connected to a nearby system, or whether they would require a permanent off-grid solution (such as a well or decentralized system). We used data on the penetration of high-speed internet service to further refine this estimate.

**Second, we estimated the type of service each home would need.** Using a subset of the ACS data on the proportion of homes lacking either only running water or only toilets, we estimated the number of homes requiring new installation versus repair of existing infrastructure, and, for each group, the percentage requiring new water-only service, wastewater-only service, or both types of services.[97]

**Third, we developed an average cost model across three possible scenarios to reduce uncertainty.** We ran three scenarios in our cost and net return models: an initial, "most likely" estimate; a "low-cost" alternative, where costs are lower, new installation rates are lower, and homes are closer in proximity to existing systems; and a "high-cost" alternative, where costs, rates of new construction, and rurality are higher. When placed in a matrix, these variables create 54 categories. Estimated costs are lowest for water-only repairs in a home with access to an existing water system, while they are highest for a home requiring a new installation of both water and wastewater service outside of an existing system's range. We estimated these costs as averages across all homes within each category to control for the expected variability in costs for a particular home.

**Finally, we estimated the expected lifespan of new infrastructure and factored in operations and maintenance costs.** We estimated the future annual service costs for households using current US average water and wastewater rates, and additional operating and maintenance costs by assuming 2% of initial capital costs per year for system solutions (on-grid) and 4% of initial capital costs for outside-of-system investments (off-grid). We assumed solutions connected to a system have a longer usable lifespan (50 years) than off-grid solutions (25 years). Finally, we incorporated costs specific to 67,200 households in Puerto Rico lacking basic water access.

## FOR EACH US COUNTY, OUR MODEL ESTIMATES THE PERCENTAGE OF HOUSEHOLDS LACKING WATER ACCESS THAT ...

**I.** Are Within Range of a Water System

**II.** Are Within Range of an Extension

**III.** Are Outside Range of Any System

## AND

**A.** Require only Water Infraestructure

**B.** Require Only Waste Infrastructure

**C.** Require Both Water and Waste Infrastructure

## AND

**I.** Require new Installation or Complete Replacement

**II.** Require only Repairs of Existing Infrastructure

## TO CREATE 18 CATEGORIES

| | | | | | |
|---|---|---|---|---|---|
| I.A.1 | I.A.2 | II.A.1 | II.A.1 | III.A.1 | III.A.1 |
| I.B.1 | I.B.2 | II.A.1 | II.A.1 | III.A.1 | III.A.1 |
| I.C.1 | I.C.2 | II.A.1 | II.A.1 | III.A.1 | III.A.1 |

## AND MODEL THESE CATEGORIES UNDER 3 COST ASSUMPTIONS

Baseline Cost Scenario

Low-Cost Alternative Scenario

High-Cost Alternative Scenario

## USING DATA FROM THE FOLLOWING SOURCES ...

**I.** US Census County Urban Influences Measures

**II.** Penetration of Wired High-Speed Internet

**I.** Prior US Census Data on "No Toilet" vs. "No Running Water" Presence

**I.** Estimates Based on Expert Opinion

## THE COST TO CLOSE THE WATER ACCESS GAP

We estimate that it will cost $42.5 billion to close the water access gap. This amounts to an average total discounted cost per household of $78,900.[98] Our base scenario estimates that 191,000 households requiring new infrastructure are already within an existing water system service region, an additional 172,000 are within possible extension of an existing system, and 176,000 are permanently outside an existing system's reach, requiring an off-grid solution.

While $42.5 billion is a significant cost, most of that spending would be spread out over the lifetime of the new infrastructure, not invested all at once. In our base scenario, the initial investment required for new infrastructure is just $18.4 billion, less than Americans spend every year on ice cream.[99]

# THE COST OF CLOSING THE WATER ACCESS GAP

## 191,000

**HOMES WITHIN SYSTEM**



## 172,000

**HOMES WITH POSSIBLE CONNECTION TO SYSTEM**



## 176,000

**PERMANENTLY OUTSIDE OF SYSTEM**


# THE COST OF CLOSING THE WATER ACCESS GAP

## 191,000

**HOMES WITHIN SYSTEM**

An estimated **191,000** homes are within an existing utility district and simply require a connection. This is the case in Cochran *colonia* near El Paso, Texas—a community of 72 lots that has been waiting for service since the mid-1980s. Cochran is working with DigDeep, El Paso County, and local housing nonprofit A.Y.U.D.A. to receive running water, fire suppression, and other basic services from the nearby Horizon Municipal Utility District.[100] The project requires outside nonprofits to help residents overcome complicated administrative barriers such as signature collection and advocacy with state legislators. Private funds will be used to cover some of the upfront installation costs, triggering additional investments from the county. Private funds will also be used to help homeowners upgrade facilities in their dwellings; generally, public funds cannot be used to build facilities on private property. The project is slated for completion in 2022 and, if successful, may become a model for assisting the thousands of other *colonias* waiting for water and sanitation in Texas, Arizona, New Mexico, and California.

## 172,000

**HOMES WITH POSSIBLE CONNECTION TO SYSTEM**

An estimated **172,000** homes are close enough to an existing utility district to be connected, provided the right funding and political will can be mobilized. One mechanism that leverages economies of scale and improves water service is consolidation. Consolidation refers to a spectrum of practices; in some instances, areas that lack service are connected to neighboring systems; in other cases, two or more utilities merge to form a single system; or systems remain physically separate but consolidate management to leverage staff capacity. This enlarges their capacity, allowing them to provide a better quality of service to existing ratepayers and even extend service into new areas.

When private wells in East Porterville, California, failed during the last drought, the state paid **$650,000** a month for water deliveries. A coalition of state and local agencies and community-based organizations launched a consolidation effort to connect the **2,500** residents of East Porterville (755 homes) to the nearby municipal system in Porterville at a cost of about $48 million. In the end, the cost to provide running water and flush toilets was roughly equal to the amount the state paid for emergency water delivery over a five-year period.[101 102]

## 176,000

**PERMANENTLY OUTSIDE OF SYSTEM**

An estimated **176,000** homes are located permanently outside of utility system service areas. Many are located in remote areas with difficult terrain, low population density, or other challenges that may make piped water and wastewater services prohibitively difficult to extend. Homes that can't connect to a public system often use decentralized systems, such as wells or septic systems. This is true for **20% to 25%** of all homes in the US.[103] In places where soil type or groundwater issues make a home a bad candidate for a private system, however, "off-grid" systems using new technologies can be leveraged.

The Portable Alternative Sanitation System (PASS) is an off-grid household water and sanitation system suitable for the unique challenges faced by tribal families in rural Alaska, such as permafrost. PASS systems use a ventilated, separating toilet for human waste and ultra-low flow fixtures. The Alaska Native Tribal Health Consortium (ANTHC), which designed the PASS system, has installed them in hundreds of households, studying the health benefits when families replace bucket latrines with a functioning toilet.[104] Systems like the PASS often exist in "gray areas" outside of existing codes and federal funding criteria.

# THE RETURN ON INVESTMENT

If we compare the marginal cost of closing the water access gap above with the total discounted economic benefits during the lifetime of the new infrastructure, it's clear how much we stand to gain by closing the water access gap once and for all.

We find the direct economic return from improvements in health, labor market, and school outcomes for marginalized households (previously estimated in our work at $3.04 billion per year), would accrue to a complete total discounted value of $70 billion. As a result, when considering just the direct economic outcomes, our modeling finds the expected net societal return of closing the water access gap to be $1.65 per dollar invested. When the additional implicit benefits of reducing premature loss of life are added, we find the return to be even greater: $4.65 per dollar invested.[105] [106]

When computed as a total benefit per household over the lifespan of the new water or wastewater service (up to 50 years), we find the average direct economic benefit for each household to be $129,800. When the implicit improvements in life expectancy are added, the total value per household increases to $366,400. That's nearly $200 billion in potential economic value that could be generated by closing the water access gap.

SECTION FOUR

# Where We Go from Here: An Action Plan

**This section lays out four recommendations for achieving universal water access in our lifetimes.**

# "I turned on the nozzle and oh my god, the sound, the smell. I even washed my face with the water to see if it was real ... There's nothing, no life without water. And to me, when I turned on that faucet, it felt like how I felt when I gave birth to my first child. He's perfect, pure, and a necessity! He was necessary— just the same as the water."

– Velma M. Navajo Nation

This report is written for anyone seeking a more comprehensive understanding of the impact the water access gap has on individuals, their communities, and the nation at large. We hope a clearer accounting of the costs and benefits of closing the water access gap is especially helpful to those setting state and national priorities, appropriating funds, and directing the work of government agencies.

So how specifically can we ensure that everyone in the United States has access to the running water and basic sanitation they need to thrive?

Closing the water access gap will require dedicated resources, ingenuity, new partnerships, and efforts to increase public awareness and political will. Each of us has a role to play. In this section we update sections from the Action Plan in our 2019 report, *Closing the Water Gap in the United States,* to incorporate the key findings from this economic analysis. We highlight opportunities for action by the water sector, government agencies, philanthropy, nonprofits, and the public.


**THE ACTION PLAN.**

Our 2019 report co-authored with the US Water Alliance, *Closing the Water Access Gap in the United States,* includes a multi-faceted Action Plan based on that study's findings and input from the 30 members of that report's Advisory Council. Every one of the report's recommendations remains urgently relevant today, especially considering these economic findings. To read the full Action Plan visit: digdeep.org/close-the-water-gap

## WANT TO CLOSE THE WATER ACCESS GAP?

1. Expand and refocus federal and state funding.

2. Use data to bring visibility to communities.

3. Define the water access gap as a crisis.

4. Build a domestic water, sanitation, and hygiene (WaSH) sector.

# 1. EXPAND AND REFOCUS FEDERAL AND STATE FUNDING.

## WHAT THE ECONOMIC DATA TELL US:

Our analysis shows that roughly $42 billion in new spending can universalize access to water and sanitation in the US and produce meaningful, long-lasting societal benefits. But solving this problem won't just require new spending; it will require smarter, more flexible spending that targets the water access gap directly and keeps it from growing.

New programs and technologies are needed to reach the 176,000 households we estimate are permanently outside of utility service areas. Our analysis demonstrates that the economic benefits of expanding access to water and sanitation outweigh the costs by nearly 5 to 1, even when a system cannot sustain itself through rate payment. This presents an opportunity to realign federal and state funding policies in a way that recognizes the overall economic contribution of a water or wastewater system. Finally, while there are roles for the private, philanthropic, and nonprofit sectors to play in funding water and wastewater projects, the federal government must take a strong funding lead to overcome the "wrong pockets" problem identified in our research.

# WHAT SHOULD BE DONE:

**Invest dedicated funds to close the water access gap:** Congress should begin by appropriating an initial $18.4 billion (as estimated under The Cost to Close the Water Gap in Section Three of this report) to execute a policy to completely close the water access gap over the next 10 years. This work should be overseen by an interagency task force led by EPA. While the long-term investment required will be much higher (estimated at $42 billion), many of those costs will be spread out over the lifespan of the new infrastructure, buying time for federal and state governments to collect more granular, actionable data on the location and condition of households without access. (Collecting better data is addressed in Recommendation Two, below.)

Congress must also dramatically increase the federal share of spending on water and wastewater systems and make that funding more flexible to ensure the water access gap does not continue to grow. Over the past several decades, the federal share of water-related spending has been reduced to a mere trickle.[107 108] Communities that did not benefit from past investments have struggled to catch up, while once-functioning systems have fallen into disrepair, a process accelerated by the stress of climate change. While the IIJA's $55 billion in new, water-related spending is an important first step, that one-time funding increase will not completely close the water access gap and represents just a fraction of the overall need.[109]

**Expand existing funding sources to keep the gap from growing:** Congress should expand funding sources like State Revolving Funds (SRFs), Community Development Block Grants, USDA Rural Development (RD) grants, and programs under the Water Infrastructure Finance and Innovation Act, making them more accessible by offering grants and 100% principal forgiveness loans to rural and disadvantaged communities. Technical assistance (TA) providers also need increased funding; they are essential in helping understaffed systems navigate funding applications, manage operations, become financially sustainable, and meet regulations, but the financial need outpaces existing TA capacity. The White House should continue to coordinate the work of relevant agencies through the water subcabinet[110 111] and ensure that new infrastructure investments benefit the communities that need them most, using an interagency organizing mechanism such as Justice40.[112]

Additionally, the formulas used to calculate funding eligibility should be modernized. SRF eligibility, for example, is determined on a state-by-state basis, and therefore certain criteria, such as what constitutes a disadvantaged community, may vary. This presents a unique challenge to tribes that reside in multiple states. Agencies offering loans and grants should engage in proactive outreach to impacted communities and support them with concierge-like services as they undertake the application process. Many communities cannot access funding simply because they lack capacity or expertise to complete an application.

**Invest in new solutions and technologies:** Closing the water access gap will require funding for interim solutions and new technologies, such as decentralized systems to serve the estimated 176,000 households we estimate are located permanently outside of utility service areas. While the IIJA directed EPA to form a pilot program for decentralized wastewater projects in rural and disadvantaged communities, Congress has not yet appropriated the funds for that program.[113] A sister program focused on decentralized drinking water should also be created.[114] [115] Restrictions on public funding should be loosened to allow decentralized technologies to reach scale; in some cases that may mean granting funds to homeowners (directly or through an intermediary), making funds available to WaSH nonprofits (which often have direct relationships with impacted communities), and allowing federal funds to be used to purchase equipment installed on private property.

**Begin funding system operations and maintenance:** Federal funding statutes must be updated to support the ongoing operation and maintenance (O&M) of water and wastewater systems. When a system falls into disrepair, more people fall into the water access gap. Targeted investments in O&M, however, can keep a system functioning and prevent problems from compounding. Unfortunately, even small investments in O&M may be out of reach for as many as half of the nation's 45,000 small community water systems facing financial challenges.[116] Armed with the knowledge that the overall economic benefits of expanding access to water and sanitation outweigh the costs by nearly 5 to 1, federal programs should finally abandon the principle that all water and wastewater systems must be financially self-sufficient through rate payment.

**Develop cross-sector funding partnerships:** The federal government must take the lead on investment if we are to overcome the "wrong pockets" problem outlined earlier in this report, but the private and philanthropic sectors have a role to play too.[117] Philanthropy can partner with universities and private businesses to invest in promising new technologies that fall into gray areas, outside of existing codes and federal funding requirements. Private investment can help demonstrate the effectiveness of new technologies, providing the data that regulators need to adopt new standards. Congress and state governments should also provide the private sector dedicated support in the form of funding, enforcement flexibility, and tax credits to incentivize utilities to consolidate with or support smaller systems that are out of compliance.[118][119]

**Work directly with impacted communities:** All this funding should be informed by—and designed to meet—the real needs of impacted communities, which must co-design their own solutions. Government, philanthropy, and private businesses should consult with communities facing access challenges through dedicated outreach, consultations with community groups and nonprofits, and feedback mechanisms such as the Decentralized Wastewater Innovation Cohort (DWIC).[120][121]

# 2. USE DATA TO BRING VISIBILITY TO COMMUNITIES.

## WHAT THE ECONOMIC DATA TELL US:

The United States does not currently have a central, reliable dataset that shows how many people in the US lack water and sanitation access, meaning there is no baseline against which to track our progress. In fact, the best available data—Census ACS estimates—have become less reliable in recent years due to the removal of the toilet question. In many underserved communities, a lack of actionable data has resulted in insufficient financial assistance and infrastructure investment. The few places with better data collection efforts, however, have seen more funding. American Indian and Alaska Native tribes surveyed by the Indian Health Service's Sanitation Facilities Deficiency List, for instance, received $3.5 billion in IIJA funding to completely fund their outstanding water and wastewater projects.[122]

# WHAT SHOULD BE DONE:

**Update the Census to incorporate Water, Sanitation, and Hygiene (WaSH) questions:** You can't manage what you don't measure. We need better data to understand the full scope of what the water gap is costing us and what we stand to gain by fixing it. We also need more actionable data—for example, information showing the location and nature of infrastructure deficits—to help government and nonprofits prioritize and plan infrastructure projects more effectively. Again, this is an area where the federal government must lead.

Congress should direct the Census Bureau to restore its survey question on access to toilets, and add questions on wastewater services, water quality, and cost.[123] EPA should collect and standardize geospatial data on water and wastewater system service areas in order to better map areas of need. Other government data sources can be made more relevant to water access issues too. With additional funding, the United States Geological Survey, which collects data on water quality, groundwater levels, and water use, could release new datasets more frequently. The American Housing Survey, which includes questions on plumbing access, could sample more extensively in rural areas. The need for better data is more urgent than ever because of the negative impact Covid-19 may have had on the accuracy and integrity of the 2020 Decennial Census.

**Establish a Water and Sanitation Needs Working Group:** Congress should establish an interagency Water and Sanitation Needs Working Group, led by EPA, to streamline data collection for water and sanitation access across all relevant agencies and more accurately survey impacted households.[124] Such a mechanism was recently proposed in the US Senate via the Water, Sanitation, and Hygiene (WaSH) Sector Development Act of 2022.[125] This work would parallel EPA's data collection efforts on the Drinking Water Infrastructure Needs Survey and Assessment and the Clean Watersheds Needs Survey. The Working Group should report periodically to Congress on the cost of capital improvements needed to ensure that all households in the US have water and sanitation, with estimates disaggregated by congressional district.

**Conduct new research on the size and scope of the water access gap:** Armed with better data, universities and think tanks could more precisely estimate the location and nature of household infrastructure gaps, and the average lifespan and cost of system replacement, leading to more targeted policy. Centralized data would also make it possible to create an "early warning system" that identifies communities most at risk of falling into the water access gap by analyzing factors like well failure, contamination threats, and persistent Safe Drinking Water Act or Clean Water Act violations. Additional academic research should be conducted to better understand what impact water quality, affordability, and shutoffs are having on the water access gap. All data collection efforts—private and public—must be accompanied by outreach to vulnerable communities to assist them in leveraging those data for their own advocacy.

# 3. DEFINE THE WATER ACCESS GAP AS A CRISIS

## WHAT THE ECONOMIC DATA TELL US:

More than 2.2 million people live inside the US water access gap, without the taps and toilets many of us take for granted. These communities are in crisis: They drink unsafe water and risk exposure to raw sewage every day. Our modeling demonstrates that a lack of access to water and sanitation quantifiably impacts every aspect of a person's life. In addition to the human misery resulting from sickness, suffering, and premature death caused by a lack of access to water and sanitation, the US economy loses $8.58 billion every year that the gap remains open. This crisis is only becoming more urgent as climate change puts additional stress on infrastructure.

## WHAT SHOULD BE DONE:

**Recognize the human right to water and sanitation (HRWS):** Many countries, along with the UN, have recognized the urgency of this issue by passing resolutions recognizing the human right to water and sanitation (HRWS). This right requires governments to ensure that all people have safe, acceptable, accessible, and affordable water and wastewater services provided in a non-discriminatory way. The federal government should signal its leadership on this issue by doing the same.[126] [127] The federal government should update its view on the HRWS in international law, communicating that stance to the Office of the United Nations High Commissioner for Human Rights.[128] Congress could go a step further by passing a new law formally recognizing the HRWS.

In 2012, California passed Assembly Bill 685 recognizing the human right to water. Though the law lacks an enforcement mechanism, that recognition is widely credited with creating a policy environment resulting in the passage of numerous other laws that support equitable water access, funding, and enforcement. Recognizing the HRWS in more state legislatures and at the federal level would enable similar progress nationwide.

**Use human rights language across private and philanthropic sectors:** US businesses, foundations, and nonprofit organizations touching water and sanitation should recognize the HRWS and use human rights language when describing their work. The 215 companies that have endorsed the CEO Water Mandate, for example, have agreed to respect the HRWS through their business practices. This, in turn, has helped them more effectively manage their water risks and united them in efforts to extend water and sanitation access to communities near key business locations like manufacturing hubs.[129 130 131] The economic findings here should be used to revise corporate environmental, social, and governance (ESG) standards so that they appropriately value investments in access to water and sanitation alongside volumetric water benefit accounting.[132 133] By using human rights language more broadly, the private, philanthropic, and nonprofit sectors can signal to impacted communities, government, and the public that all people deserve access to water and sanitation, and that the water access gap must be closed immediately.

# 4. BUILD A DOMESTIC WATER, SANITATION, AND HYGIENE (WaSH) SECTOR.

## WHAT THE ECONOMIC DATA TELL US:

Census data show that the water access gap has persisted in recent years, and even widened. Until recently, the millions of Americans without access to water and sanitation have been on their own, lacking the support, resources, and visibility needed to solve this problem. A few lucky communities may receive new access to services through the IIJA, but for many, a working tap and toilet will still seem like a distant dream. If the United States is to solve this problem, we need to confront it as we have in other countries: as an urgent public health crisis that demands an intelligent, coordinated, and rapid response.

## WHAT SHOULD BE DONE:

**Establish a domestic WaSH sector:** We need a robust domestic WaSH sector to lead this work— a "community of practice" made up of NGOs, funders, research institutions, private businesses, government agencies, and impacted communities working together toward shared goals. [134] As a model, the global WaSH sector has successfully improved water and sanitation access for more than 2.6 billion people in low-income countries over the past 60 years, in large part due to its well-developed mechanisms for setting regional priorities, sharing data and technical knowledge, and coordinating responses to new or existing challenges. By leveraging combined resources, the sector secures funding, aligns policy advocacy, and holds governments accountable to impacted communities. Within this community of practice, experiences are shared—successes and failures—through regular, in-person convenings.

There are more than 150 entities working to advance access to water and sanitation in the US. More than 30 of them contributed to the development of this report. Recent research, however, found that many of those entities do not self-identify as WaSH organizations or see themselves as part of a larger WaSH sector.[135] The consequence of this fragmentation is a significant loss of efficiency, collaboration, and strategic planning. Organizations advancing access to water and sanitation in the US should begin to define their efforts as WaSH.

**Hold regular sector convenings:** Domestic WaSH organizations should meet regularly to align strategies and share information through regional and national convenings. A few focused coalitions, including the Navajo Nation Water Access Coordination Group (WACG),[136,137] the Water Resilience Coalition,[138] and PolicyLink's Water Equity and Climate Resilience Caucus,[139] have already begun meeting regularly. In October 2022, DigDeep and 15 other organizations will meet in Washington, DC, to lay the groundwork for an annual, national convening open to all US WaSH actors.[140] Philanthropy and the private sector should fund these convenings and other efforts aimed at sector coordination, especially those that include impacted communities.

**Advocate for change with federal and state governments as a sector:** Once this coordination takes place, the WaSH sector should use its collective power to advocate on behalf of impacted communities with lawmakers and federal and state agencies. This is already happening to a degree, as evidenced by recent efforts to secure funding for the IHS Sanitation Facilities Deficiency List,[141] or to create a system for better national data collection around water and sanitation needs.[142] Private businesses have an important role to play too, since they often have valuable cachet with lawmakers and work inside or near impacted communities. Every piece of new legislation aimed at closing the water access gap should require federal agencies to consult with community groups and WaSH nonprofits, leveraging this network to connect with impacted communities that may be otherwise hard to reach.

# CONCLUSION

It seems inconceivable that the United States, with its vast resources, technological expertise, and long-standing commitment to improving public health, would be home to more than 2.2 million people lacking access to basic water and sanitation services. Many Americans wake up every morning wondering how they'll get enough clean water to care for themselves and their families. That insecurity takes a toll on their health and happiness. It also costs real money. As things stand, the United States loses a staggering $8.58 billion every year that the water access gap remains open.

Closing the water access gap would create prosperity. It would improve physical health and reduce health care costs, improve mental health, labor market outcomes, school time for children, and even GDP output. Closing the water access gap would also prevent more than 600 unnecessary deaths each year, saving real lives. All told, the US economy would gain nearly $200 billion over the next 50 years. That means for every $1 we invest in taps and toilets for the Americans who need them most, we would generate nearly $5 in economic return.

This 5-to-1 return on investment presents the possibility for a new way of thinking about the value of our water and wastewater systems. Even in places where those systems cannot support themselves through rate payment, investing in them still makes economic sense. That investment must be led by the federal government, since the broad distribution of economic benefits may mean that no other actor will be motivated enough to invest on their own. While the recent passage of the IIJA may help compensate for the precipitous decline in federal funding for water and wastewater in recent decades, more and better targeted investment will be required to close the water access gap for good.

In the end, this is an issue of economic, environmental, and social justice. Closing the water access gap will advance equity and right historical wrongs that go back nearly 100 years, when the US government made enormous investments in water infrastructure that excluded many tribes, communities of color, immigrant communities, and rural areas. These dollars will benefit the families who need them the most, allowing them to reinvest in their broader communities—often places facing economic decline, fiscal shortfalls, and loss of financial opportunities. Eventually, the benefits will accrue to government, private businesses, and the nation as a whole.

We must ensure that everyone in the US can enjoy safe, running water; the convenience of an indoor tap, toilet, and shower; and the safe and healthy treatment of their household wastewater. We must ensure that the investment and hard work that brought water to most of this country are not undermined, and that those with access to clean water and sanitation today do not lose it tomorrow because of aging infrastructure or climate change.

Together, we can close the water access gap in our lifetimes. A great deal of work remains, but we can't afford to wait any longer. The stakes are too high.

# NOTES

1 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

2 On page 21 of our previous analysis in Closing the Water Access Gap in the United States: A National Action Plan, we highlight that the number of people without access to complete plumbing had recently increased in six states and Puerto Rico.

3 New 2020 ACS estimates of the same variable show that the size of the water access gap has persisted in recent years, with the number of impacted households remaining constant and even increasing slightly over the period since 2016.

4 American Community Survey (ACS). 2020 ACS 1-year experimental data release. (ACS, 2020). https://www.census.gov/programs-surveys/acs/data/experimental-data.html

5 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

6 Ibid.

7 In 1977, 63% of capital spending on water and wastewater systems came from the federal government; until the passage of the bipartisan Infrastructure Investment and Jobs Act in 2021, that was less than 9%—much of it tied up in low interest loans that must be repaid.

8 Recent studies have found that urban areas have high rates of "plumbing poverty" too.

9 Meehan et al. "Geographies of insecure water access and the housing-water nexus in US cities." (Proceedings of the National Academy of Sciences of the United States of America; 117 (46) 28700-28707; 2020). https://www.pnas.org/doi/10.1073/pnas.2007361117.

10 Reidmiller et al. (eds). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. (US Global Change Research Program, 2018). https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf

11 American Society of Civil Engineers (ASCE) and the Value of Water Campaign. The Economic Benefits of Investing in Water Infrastructure: How a Failure to Act Would Affect the US Economic Recovery. (ASCE and the Value of Water Campaign, 2020).

12 US Environmental Protection Agency (EPA) Office of Water. Drinking Water Infrastructure Needs Survey and Assessment: Sixth Report to Congress. (US EPA Office of Water, 2015). https://www.epa.gov/sites/default/files/201810/documents/corrected_sixth_drinking_water_infrastructure_needs_survey_and_assessment.pdf

13 American Water Works Association (AWWA). Buried No Longer: Confronting America's Water Infrastructure Challenge. (AWWA, 2013). https://www.awwa.org/Portals/0/AWWA/Government/BuriedNoLonger.pdf?ver=2013-03-29-125906-653

14 Some tribal communities, for example, will receive first time access to running water and wastewater services through the $3.5 billion earmarked for sanitation facilities construction by the Indian Health Service.

15 US EPA. Fact Sheet: EPA and the Bipartisan Infrastructure Law. (EPA, 6 November 2021). https://www.epa.gov/infrastructure/fact-sheet-epa-bipartisan-infrastructure-law

16 American Water Works Association (AWWA). Buried No Longer: Confronting America's Water Infrastructure Challenge. (AWWA, 2013). https://www.awwa.org/Portals/0/AWWA/Government/BuriedNoLonger.pdf?ver=2013-03-29-125906-653

17 US Environmental Protection Agency (EPA) Office of Water. Drinking Water Infrastructure Needs Survey and Assessment: Sixth Report to Congress. (US EPA Office of Water, 2015). https://www.epa.gov/sites/default/files/2018-10/documents/corrected_sixth_drinking_water_infrastructure_needs_survey_and_assessment.pdf

18 The Value of Statistical Life (VSL) is arguably the most important number in cost-benefit analyses of environmental, health, and transportation policies. We use the Environmental Protection Agency's (EPA) current guidance to estimate the total implicit value of life based on $7.4 million (as measured in 2006 dollars) and inflate this estimate to 2020 dollars ($9.3 million per individual preventable death).

19 US EPA. Mortality Risk Valuation. https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatisvsl

20 The term "measurable" means that the impact can be defined economically, in dollars. The term "meaningful" is qualitative and indicates that the impact has been well documented in existing literature that the researchers deemed that literature rigorous enough to include.

21 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

22 Author analysis of American Community Survey (ACS) data. American Community Survey 2015-2019 5-Year Data Release (ACS, 2020). https://www.census.gov/newsroom/press-kits/2020/acs-5-year.html. Note these counts do not include Puerto Rico.

23 United Nations General Assembly Fifteenth Session of the Human Rights Council. Resolution 15/9. Human rights and access to safe drinking water and sanitation. A/HRC/RES/15/9. (6 December 2010). https://undocs.org/en/A/HRC/RES/15/9

24 The US Census Bureau has collected data about household plumbing since 1960 based on the definition of "complete plumbing facilities" located within a housing unit and used only by the occupants. That information is now collected through the American Community Survey, which collects more detailed socioeconomic information than the decennial Census and is conducted every year. The survey is sent to a small percentage of the population, roughly three million households a year, on a rotating basis. Its data provide demographic, economic, and housing estimates that are used by government agencies, researchers, and advocacy organizations. The ACS is often the only source of local-level data on these topics.

25 S. Deitz, K. Meehan. "Plumbing poverty: Mapping hot spots of racial and geographical inequality in US: Household water insecurity." Annals of the American Association of Geographers. 109:1092–1109. 2019). https://doi.org/10.1080/24694452.2018.1530587

26 For example, the survey asks whether households have running water and indoor plumbing, but it does not ask whether water service is affordable or reliable, or whether households have wastewater services.

27 This question was removed in 2015 by the Census Bureau's audit of the ACS, called a Content Review. Although the decisionmaking process is opaque, it is generally thought that the question (and several others) were removed after respondents complained that it was too personally invasive.

28 An update on how the Census Bureau plans to include or omit this question going forward is forthcoming.

29 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

30 Our estimate does not include people that are being served water by public water systems that are not in compliance with the Safe Drinking Water Act. According to data reported to EPA's Safe Drinking Water Inventory System (SDWIS), this has ranged from 21.4 to 30.6 million people annually over the last 10 years.

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31 EPA Safe Drinking Water Inventory System (SDWIS) Federal Reports Search. (EPA, 2021). https://ordspub.epa.gov/ords/sfdw/sfdw/r/sdwis_fed_reports_public/200.

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33 Food & Water Watch. "America's Secret Water Crisis: National Shutoff Survey Reveals Water Affordability Emergency Affecting Millions." (October 2018).

34 Mack and Wrase.. "A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States." (PLoS ONE 12(1): e0169488; 2017). https://doi.org/10.1371/journal.pone.0169488

35 The Center for Water Security and Cooperation. American Water Access Survey: First Edition. (Center for Water Security and Cooperation, Spring 2022).

36 See, for example, evidence of intergeneration impacts in: N. Kaushal. "Intergenerational Impacts of Education." (The Future of Children) vo. 24, no. 1. Pp 61-78. https://www.jstor.org/stable/23723383

37 American Water Works Association (AWWA). Buried No Longer: Confronting America's Water Infrastructure Challenge. (AWWA, 2013). https://www.awwa.org/Portals/0/AWWA/Government/BuriedNoLonger.pdf?ver=2013-03-29-125906-65

38 Researchers have noted a positive correlation between Covid-19 cases and a lack of complete plumbing which is thought to be attributable to a lack of access to water, which creates a barrier for personal hygiene.

39 L.M. Andersen, S.R. Harden, M.M. Sugg, J.D. Runkle, T.E. Lundquist, Analyzing the spatial determinants of local Covid-19 transmission in the United States, Sci. Total Environ. 754 (2021) 142396. https://doi.org/10.1016/j.scitotenv.2020.142396

40 Native American households are 19 times more likely than white households to lack indoor plumbing.

41 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

42 Notably, the data limitations resulted in an underestimate of the actual Covid-19 incidence among American Indians and Alaska Native Persons.

43 Centers for Disease Control (CDC). Covid-19 among American Indian and Alaska Native Person – 23 States. Morbidity and Mortality Weekly Report for the period 31 January 2020 to 3 July 2020. https://www.cdc.gov/mmwr/volumes/69/wr/mm6934e1.htm

44 Ibid.

45 Lonebear, et al. "American Indian Reservations and Covid-19: Correlates of Early Infection Rates in the Pandemic." (Journal of Public Health Management Practice, 26(4): 371-77; Jul./Aug. 2020).

46 The WHO has estimated the direct economic impacts for countries investing in water and sanitation services by major region, incorporating the benefits resulting from decreased disease prevalence, lower rates of malnutrition, lower health care costs, reductions in travel and wait times, and quality of life impacts.

47 G. Hutton. "Global costs and benefits of reaching universal coverage of sanitation and drinking-water supply." Journal of Water and Health. (World Health Organization, 2013). https://www.publichealth.columbia.edu/sites/default/files/pdf/hutton_cost_and_benefits_of_global_w_s_update.pdf

48 Sanitation and Water for All. Water and Sanitation: How to make public investment work. (Sanitation and Water for All, December 2020). https://www.sanitationandwaterforall.org/sites/default/files/2020-12/Financial%20Handbook_EN.pdf

49 A key component of the prior work in the WHO study was the initial list of known impacts on households due to improvements in water and sanitation access. While the magnitude of the effects of changes in health, labor force participation, education, and economic productivity are significantly different for a US population, and the proportion of the country requiring new investments in the US is far smaller than in low-income regions, the categories of benefits were nonetheless useful for our analysis. Like the WHO work, in this study we pared the list of economic impacts of water access down to those that were measurable and meaningful in size, and then constructed models based on the US population known to lack water access, thus finding the estimated economic costs of current gaps in water infrastructure.

50 A full breakdown of these economic benefits is outlined in Section Two of this report.

51 Congressional Budget Office (CBO). Public Spending on Transportation and Water Infrastructure, 1956 to 2017. (CBO, October 2018). https://www.cbo.gov/system/files/2018-10/54539-Infrastructure.pdf

52 CBO. Exhibit 9. Disaggregated data on water utilities underlying figures presented in the previous citation. (2018). https://www.cbo.gov/publication/54539

53 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

54 See Table A-2 in: E. Shrider, et al. "Income and Poverty in the United States: 2020, Current Population Reports." US Census Bureau. 2021. https://www.census.gov/library/publications/2021/demo/p60-273.html.

55 Malik, Vasanti S et al. "Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk." Circulation vol. 121,11 (2010): 1356-64. doi:10.1161/CIRCULATIONAHA.109.

56 American Diabetes Association. Economic Costs of Diabetes in the U.S. in 2017. Diabetes Care. 2018 May;41(5):917-928. doi: 10.2337/dci18-0007. Epub 2018 Mar 22. PMID: 29567642; PMCID: PMC5911784.

57 Ibid.

58 An example of GDP calculations is in: K. Mantinan et al. "The Obesity Epidemic in Marion County Indiana" Altarum Institute. (2019). https://altarum.org/sites/default/files/uploaded-publication-files/ObesityReport2019_Altarum_RMFF_FINAL.pdf.

59 Lena Begay personal interview. Prewitt, New Mexico. 2015.

60 Tori Sattow personal interview. Keystone, West Virginia. 2019.

61 United Nations General Assembly Fifteenth Session of the Human Rights Council. Resolution 15/9. Human rights and access to safe drinking water and sanitation. A/HRC/RES/15/9. (6 December 2010). https://undocs.org/en/A/HRC/RES/15/9

62 Of course, many of the conditions that led to that historic underinvestment, including the trans-Atlantic slave trade and the expropriation and extermination of Indigenous people, are much older.

63 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

64 Recent studies have shown that access to complete plumbing decreases as the number of family members in a household increases, suggesting that "plumbing poverty" may correlate with other forms of poverty.

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65 J.T. Mueller, S. Gasteyer. "The widespread and unjust drinking water and clean water crisis in the United States" (Nature Communications.12: 3544. 2021) https://doi.org/10.1038/s41467-021-23898-z

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67 G. McGraw. "How do you fight the coronavirus without running water?" (The New York Times, 2 May 2020). https://www.nytimes.com/2020/05/02/opinion/coronavirus-water.html

68 Z. Podmore. "For many on the Navajo Nation, getting water requires travel, a wait in long lines and lots of patience." (National Tribal Utility Authority, 2020).

69 These experiences are well represented in news reports, firsthand accounts, and academic studies.

70 K.A. Hickel, A. Dotson, T.K. Thomas, M. Heavener, J. Hebert, J.A. Warren. "The search for an alternative to piped water and sewer systems in the Alaskan Arctic." (Environmental Science and Pollution Research. 25: 32873–32880. 2018) https://doi.org/10.1007/s11356-017-8815-x

71 Velma Martinez personal interview. New Mexico, 2018.

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73 Global Communities. Closing the US Sanitation Equity Gap: Exploring Opportunities to Learn from the Global Sanitation Sector Experience. (Global Communities Technical Brief, September 2021). https://globalcommunities.org/wpcontent/uploads/2022/01/GC_Tech_Brief_US_Sanitation_Equity_Landscape_Analysis_Final_Sept2021.pdf

74 Ibid.

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77 Tori Sattow personal interview. Keystone, West Virginia. 2019.

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81 Estimated for 2020 using: American Community Survey (ACS). 2020 ACS 1-year experimental data release. (ACS, 2020). https://www.census.gov/programs-surveys/acs/data/experimental-data.html.

82 G. Psacharopoulos et al. "The COVID-19 Cost of School Closures in Earnings and Income across the World." Comparative Education Review. Vo 65, no 2. (2021). https://www.journals.uchicago.edu/doi/epdf/10.1086/713540.

83 Calculations based on data from Ibid.

84 Small group interview with residents of Gary, West Virginia. 2019.

85 Linda McKinney personal interview. Kimball, West Virginia. 2019.

86 The cost of bottled water is expected to vary significantly depending on local factors and the form in which it's purchased. The 2021 California Water Board's Drinking Water Needs Assessment (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/needs/2021_needs_assessment.pdf) found an expected median cost for bulk purchase of bottled water in their "interim solutions" cost modeling of $0.98 per gallon (mean of $1.18 per gallon), while some anecdotal reporting recently cited costs as low as $0.25 per gallon from grocery store refilling stations (https://www.theguardian.com/us-news/2019/dec/02/california-water-vending-machines-quality). We use $0.50 per gallon as a likely conservative estimated cost per gallon in the modeling. The estimate of 40% of households purchasing water based on expert opinion. The volume of water purchased per day is based on an average of 15L per day from P. Gleick. "Basic Water Requirements for Human Activities: Meeting Basic Needs". Water International, 21 (1996). https://pacinst.org/wp-content/uploads/2012/10/basic_water_requirements-1996.pdf and DigDeep, https://www.digdeep.org/4liters.

87 Our qualitative research found that a gallon of water in Shishmaref, Alaska (where many Alaska Native families lack indoor plumbing) can be as high as nine dollars.

88 New Mexico State University, College of Agricultural, Consumer and Environmental Sciences. "Income Multipliers in Economic Impact Analysis". (2011). https: pubs.nmsu.edu/_z/Z108/ [89] Personal interview with Sandra W. May 2022.

90 Ibid.

91 US EPA. Mortality Risk Valuation. https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatisvsl

92 This estimate was constructed using Altarum's Value of Health Tool by aggregating the proportion of premature deaths attributable to the water access gap caused by each of the diseases included in the dataset. Please see the Appendix for full details on data analysis methodology and computationz

93 EPA recommends that all benefits analyses use a standard estimate of $7.4 million per life in mortality risk reduction benefits, updated to the current dollar value in the year of the analysis. To convert 2006 dollars to 2020 dollars we used a GDP deflator rather than a CPI-based inflation tool, resulting in a slightly more conservative estimate.

94 US EPA. Mortality Risk Valuation. https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatisvsl

95 CBS Sunday Morning. "Without Water." https://www.cbsnews.com/news/without-water/

96 See for instance discussions of US Physical Infrastructure data here: L. Parker. "Where are the Data on America's Physical Infrastructure". Policy Map. (2015). https://www.policymap.com/blog/physical-infrastructure-data.

97 We used a 2015 subset of the ACS data on the proportion of homes lacking either only running water or only toilets, the most recent period for which that question was included. We then applied that same proportion to our 2020 population estimates, assuming that the number of households without a toilet remained relatively constant, as was the case for households lacking access to complete plumbing generally during the same period.

98 Total costs are discounted over an estimated lifespan of 50 years for an on-grid solution and 25 years for an off-grid solution.

99 Nills-Gerrit Wunsch. US household expenditure on ice cream and related products 2007-2020. https://www.statista.com/statistics/254990/us-expenditure-on-ice-cream/

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[102] California State Water Resources Control Board. East Porterville Water Supply Project. (CA State Water Resources Control Board, 24 April 2018). https://www.waterboards.ca.gov/drinking_water/certlic/drinking-water/documents/partnership_success/east_porterville.pdf

[103] US EPA. Onsite wastewater treatment systems manual. (EPA, 2022). https://www.epa.gov/sites/default/files/2015-06/documents/2004_07_07_septics_septic_2002_osdm_all.pdf

[104] Alaska Native and Tribal Health Consortium. ANTHC Portable Alternative Sanitation System (PASS). (ANTHC, accessed 2022). https://www.ruralhealthinfo.org/assets/2203-8553/933-portable-alternative-sanitation-system-flyer.pdf

[105] These expected returns per dollar invested are similar to findings from prior work in low-income countries.

[106] G. Hutton. "Global costs and benefits of reaching universal coverage of sanitation and drinking-water supply." Journal of Water and Health. (World Health Organization, 2013).

[107] The federal share of water and wastewater spending has fallen from 63% in 1977 to less than 9% today.

[108] Congressional Budget Office (CBO). Public Spending on Transportation and Water Infrastructure, 1956 to 2017. (CBO, October 2018). https://www.cbo.gov/system/files/2018-10/54539-Infrastructure.pdf

[109] The estimated cost of repairing our existing water infrastructure is between $750 billion and $1 trillion over the next 20 to 25 years: American Water Works Association (AWWA). Buried No Longer: Confronting America's Water Infrastructure

[110] In October 2020, the White House established the Water Subcabinet to closely coordinate the work of relevant agencies on water policy and the oversight of water systems and supplies.

[111] Executive Office of the President. Executive Order 13956. Modernizing America's Water Resource Management and Water Infrastructure. 85 FR 65647; 65647-65650. (Federal Register, 16 October 2020). https://www.federalregister.gov/documents/2020/10/16/2020-23116/modernizing-americas-water-resource-managementand-water-infrastructure

[112] S. Young, B. Mallory, G. McCarthy. "The Path to Achieving Justice40." The White House OMB Briefing Room blog. (The White House, 20 July 2021). https://www.whitehouse.gov/omb/briefing-room/2021/07/20/the-path-to-achieving-justice40/

[113] Congressional Research Service (CRS). Infrastructure Investment and Jobs Act (IIJA): Drinking Water and Wastewater Infrastructure. Section 50109. (CRS, 2022).

[114] Such as the WaSH Sector Development Act introduced in the Senate in 2022.

[115] 117th Congress of the United States. Senate Bill 3893 – WaSH Sector Development Act of 2022. https://www.congress.gov/bill/117th-congress/senate-bill/3893/text

[116] Rate increases to support O&M costs can create affordability concerns, and may not be feasible when a utility has a high number of low- or fixed-income customers.

[117] As noted above, the benefits of improved access to water and sanitation accrue to too many stakeholders, including households, their communities, the federal government, state and local governments, and even private businesses. In economics, this is called a "wrong pockets" problem. Because no single investor recoups the entire expected societal return of access to water, we face a market failure.

[118] These actions were proposed by the US Chamber of Commerce Letter on 2022 Water Policy Priorities.

[119] US Chamber of Commerce. US Chamber Letter on 2022 Water Policy Priorities. (US Chamber of Commerce, 25 February 2022.) https://www.uschamber.com/environment/u-s-chamber-letter-on-2022-water-policy-priorities

[120] The DWIC unites representatives from rural communities across the US to improve understanding of their wastewater challenges through facilitated working groups, site exchanges, and roundtables with federal regulators. Recent recommendations from these communities include simplifying application and reporting processes and making applications uniform across state lines, an essential improvement for tribes with multi-state territories.

[121] DigDeep. Decentralized Wastewater Innovation Cohort. https://www.digdeep.org/dwic

[122] The White House. Fact Sheet: President Biden's Bipartisan Infrastructure Law Advances Economic and Public Health Opportunities for Tribal Communities. (The White House, 18 November 2021). https://www.whitehouse.gov/briefingroom/statements-releases/2021/11/18/fact-sheet-president-bidens-bipartisan-infrastructure-law-advances-economic-andpublic-health-opportunities-for-tribal-communities/

[123] An update on how the Census Bureau plans to include or omit this question going forward is forthcoming.

[61] United Nations General Assembly Fifteenth Session of the Human Rights Council. Resolution 15/9. Human rights and access to safe drinking water and sanitation. A/HRC/RES/15/9. (6 December 2010). https://undocs.org/en/A/HRC/RES/15/9

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[125] "Wyden, Merkley, Heinrich Introduce Bill to Expand Access to Clean Drinking Water, Safe Sanitation for Underserved Communities." Press release. (Office of US Senator Ron Wyden, 22 March 2022).https://www.wyden.senate.gov/news/pressreleases/wyden-merkley-heinrich-introduce-bill-to-expand-access-to-clean-drinking-water-safe-sanitation-for-underservedcommunities

[126] The US does not currently recognize the human right to water and sanitation in international law. It is important to note that the "right to water" is different from the concept of "water rights" which are recognized by the US government. Water rights are the rights to access or use water held by individuals, private entities, or the government, and are primarily implemented at the state level under the principle of Federalism. The application of that concept varies widely from state to state depending on that state's colonial history, geography, and case law.

[127] Office of the United Nations High Commissioner for Human Rights. Issues paper: Views of the United States of America on Human Rights and Access to Water. (OHCHR, June 2007). https://www2.ohchr.org/english/issues/water/contributions/UnitedStatesofAmerica.pdf

[128] While not strictly necessary before updating the State Department's stance on HRWS, this action would be stronger if Congress first ratified the International Covenant on Economic, Social and Cultural Rights (ICESCR) signed by President Jimmy Carter in

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1977. Ratifying the ICESCR would provide a powerful legal framework for the recognition of water and sanitation as a fundamental human right.

129 Collective investments in water and sanitation projects by companies endorsing the CEO Water Mandate have been made under the auspices of the Water Resilience Coalition.

130 CEO Water Mandate. "What is the mandate?" https://ceowatermandate.org/about/what-is-the-mandate/

131 CEO Water Mandate. Water Resilience Coalition. https://ceowatermandate.org/resilience/

132 See, for instance, the method for Volumetric Water Benefit Accounting developed by the World Resources Institute with partners Quantis, Limnotech, and Valuing Nature:

133 World Resources Institute. Volumetric water benefit accounting (VWBA): A method for implementing and valuing water stewardship. Working paper. (WRI, 22 August 2019). https://www.wri.org/research/volumetric-water-benefit-accountingvwba-method-implementing-and-valuing-water-stewardship

134 G. McGraw. "The United States needs its own WaSH sector." Philanthropy News Digest. (Philanthropy News Digest/Stanford Social Innovation Review, 29 June 2020). https://philanthropynewsdigest.org/features/ssir-pnd/the-united-states-needs-itsown-wash-sector

135 DigDeep. United States WaSH Sector Database. https://www.digdeep.org/assets/DigDeep_WashSector_Whitepaper.pdf

136 During the Covid-19 pandemic more than 20 partners including the Navajo Nation government, federal agencies, universities and nonprofits including DigDeep began meeting regularly to address ongoing water access challenges on the Navajo Nation.

137 Haury Program. "Navajo safe water: Protecting you and your family's health." (Agnese Nelms Haury Program in Environment and Social Justice, 2019). https://www.haury.arizona.edu/news/navajo-safe-water-project-protecting-navajo-peoples-health

138 CEO Water Mandate. Water Resilience Coalition. https://ceowatermandate.org/resilience/

139 PolicyLink. Water Equity and Climate Resilience Caucus. https://www.policylink.org/our-work/community/water-climate [140] DigDeep. 2022 WaSH Convening. Concept Note. (DigDeep and Water for People, 2022). https://www.digdeep.org/assets/ConceptNote2022.pdf

141 Rural Community Assistance Partnership and DigDeep et al. Letter to Speaker Pelosi, Majority Leader Schumer, and Minority Leaders McCarthy and McConnell on tribal access to clean water. (29 July 2021). https://docs.google.com/document/d/164wx5S69nfbOyALtaGdJjT7wqU-vKy-9NTxtm4WrxnHI/edit?usp=sharing

142 Congressional Research Service (CRS). Infrastructure Investment and Jobs Act (IIJA): Drinking Water and Wastewater Infrastructure. (CRS, 2022).

143 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

144 Miller et al. " Creating an Analytical Structure to Demonstrate the Value of Investments in Primary Prevention to Health Outcomes and Health Care Costs" Altarum Institute. (2014). https://altarum.org/sites/default/files/uploaded-related-files/70842GPreport.pdf

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147 Roller et al. Closing the Water Access Gap in the United States. (DigDeep and US Water Alliance, 2019).

148 Collier, Sarah A et al. "Estimate of Burden and Direct Healthcare Cost of Infectious Waterborne Disease in the United States." Emerging infectious diseases vol. 27,1 (2021): 140-149. doi:10.3201/eid2701.190676

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150 Ibid.

151 Institute for Health Metrics and Evaluation, University of Washington. "Tracking personal health care spending in the US | Viz Hub" (2019). https://vizhub.healthdata.org/dex/

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153 Centers for Disease Control and Prevention (CDC). CDC Wonder Online Databases, Underlying Causes of Death. https://wonder.cdc.gov/

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155 Drouin-Chartier, Jean-Philippe et al. "Changes in Consumption of Sugary Beverages and Artificially Sweetened Beverages and Subsequent Risk of Type 2 Diabetes: Results From Three Large Prospective U.S. Cohorts of Women and Men." Diabetes care vol. 42,12 (2019): 2181-2189. doi:10.2337/dc19-0734

156 Towne, Samuel D et al. "Assessing Diabetes and Factors Associated with Foregoing Medical Care among Persons with Diabetes: Disparities Facing American Indian/Alaska Native, Black, Hispanic, Low Income, and Southern Adults in the U.S. (2011-2015)." International journal of environmental research and public health vol. 14,5 464. 26 Apr. 2017, doi:10.3390/ijerph14050464.

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[163] Chari, Amalavoyal V et al. "The opportunity costs of informal elder-care in the United States: new estimates from the American Time Use Survey." Health services research vol. 50,3 (2015): 871-82. doi:10.1111/1475-6773.12238 and K. Ray et al. "Opportunity Costs of Ambulatory Medical Care in the United States." The American Journal of Managed Care. Vo 21, issue 8. (2015). https://www.ajmc.com/view/opportunity-costs-of-ambulatory-medical-care-in-the-united-states

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[168] The estimate of 40% of households purchasing water based on expert opinion. The volume of water purchased per day is based on an average of 15L per day from P. Gleick. "Basic Water Requirements for Human Activities: Meeting Basic Needs". Water International, 21 (1996). https://pacinst.org/wp-content/uploads/2012/10/basic_water_requirements-1996.pdf and DigDeep, https://www.digdeep.org/4liters.

[168] The estimate of 40% of households purchasing water based on expert opinion. The volume of water purchased per day is based on an average of 15L per day from P. Gleick. "Basic Water Requirements for Human Activities: Meeting Basic Needs". Water International, 21 (1996). https://pacinst.org/wp-content/uploads/2012/10/basic_water_requirements-1996.pdf and DigDeep, https://www.digdeep.org/4liters.

[169] The 2021 California Water Board's Drinking Water Needs Assessment (https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/needs/2021_needs_assessment.pdf) found an expected median cost for bulk purchase of bottled water in their "interim solutions" cost modeling of $0.98 per gallon (mean of $1.18 per gallon).

[170] https://www.theguardian.com/us-news/2019/dec/02/california-water-vending-machines-quality

[171] Javidi, A., & Pierce, G. (2018). U.S. households' perception of drinking water as unsafe and its consequences: Examining alternative choices to the tap*. Water Resources Research, 54, 6100–6113. https://doi.org/10.1029/2017WR022186

[172] The volume of water purchased per day is based on an average of 15L per day from P. Gleick. "Basic Water Requirements for Human Activities: Meeting Basic Needs". Water International, 21 (1996). https://pacinst.org/wpcontent/uploads/2012/10/basic_water_requirements-1996.pdf and DigDeep, https://www.digdeep.org/4liters.

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[177] https://fred.stlouisfed.org/series/GDPDEF#0

[178] American Community Survey data accessed via IPUMS USA: Steven Ruggles, Sarah Flood, Ronald Goeken, Megan Schouweiler and Matthew Sobek. IPUMS USA: Version 12.0 [dataset]. Minneapolis, MN: IPUMS, 2022. https://doi.org/10.18128/D010.V12.0

[179] https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html

[180] When necessary, American Community Survey (ACS) data for Public Use Microdata Area (PUMA) regions are mapped to their constituent counties.

[181] Only 2014-2015 data in the 5-year dataset contain data on the presence of toilets in homes.

# APPENDIX DATA ANALYSIS METHODS AND COMPUTATION

## OVERVIEW

This report includes assessments of the population of the United States lacking access to water and sanitation infrastructure, the economic harms associated with that access gap, and the potential societal return on investment from providing or restoring access via new infrastructure. We build these estimates on the population of household members estimated to currently lack access based on the definitions used in the previously published *Closing the Water Access Gap* report.[143] The economic calculations of harms in lacking access are made such that they estimate only the directly attributable costs of lacking access and are measured based on quantifiable impacts on health, productivity, education, and economic outcomes. We construct these cost models using data from previously published literature on the magnitude of the harms of lacking access and apply these findings to the population known to lack access today based on US surveys of households and their members. Where relevant, we compute the value of economic losses by applying or using assets from the Altarum Value of Health Tool, a modeling framework that estimates the long-term economic costs of changes in health, productivity, and longevity that is well-suited to assessing changes in health and financial outcomes resulting from investments in the social determinants of health.[144] Both the potential benefits of providing new access and the costs of new infrastructure are compared for a consistent household population and time frame when computing societal return-on-investment values.

In this methodology appendix, we detail the major steps, underlying sources, assumptions, and calculations used in generating the data underlying this report. These include details on the scope of the analysis, the definition of the population of study, the methodology for attributing harms to the water access gap, estimates of the economic cost components, and the computation of infrastructure investment expenditures used in return-on-investment calculations. Wherever possible, we align modeling in this work to be consistent with prior academic research on the US water access gap and apply data directly to the population of those currently lacking access described in the most recently available US survey data.[145]

## MODELING APPROACH

The overall modeling approach begins with the estimation of the population currently lacking water access and compares their expected health and economic outcomes to a hypothetical counterfactual scenario in which all US households had complete water services for the entire year. We compute the total economic costs of the water access gap as the difference between the actual expected incidence of adverse outcomes (and costs) seen in 2020 to a hypothetical complete elimination of water access gap harms. We describe the list of pathways through which lack of water access contributes to long-term economic costs and then develop a model to quantify those costs in a single year for all US residents lacking complete plumbing facilities, detailing the costs by type and splitting the impacts across major stakeholders. We estimate each economic impact individually, predicting the incidence or total count of each adverse outcome for the population lacking complete plumbing and then, when necessary, further limiting the economic costs to only those directly attributable to lacking water access. Depending on the data available to make an estimate, we take two broad approaches to calculate the total annual economic costs of a specific impact: the quantity method and the apportionment method.

The quantity method is applied to impacts with known counts, frequency, or rate of risk factors for a specific household or person lacking complete plumbing facilities in a year. Examples of these economic impacts include productivity losses associated with collecting water outside the home or direct purchase costs of bottled water. In each case, we apply a percentage from prior literature or expert opinion to the counts of households/individuals lacking access to estimate a total number of instances of a cost in a year. The units of analysis may be physical units (such as gallons of water purchased) or measured data (such as hours of time spent). We multiply the number of times the harm occurred (the quantity count) per person impacted by the number of units (hours spent or bottles purchased) and then by a cost per unit (dollars) to compute a total economic cost in a single year for the population lacking water access. When necessary, the total costs are counted only for a relevant subset of the population lacking access: For example, we only count the value of lost earnings and time for the working-age population.

When a per-person or per-household count or frequency is not known in the available data, we use an alternative approach—the apportionment method— to compute total economic costs for other health and economic impacts. In this method, rather than applying a known rate/count to the population of households lacking water access, we begin with the total economic costs for the entire US population of a particular adverse outcome. Take, for example, our estimation of the costs of waterborne disease cases attributable to households lacking complete water access. For this impact, the risk of contracting any particular waterborne disease as a result of lacking complete plumbing would be extremely difficult to compute from existing studies/data. Instead, we use literature that quantifies the total cost of waterborne disease in the entire US population in a year, and then estimate the fraction of those diseases that occur for households lacking water access and the fraction of those cases directly attributable to the water access gap.

After each direct individual component of economic costs is computed, we add the varying types of costs together and then compute broader economic impacts for some of the individual components. In this model, the productivity losses due to time missed from work due to disease, lost productivity due to mental health impacts, and time lost collecting water outside the home would all be expected to create larger downstream economic harms (because of the economic multiplier that occurs when an earned dollar is spent in the economy). We compute the extent of these losses based on the ratio of 2019 Gross Domestic Product to income.

**Scope and Population of the Analysis**

The population of study for this economic analysis of the water access gap is defined in the same way as in the prior *Closing the Water Access Gap* research. Because this work focuses on the potential for new household infrastructure to close the water access gap, we narrowly define the population of individuals who fall into the water access gap, including only people who are members of a permanent occupied household that does not have a complete set of fixtures based on the above queried list by the US Census. Access to complete plumbing as defined by the US Census is roughly comparable to the Joint Monitoring Programme's (JMP) highest level of water service, categorized as "safely managed."[146]

To estimate this household and population size, we gathered data from the most recently available version of the US Census American Community Survey (ACS) Housing Component (HC) to assess the number (and percentage) of households lacking at least one of three specific water infrastructure components: 1) hot and cold running water, 2) a sink and functioning faucet, and 3) a bathtub or shower. If a household reported lacking one of these, the resulting entry in the HC data is flagged as not having "complete plumbing facilities" and is included in our population of study, as are all members of that household. It is important to note that the current version of ACS housing data did not include a question regarding either an in-home toilet or a safe and reliable wastewater solution. Since 2016, this specific component has been omitted from the survey, making evaluations of current water access gaps due to toilets impossible to determine. As a result, our count of households lacking complete plumbing may underestimate the total water access and sanitation gap due to a gap in the data surrounding wastewater.

We include residents of Puerto Rico in this analysis, although these data are an exception to our use of the US Census housing survey component as the basis for estimating the population, because the Puerto Rico questionnaire has either varied significantly from the states' version, or the entire question on household plumbing was omitted. Therefore, we follow the work of the previous analysis done for the *Closing the Water Access Gap* report and apply its independent estimate of the number of Puerto Rico residents lacking access in this report.[147]

We define the scope of analysis time period for this economic impact calculation to be the single calendar year of 2020, assessing the estimated total economic losses for households and individuals lacking access in the most recent ACS data. The ACS data report a "point in time" estimate of housing conditions, meaning that the count of households is taken when a respondent completes the survey, not based on the existence of plumbing over a prolonged period. When older survey data or prior studies based on populations in the past are used to estimate model inputs for the current year, we typically assume the same rates can be applied to a current population estimate or predict a 2020 data point based on prior trends. We inflate prior years' cost estimates to 2020 dollars when necessary.

We count the total economic costs in one period based on adverse outcomes expected to occur in a single year and only those costs directly attributable to the lack of complete plumbing facilities and water access. For the set of economic costs that occur instantaneously, such as lost productivity and direct-purchase water costs, we compute total annual costs based on the accrued impact of these harms over the entire year. For costs associated with short-term outcomes, such as acute physical health events or cases of mental illness, we estimate the incidence of those conditions during the year of study and the total costs associated with the volume of new cases in that year. For longer-term costs, such as chronic disease, we again measure the incidence of new cases only in the year of study (for example, mental health or chronic diabetes) and measure the total impact on lifetime medical spending as a result of the incidence of disease.

## PHYSICAL HEALTH IMPACT CALCULATIONS

We identify four distinct types of physical health risks associated with the lack of clean, reliable in-home drinking water service, wastewater systems, and adequate water for washing and sanitation. They are: colon increased risk of diarrheal disease, lower respiratory disease, skin disorders, and obesity/diabetes. These specific health risks were identified in a literature review and determined to have well-established pathways through which households lacking a clean water supply are more likely to drink unsafe water collected from outside the home; less likely to bathe or wash regularly; more likely to bathe in nearby lakes, rivers, or streams; and more likely to consume alternative (often sugar-sweetened) beverages, leading to increased sugar and overall calorie consumption. We estimate the increased risk of each specific disease attributable to the water access gap, the expected health care costs associated with each disease, any long-term impacts acute disease had on chronic health (if associated with the condition), expected productivity losses due to missed workdays recovering from disease, and the risk of premature loss of life due to complications from physical illness or chronic disease.

The initial primary source used to estimate the economic costs of diarrheal, respiratory, and skin conditions is work by Collier et al (2020), titled “Estimate of Burden and Direct Healthcare Cost of Infectious Waterborne Disease in the United States.” [148] We use this work to establish the total prevalence of these conditions in the US, the proportion of conditions attributable to different water sources, and the expected average health care costs and outcomes for each case. We then use the apportionment method discussed above to estimate the proportion of these waterborne disease cases attributable specifically to increased risks from households and individuals lacking water access for drinking, bathing, and sanitation. We compute the proportion of attributable cases based on the following formula: Attributable Cases of Each Waterborne Disease = (Total Annual Cases) * (Proportion of Households Lacking Access) * (Relative Risk of Exposure to Water Outside the Home for those Lacking Access Compared to those With Access)

The source for total annual cases comes from Collier et al, the source for the proportion of households lacking complete plumbing from our analysis of the 2018 ACS data, and the relative risk of exposure for those households comes from our analysis of American Housing Survey (AHS) data. We estimate from the AHS that the relative disease risk of exposure is 30.7 times for those lacking water access based on the relative risk of using water from a stream, spring, lake, or other external source for a primary drinking water source, assuming that the risk of disease exposure comes from using contaminated water collected outside the home.

With an estimate of the number of attributable cases for waterborne disease to households lacking complete plumbing, we determine the potentially reducible proportion of these cases that could plausibly be prevented by installing new water infrastructure to a home. We use data from a previous study (Thomas et al)[149] that assessed the impact on the three major categories of disease: diarrheal, respiratory, and skin following an intervention that provided a new water source to homes in Alaska. We found a reduction in cases of 38%, 16%, and 20% respectively.[150] We apply this reducible factor to all health care outcomes and costs of the waterborne diseases, estimating the number of cases and direct health care savings that would be expected from new water infrastructure factors driving improved health.

The health care outcomes and cost categories measured by Collier et al include counts of illnesses, emergency department visits, hospitalizations, and deaths. We expand on these cost categories by estimating additional costs for ambulatory visits, prescription drugs, and nursing care that would be expected for these conditions but that were not tracked by Collier et al. Data from the Institute for Health Metrics and Evaluation (IHME) provide an estimate of the additional proportion of health care spending costs for lower respiratory and diarrheal conditions, increasing the estimated health care savings from each reducible case.[151] Lastly, we use data on the number of days spent ill and/or in the hospital for each case to estimate the productivity losses and lost earnings for each illness. Earnings data are collected from our analysis of ACS data, and all health care cost earnings data and are inflated to 2020 dollars using economy-wide inflation and health care cost inflation from Altarum's Health Sector Economic Indicators (HSEI).[152]

Data on the average age of mortality for each waterborne disease are required to estimate the extent to which future earnings are forgone due to premature mortality. We use the Center for Disease Control and Prevention's (CDC) WONDER database on "Underlying Causes of Death"[153] and compute the proportion of deaths by 10-year age groups in 2020 for each disease measured. The same earnings data from ACS are used to monetize the productivity losses associated with premature mortality (based on the age of death and the working years lost due to death).

In addition to the health impacts from waterborne diseases, we estimate the health care costs, productivity losses, and premature mortality costs associated with an increased risk for diabetes for individuals living in homes lacking complete plumbing facilities. This risk occurs because individuals will often substitute sugar-sweetened beverages for water from the tap when safe, reliable drinking water is not available. As a result, individuals consume a greater number of calories and added sugars in their diets, increasing the risk of diabetes, obesity, and the associated adverse health outcomes.

We begin with data from Mosites et al that indicate that adults in rural Alaska consume sugarsweetened drinks 7.8 times/week with running water and 12.5 times/week without (8.5 overall); 0.66 more sugar-sweetened drinks per day with than without and 0.57 more drinks than overall.[154] This excess consumption is 29% greater when adjusted for age, income, and education (unadjusted is 47%). We apply this estimated 29% increase to evidence from Drouin Chartier et al, who estimate Type II Diabetes risk based on sugary beverage consumption to find an increased risk of 16.4% for Type II Diabetes among those without an in-home water source.[155]

We then use Towne et al, which measures higher than overall diabetes prevalence for American Indian and Alaska Native adults at 17% in 2015 (using survey data from the CDC Behavioral Risk Factor Surveillance System (BRFSS)).[156] Combining this with the 17% of the population with no piped water (from Mosites et al) results in 16.4% higher diabetes prevalence for adults with no piped water than for those with a connected water line. Therefore, we estimate 2.6% of the adult population without running water is diabetic as a result of no access to running water, based on the following formula:

$P_T=(P_G n_G+P_L n_L)/(n_G+n_L)$ and $PG= R_G P_T$
Where:
$P_x$= risk of diabetes, x = T is overall consumption, x= L is with lesser consumption
$n_x$= proportion of population with greater consumption (X=G) or lesser consumption (x=L)
$R_G$= Increased risk of diabetes with increased consumption (used a relative risk associated with greater consumption)

Solving for $P_L$:
$P_L= P_T\ (n_G+n_L-R_G n_G)/n_L$

We apply this 2.6% to the population lacking complete plumbing facilities and find that 36,424 diabetes cases annually are potentially reducible based on improvements in access to a clean in-home drinking water supply. The resulting economic impacts of increased diabetes are computed using data from the American Diabetes Association and include the estimated health care costs associated with managing a Type II Diabetes case over time, plus other direct health care costs, worker productivity losses, and increased premature mortality risks.[157]

A summary of the physical health costs is shown in the below table (premature loss-of-life data are discussed in a following section).

| | DIARRHEAL | LOWER RESPIRATORY | SKIN | DIABETES | TOTAL |
|---|---|---|---|---|---|
| Preventable Cases Attributable to Lacking Access | 65,119 | 2,484 | 151,364 | 36,424 | 255,391 |
| Combined ED and Hospitalization Visits | 844 | 2,171 | 19,130 | N/A | 22,145 |
| Direct Annual Hospitalization/ED Costs | $22M | $69M | $20M | $368M | $526M |
| Additional Ambulatory Visits and Rx Costs | $10M | $29M | $9M | | |
| Lost Productivity due to Hospitalizations | $3M | $2M | $3M | $61M | $68M |
| Lost Productivity due to Premature Death | $9M | $23M | $1M | $123M | $156M |
| Chronic Fatigue Syndrome Costs (Giardia) | $12M | N/A | N/A | N/A | $12M |
| Total Physical Health Economic Costs | | | | | $762M |

## MENTAL HEALTH IMPACT CALCULATIONS

In this work, we estimate the magnitude of the impact of an increased prevalence of mental health conditions among those lacking complete plumbing using the quantity method described above. Literature has identified a broad range of mental health conditions that are affected by the stress of water access gaps, and we estimate the proportion of mental health conditions that would be expected for residents of US households that lack complete water access and then the additional number of cases that would be expected to occur due to water access issues. We estimate the baseline frequency of US mental health conditions using statistics from the National Institute of Mental Health (NIMH) [158] and then apply the factor of increased risk for mental health conditions from Brewis et al.[159] With this count of new mental health conditions, we use data from the Agency for Healthcare Research and Quality (AHRQ) Medical Panel Expenditure Survey (MEPS) to estimate the annual cost per case and compute a total health care cost impact, while inflating those health care costs to 2020 dollars using Altarum's Health Care Price Index.[160 161] Lastly, we use data on the independent risk of depression from Brewis et al to estimate the number of new cases of depression and the resulting impacts on labor force outcomes and earnings.[162]

## TIME LOST FOR COLLECTING/ PURCHASING WATER IMPACT CALCULATIONS

For this report, we calculate the estimated time lost to collecting or purchasing water outside the home for those who lack water access and the resulting impacts on an individual's ability to either work, complete household tasks, or engage in leisure. Previous economic literature has highlighted how the prevailing wage of an individual can be used to estimate the economic losses of time (see, for example, work on losses due to taking care of family members)[163] and we apply this approach to make an estimate of the time required for the 1.57 million individuals in the water access gap to collect water during the day. This approach has also been used in low-income countries, where water collection tasks can take up a substantial part or even a majority of one's day for some family members;[164] however, we derive our own estimates of the expected prevalence and hours required for our US population, as the circumstances are quite different in a lower-income country.

We split our population of those impacted by water collection activities into two groups: working-age adults for whom time spent collecting water comes at the expense of paid work, home duties, or leisure, and school-age children for whom time spent impinges on either school hours or time working on schoolwork. Therefore, our overall time estimate is conservative, in that it only counts economic harms for individuals in either of the two above categories.

For adults, we estimate the direct lost earnings (or hours on similarly valued home tasks) using ACS data on the prevailing wage among the lacking-access population.[165] For children, we instead estimate the long-term value of lost school hours and the impact on lifetime earnings.[166] Similar to adults, we estimate that the lost time collecting for children comes at the expense of hours spent in school or engaging in homework/school-related activities, such that any lost time for a child is equivalent to lost time in school.

In order to estimate the amount of time spent collecting water each day, we apply some data from prior studies on the time cost of collecting water in other countries, and, where necessary, estimate model coefficients in collaboration with our advisory committee. We estimate the expected total economic cost of time based on assumptions that on average 25% of individuals in a household collect water (e.g., one person each day collecting water for an average US household size of approximately four persons) and that it takes 0.5 hours per day. We apportion this time of 25% of individuals in a household collecting water between the two groups of interest above using data on the number of adults and school-age children per household lacking complete access, using data from the most recent ACS.[167]

It is important to note these are average assumptions, accounting for the fact that not all household members need to engage in water collection/purchasing each day and acknowledging the time spent collecting water likely varies widely based on local circumstances.

## DIRECT PURCHASE OF SUBSTITUTE WATER (BOTTLED WATER)

To estimate the excess purchases of bottled water required for households due to water access limitations, we build on prior research that assessed the extent to which individuals consumed bottled water as their main source of drinking water.[168] We then extend that work to estimate the amount of bottled water consumed and a conservative estimate of the cost per gallon. A 2018 paper by Javidi and Pierce provides data on the frequency of bottled water use, while work in the California Drinking Water Needs Assessment informs an expected cost per gallon (in combination with data from a review of filling station costs), with additional data taken for this model from Hutton et al.

We conservatively estimate the cost of purchasing water for consumption as we 1) assume an estimate of cost per gallon based on large, bulk purchases of water either from filling stations or bulk bottled water, which many families will not have available to them; and 2) only count the additional costs of bottled water without including additional costs of purchasing other drinks to compensate for the lack of drinking water in the home. The cost of bottled water is expected to vary significantly depending on local factors and the form in which it's purchased. The 2021 California Water Board's Drinking Water Needs Assessment found an expected median cost for bulk purchase of bottled water in its "interim solutions" cost modeling of $0.98 per gallon (mean of $1.18 per gallon),[169] while some anecdotal reporting recently cited costs as low as $0.25 per gallon from grocery store refilling stations.[170] We use $0.50 per gallon as a likely conservative estimated cost per gallon in the modeling.

To estimate the frequency and volume of bottled water used per person, we rely on a recent study that looked at the use of bottled water for those households that perceived their drinking water as unsafe.[171] This work found that among those perceiving their tap to be unsafe, 65.4% used bottled water as a substitute and 26.7% used filtered tap water. We expect our population of those lacking access have slightly different options for water substitutes and that a greater proportion of the lacking-access population will collect (rather than purchase) water from outside the home. Therefore, we conservatively estimate only 40% of households lacking access will purchase bottled water in this modeling. We then estimate the volume of water purchased per person per day based on two prior estimates: research on the "minimum consumption necessary for survival" at 15 liters per person per day[172] and four liters per person per day based on prior Dig-Deep assessments of US homes that lack access and use bottled substitutes. We average these two values to assume 9.5 liters of water used per person per day for those purchasing it outside the home. On average, for the population of study, this leads to an economic cost of $1,350 per family, based on average household size for those lacking access.

## ADDITIONAL LOST GDP DUE TO LOST PRODUCTIVITY

Some of the economic costs of the water access gap described in this report include economic losses associated with lower worker productivity and lost lifetime earnings. These economic losses not only result in costs to individuals and households who miss out on the potential income that would have been earned and costs to federal and state governments that would have received a portion of these earnings as paid taxes, but also broader macroeconomic economic losses resulting from the lost spending that would have otherwise occurred using those earnings. When a dollar is earned by an individual, it is typical that a portion of that dollar is spent in the real economy on goods and services, leading to additional income for other economic entities (that then spend a portion of those dollars). All this leads to an economic multiplier of earnings that can be estimated using the proportion of US GDP to income, and we gather this data point from Bureau of Economic Analysis (BEA) income tables.[173] After limiting the above cost components to only those connected to productivity/earnings, we compute the lost economic growth that would have been felt in the larger economy as a result of spending deriving from those earnings, being sure to not double count the productivity impacts. We compute an annual estimate of the lost GDP as an additional component, on top of the underlying earnings lost.

The additional lost future GDP growth and macroeconomic activity equate to $924 million annually: $65 million comes from the lost productivity due to illness, $148 million from productivity lost due to premature loss of life, $33 million from the mental health impacts on labor force outcomes, and $678 million from the time costs for adults collecting water.

## PREMATURE LOSS OF LIFE (VALUE OF STATISTICAL LIFE)

In addition to the direct economic costs modeled for those lacking water access, we consider in this cost analysis the implicit value of the premature mortality from the physical illnesses described above. Based on data on increased cases of diabetes and waterborne diseases described above, an estimated 610 US residents die prematurely each year due to the water access gap. Of these deaths, an estimated 408 occur from preventable diabetes, based on the frequency and mortality risk described above,[174] and 202 from the attributable, reducible cases of waterborne disease.[175]

To compute the value in dollars of this premature loss of life such that it can be included in broader economic analyses, a "value of a statistical life" (VSL) estimate, is often used. This approach, which estimates an implied value per premature death, does not seek to put a dollar value on any particular life, but rather derives the value from the observed willingness to pay for individuals to reduce their risk of death in their daily lives (which is then used to compute the total value of a life based on the willingness to pay divided by the relative risk reduction). These estimates can be made in a variety of ways and typically find values of a VSL to be somewhere between $5 million and $15 million per life. We use the Environmental Protection Agency's (EPA) current guidance of $7.4 million in 2006 dollars,[176] inflated to 2020 dollars using the US GDP deflator,[177] leading to a 2020 estimate of $9.34 million per premature life lost. This value is intended to include both the tangible value of life (such as earnings) as well as all implicit components. Because this value is intended to include both the tangible value of life (such as earnings) as well as all implicit components, and because in previous sections we already tabulated the lost productivity and earnings for mortality, we net those totals away from the implicit value of life calculation.

## COST OF NEW INFRASTRUCTURE

To compute the potential return on investment in new infrastructure, we develop a model to estimate the cost of providing access for those lacking access today and match it with the potential marginal economic benefits of providing complete water access to all US residents from the above components. Critically, the cost model focuses on only the marginal additional future costs of infrastructure required to close the water access gap for the 539,000 households lacking access (either new installation, replacement, or repair of existing services), but considers the full lifetime costs of those solutions (including upfront investment costs, future operations and maintenance costs, and water and sewer service fees). This stream of new marginal costs of the infrastructure in the future is discounted (to put all costs in constant dollars) and then compared directly with the expected economic returns from remediating the water access gap for these households. As a result, this cost model allows for a direct estimate of the total future cost of closing the water access gap in 2020 and the calculation of the marginal net societal returns of achieving universal, essential water and sanitation access for all US residents.

The overall approach to estimating the total current and future costs required to close the water access gap for those lacking access involves the following analytical steps. We first estimate the count of households, by county, across the US, requiring new or repaired water infrastructure to achieve our definition of water access. From the county-level household counts, we further estimate the proportion of homes in each of three proximity categories to existing water infrastructure systems, dictating the type of solution and average cost per solution applied in the model. The three proximity categories are: 1) within a current water system service range, 2) within range of a possible extension of a current water system, and 3) permanently outside of a water system range. The count of homes in each category is estimated using the known average rurality of that county's population and data on the penetration of high-speed internet services (as a proxy for proximity to existing infrastructure options). We then further estimate the proportion of the households in each category that will require new water infrastructure only, new wastewater solutions only, or both, using data from national surveys on water access, and we estimate the proportion of these activities that will be new installations/complete replacements versus repairs of existing infrastructure, while assuming repairs will come at a slightly reduced average cost.

From these categories of required solutions/proximity, we approximate a range of likely average upfront installation/investment costs for each above category, plus an expected annual operations and maintenance and household service costs based on the initial capital expenses, and the expected longevity of the solution to compute a total lifetime cost of closing the water access gap for these households. The expected longevity of investment is shorter for decentralized and experimental solutions (those permanently outside the range of existing water systems). All future costs are discounted such that they can be summed in total current dollar costs, and then compared directly to the future economic benefits over the lifetime of the infrastructure and the reductions in the economic burden of lacking access. Data from our prior work on the per-year economic burden of lacking access are adapted in the total societal return analysis by estimating the total benefits per household over an estimate of the usable lifespan of the new infrastructure.

Due to the significant uncertainty in estimating the current water access infrastructure gaps for particular households and the expected costs required to remediate these gaps, we run three scenarios in our cost and net return models: our initial, most likely estimate; a "low-cost" alternative, where costs are lower, new installation rates are lower, and homes are on average closer in proximity to existing systems; and a "high-cost" alternative, where costs, rates of new construction, and rurality are higher. We estimate these costs as averages across all homes within each category, acknowledging the expected massive variability in costs of investing in new infrastructure for any particular home. Despite the difficulty in estimating a specific project's cost (and the impossibility of estimating these direct costs in this type of modeling), we believe this work approaches a plausible estimate of the expected total national costs of closing the water access gap that can be further evaluated by sensitivity analyses.

The primary data sources used to compute the number of households in each infrastructure and proximity category described above are mostly from the US Census Bureau. We use the same datasets derived from the 2018 ACS to estimate the number of households and individuals in each county currently lacking water access [178] and further Census data on the proportion of the population in rural versus urban geographic areas by county to begin approximating the proportion of households lacking access that could be served within current water system areas or via an extension of existing areas. [179]

While these crude proportions of urban versus rural populations are imprecise in estimating the rurality status of any particular household, as a county average, they provide a useful indicator of the proximity of households to existing infrastructure. Because we expect that homes currently lacking access will skew toward rural areas (even in counties identified as having high urban populations), we do not assume all urban-classified households have access to a current system-based solution, instead using the parameters shown in the inputs section below to split each county's households among the three proximity solutions. We use data on the penetration of high-speed internet (requiring either a physical DSL, cable, or fiber line) to further refine the prediction of access to current systems, by county, using findings from ACS data. [180] We believe this refinement using high-speed internet as a proxy is useful as it is likely indicative of community density, proximity to centralized services, and ease of installation for new infrastructure. A summary of model inputs for these steps is presented in the following table:

| Model Input | **BASE SCENARIO** | **"LOW-COST" SCENARIO** | **"HIGH-COST" SCENARIO** | **MODIFIER** |
|---|---|---|---|---|
| Percent Rural Population, by County | Varies by County based on ACS data Mean: **58.7%**; Interquartile Range: **33.4% - 88.3%** | | | n/a |
| Percent within an Existing Water System Service Region | Rural: **20%**<br>Urban: **40%** | Rural: **30%**<br>Urban: **50%** | Rural: **10%**<br>Urban: **20%** | Modified by County based on % with High Speed (DSL, Cable, or Fiber) Internet Penetration |
| Percent within a Possible Extension of an Existing Region | Rural: **20%**<br>Urban: **30%** | Rural: **30%**<br>Urban: **30%** | Rural: **20%**<br>Urban: **40%** | |
| Percent Requiring New Installations/Complete Replacement, by County | 75% | 60% | 80% | n/a |
| Percent Requiring Both Water and Wastewater Infrastructure | | 70% | | n/a |
| Percent Requiring Wastewater-Only Infrastructure | Varies by County based on ACS data Mean: **17.1%**; Interquartile Range: **16.2% - 17.8%** | | | n/a |
| Percent Requiring Water-Only Infrastructure | Varies by County based on ACS data Mean: 12.9%; Interquartile Range: **12.2% - 13.8%** | | | n/a |

We then estimate the proportion of households in each proximity category and county requiring water-only, wastewater-only, or both investments, based on data from a subset of the ACS data on the proportion of homes lacking either only running water or only toilets (only including the years for which this question was asked in the most recent five-year ACS dataset).[8] From there, we estimate for the model the proportion of infrastructure installations that will be "new" or "complete replacements" versus "repairs" of existing malfunctioning infrastructure using our best estimates and the expected costs per installation of each of the resulting 18 categories derived as permutations of the above indications. Installation and infrastructure costs are lowest for water-only repairs within a current system region, while they are highest for a home requiring a new installation of both water and wastewater solutions outside of an existing system's range. We estimate the future annual service costs for households from current US average water and wastewater rates and additional operating and maintenance costs by assuming 2% of initial capital costs per year for system solutions and 4% of initial capital costs for the outside-of-system investments. Lastly, we assume in-system solutions have a longer usable lifespan (50 years) than off-system solutions (25 years).

It is important to note that the estimates of cost per installation/repair type per household are very difficult to find and reasonable average expected costs are mostly unknown. While a variety of academic, governmental, and non-academic sources can be cited on this subject, even from any one source the variance in expected costs is often greater than an order of magnitude (indicating that individual site characteristics drive much of the cost variation). Further, no data have been found to date that assess the costs of new infrastructure specifically for the water access gap households, which may vary significantly from the standard cost assessment literature. As a result, we rely on a mix of reviewed sources, but primarily on expert judgment, for the cost per infrastructure scenario, as summarized in the following table:

| Model Input | **BASE SCENARIO** | **"LOW-COST" SCENARIO** | **"HIGH-COST" SCENARIO** |
|---|---|---|---|
| Within Existing Region (Waste and Water) | New: **$25,000**<br>Repair: **$15,000** | New: **$18,750**<br>Repair: **$8,438** | New: **$31,250**<br>Repair: **$23,438** |
| Within Existing Region(Waste or Water) | New: **$18,000**<br>Repair: **$10,800** | New: **$13,500**<br>Repair: **$6,075** | New: **$22,500**<br>Repair: **$16,875** |
| Within Extension Region (Waste and Water) | New: **$40,000**<br>Repair: **$24,000** | New: **$30,000**<br>Repair: **$13,500** | New: **$50,000**<br>Repair: **$37,500** |
| Within Extension Region (Waste or Water) | New: **$28,000**<br>Repair: **$16,800** | New: **$21,000**<br>Repair: **$9,450** | New: **$35,000**<br>Repair: **$26,250** |
| Outside Existing Service Areas, Waste and Water | New: **$60,000**<br>Repair: **$36,000** | New: **$45,000**<br>Repair: **$20,250** | New: **$75,000**<br>Repair: **$56,250** |
| Outside Existing Service Areas (Waste or Water) | New: **$45,000**<br>Repair: **$27,000** | New: **$33,750**<br>Repair: **$15,188** | New: **$56,250**<br>Repair: **$42,188** |
| Within Existing Region (Annual O&M % of Initial Cost) | | **2%** | |
| Outside Existing Region (Annual O&M % of Initial Cost) | | **4%** | |
| Within Existing Region (Expected Usable Lifespan) | | **50 years** | |
| Outside Existing Region (Expected Usable Lifespan) | | **25 years** | |

## RETURN-ON-INVESTMENT CALCULATIONS

We compute the net return shown as dollars in societal benefits compared to infrastructure costs based on the ratio of all future discounted economic benefits to discounted costs, reporting both total costs and benefits and the expected dollar return, per dollar invested based on the following formula:

Net Return ($ per dollar invested) = Total Discounted Benefits (2020$) / Total Discounted Costs (2020$)

Benefits are computed based on calculations above of the annual health and economic harms for individuals in households lacking access, multiplied by the number of years the new infrastructure would be used by the household. We assume the costs and benefits persist for homes across all future families and households for the lifespan of the new infrastructure. Because the future economic costs of maintaining the new investments and the benefits of reductions in the annual water access gap burdens accrue over time, it is possible the current household population may increase, decrease, or change due to home sales, moves, or new family entrants. We assume in our model that the benefits of new infrastructure relative to the status quo persist through all families living in a home, regardless of whether they are the "current" family or new household members. Failing to account for the permanence of a water infrastructure investment across new families would undercount the long-term total benefits of these improvements.

We use a currently accepted discount rate of 3% per year to put all future costs and benefits into current dollars and then summarize all costs by category. We compare the total costs to the total discounted future benefits of improved health, labor productivity, and economic output using data from our prior study. These costs and benefits are modeled for the life of the infrastructure installed (if an off-system solution, 25 years; if an on-system solution, 50 years), accounting for the number of households falling into each category based on the factors described above.