Attachment A

Water and Sewer Price and Affordability Trends in the United States, 2017–2023

Manuel P. Teodoro and Ryan Thiele

Key Takeaways

Biennial data from 2017 to 2023 show that water and sewer prices increased substantially, from an average combined monthly price of $79.39 in 2017 to $95.02 in 2023 at 6,200 gallons per month for single-family residential customers.

Water rate structures became more regressive during that time, with utilities collecting an increasing share of revenue through fixed charges and less revenue through volumetric charges.

Average low-income affordability in the United States has worsened over the past six years, mainly driven by extreme unaffordability in a small minority of utilities.

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Affordability has emerged as a prime concern for US water and sewer utilities over the past decade, as paying for long-deferred infrastructure replacement needs and upgrades has increased customer prices for these critical services. Combined with rising costs of living and uneven income growth, increasing water and sewer prices can cause financial challenges for low-income customers.

In an effort to depict the state of water and sewer affordability accurately and meaningfully, researchers at Texas A&M University (College Station, Texas) and the University of Wisconsin-Madison have measured residential water and sewer prices and affordability for a nationally representative sample of utilities with biennial data beginning in 2017 (Teodoro & Saywitz 2020, Teodoro 2019). This new study replicates and updates those studies with similar nationally representative data from 2021 and 2023. With four biennial waves complete, it is possible to track national trends over a six-year period. From 2017 to 2023, US utilities and the communities they serve saw marked shifts in rate structures, a global pandemic, increased consumer inflation, and a significant influx of federal infrastructure funding. Comparisons of pricing and affordability from 2017 to 2023 provide a useful picture of short-term national trends.

This article briefly describes our sampling and measurement methodology for the new study and then reports levels and trends in water and sewer prices from 2017 to 2023. We then discuss subtle but important recent changes to rate structures nationwide before turning to affordability. We conclude with observations about the state of water and sewer affordability in the United States, and what the data indicate about the possibilities and limitations of utilities' efforts to address affordability challenges.

Assessing Affordability, Progressivity, Trends, and Structures

The affordability of water and sewer services is a function of their prices relative to other goods and services as well as the resources customers have to pay for them. This study analyzes trends in water and sewer utility pricing and low-income affordability for these services at the household level, with attention to changes between 2017 and 2023. The focus here is household affordability rather than utility-level financial capability, which refers to a community's overall capacity to pay for its capital and operating needs (Davis & Teodoro 2014).

Popular interest in water and sewer affordability in the United States has grown considerably over the past decade. Before 2019, systematic and rigorous research on the subject was uncommon. Most studies that previously attempted to gauge affordability nationally or across large numbers of utilities emerged from the nonrefereed "gray literature" (Rockowitz et al. 2018, S&P Global 2018, Bartlett et al. 2017, Jones & Moulton 2016). Earlier peer-reviewed studies suffered from sample bias or measurement problems that limited their empirical validity (Mack & Wrase 2017, Mirosa 2015). Recent years have seen improvements in the state of research on the subject, with better measurement and sampling leading to more valid depictions of pricing and affordability (Patterson & Doyle 2023, Cardoso & Wichman 2022, Teodoro & Saywitz 2020, Teodoro 2019). However, no research to date has analyzed national trends in water and sewer affordability with consistent, nationally representative data. The present study provides such an analysis by replicating and extending Teodoro and Saywitz's (2020) study with two more biennial waves of data.

Sampling and Sources

No comprehensive, nationally representative, publicly available data set on water and sewer rates in the United States currently exists. Consequently, some studies of affordability rely on secondary compilations of rates and/or discuss rising system-level expenses rather than measuring household affordability directly (e.g., Bartlett et al. 2017, Jones & Moulton 2016). Others rely on proprietary data sets made up of convenience samples (S&P Global 2018) or nonrandom, skewed samples (Patterson & Doyle 2023, Cardoso & Wichman 2022, Mack & Wrase 2017). Inferring national affordability conditions from biased samples risks under- or overestimating costs with errors of unknown direction and magnitude.

To depict water and sewer utility prices in the United States accurately, we use the same randomized, stratified sample of US water and sewer rates data that were used in earlier studies by Teodoro (2019) and Teodoro and Saywitz (2020). As in those studies, the sampling frame is the US Environmental Protection Agency's (EPA's) Safe Drinking Water Information System (SDWIS). The SDWIS contains basic system information and regulatory compliance data for each of the country's nearly 50,000 community water systems.

Combined with rising costs of living and uneven income growth, increasing water and sewer prices can cause financial challenges for low-income customers.

The overwhelming majority of community water systems in the United States serve populations of less than 3,000, so a purely random sample would likely result in a sample of small utilities and very few medium and large utilities, where most of the US population resides. In addition, almost half of the very small utilities are privately owned, while larger systems are generally owned by local governments.

To obtain a representative sample, the SDWIS frame was stratified in two ways: by ownership (government versus private) and then by EPA's five population strata. The smallest stratum (systems serving fewer than 3,300 people) was dropped from the sample as a result of the difficulty of securing reliable rates data and because they collectively serve a very small portion of the total US population. Utilities serving US territories were also excluded from the sample. The final sample includes 340 local government utilities and 76 investor-owned (private) utilities in each of the four population strata, for a total of 416 utilities. We applied inverse probability post-stratification weights to the parametric calculations that follow, which allows unbiased population inferences with the stratified data.

As this study explores the combined affordability of both essential drinking water and sanitary sewer services, an accompanying sewer system was identified for each sampled water utility. In 65.7% of the cases in the 2023 sample, a single organization provided both water and sewer services to the same geographic location (e.g., a city government that operates water and sewer utilities for its own city or a joint water–sewer special district). In the remaining cases, separate organizations provided the sewer service for the city or county identified in the SDWIS service area.

Data Collection

Single-family residential water and sewer rates for the sampled utilities were collected directly in 2021 and 2023 to analyze with the 2017 and 2019 samples. The 2019 sample was expanded from 2017, with 82 local government utilities randomly sampled from each of four size strata (up from 75 per stratum in 2017) and 22 private utilities in each stratum (up from 16 in 2017). The 2019 sample was retained through subsequent waves of data collection in 2021 and 2023.

For most utilities, rates were available online from utility websites. We contacted the remaining utilities directly by telephone, email, and postal mail. Sewer rates were occasionally unavailable because the water system's service area had no sanitary sewer service or refused to provide the information; accordingly, those utilities are excluded from analysis. The final data set of utilities with complete water and sewer rate data includes 399 of the 416 sampled utilities (95.9%). The utilities in this sample serve a combined population of almost 44 million across the United States.

The affordability of water and sewer services is a function of their prices relative to other goods and services as well as the resources customers have to pay for them.

The remaining data used in this study come from SDWIS, the US Census Bureau's 2021 American Community Survey (ACS) five-year estimates, and the Census Bureau's 2021 and 2022 Consumer Expenditure Surveys. The SDWIS provided data on population served and utility ownership. Demographic and income data for the cities served by the water utilities were obtained from the ACS.

Accurately matching demographic and income data to special district, county, and private utility jurisdictions is challenging because utility service areas do not always correspond perfectly with municipal boundaries. For the sake of consistency, this update uses the same method to match demographic and income data to special district, county, and private utility jurisdictions, as employed in earlier studies: where utilities served multiple cities or unincorporated areas, the city identified with the city's mailing address in SDWIS was used. We also collected the applicable minimum wage data for every utility's jurisdiction.

Measurement

Water and sewer utilities across the United States employ a wide range of rate structures and billing practices. To ensure comparability, the present study measures prices as the price of one month of service for a single-family residential customer that uses 6,200 gallons of water in a month. The 6,200-gallon benchmark volume reflects basic indoor water consumption of approximately 50 gallons per person per day for a four-person household in a 31-day month. Where utilities employ seasonal rates or differential prices across different geographic zones within their service areas, this study uses the highest applicable prices. Although this approach results in somewhat high prices relative to average consumption in much of the United States, these high prices offer a conservative way of evaluating affordability.

Attachment A

We measure affordability using AR_{20} and *HM,* following the methodology advanced by Teodoro (2018). The affordability ratio (*AR*) accounts for basic household water needs and essential nonutility costs:

$$AR = (\text{Cost of Basic Water + Sewer Service}) \div (\text{Household Income} - \text{Essential Nonwater Costs}) \quad (1)$$

This *AR* reflects basic water and sewer costs as a share of discretionary income. Assessing *AR* at the 20th percentile income (AR_{20}), rather than at median income, focuses analysis on low-income households. Assessments of welfare economics typically identify the 20th percentile as the lower boundary of the middle class. These "working poor" households have limited financial resources but may not qualify for many income assistance programs.

To calculate AR_{20}, we gathered income data at the 20th percentile for each utility and then estimated essential expenditures for a household at the 20th percentile of household income using Consumer Expenditure Survey data. In this study, estimated essential non-water/sewer expenses include housing, health care, food, home energy, and taxes; for methodological details, see Teodoro (2018).

Basic household water and sewer costs expressed in *HM* is an intuitively appealing complementary metric that represents the opportunity cost of water and sewer service in terms of working-class labor.

$$HM \text{ (in hours)} = (\text{Cost of Basic Water + Sewer Service}) \div (\text{Area Minimum Wage}) \quad (2)$$

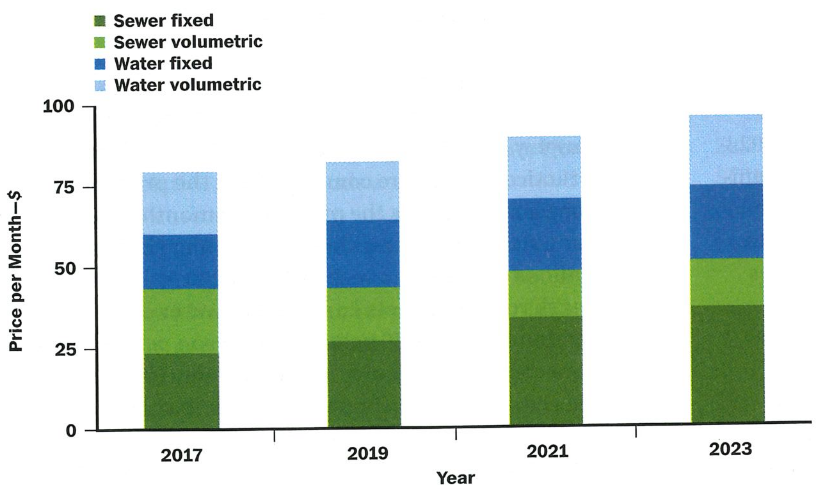
Notably, we eschewed the traditional affordability metric that was widely used in the past: average water and sewer bills as a percentage of median household income (%MHI), with a combined value less than 4.0% or 4.5% designated as "affordable." Often erroneously cited as an EPA standard for household affordability, the %MHI guidelines as developed by EPA were intended to measure community-level financial capability for purposes of negotiating regulatory compliance (EPA 1997, 1995; see also NAPA 2017). That metric has been widely criticized, and recent peer-reviewed studies on water affordability have largely abandoned it (Teodoro 2018).

Residential Price Trends

In 2023, the price of monthly residential water and sewer service for the average US utility in 2023 was $95.02 for a customer that used 6,200 gallons. This price represents a 6.6% increase from 2021, when the average monthly price of a household's water and sewer bill was $89.10. That biennial increase continued a trend of rising prices: in 2019 the average combined price was $82.10, and in 2017 it was $79.39 per month. Thus, the average monthly household bill in 2023 is 20% higher than it was in 2017.

Average water and sewer prices rose substantially over the six-year period of analysis, but as in earlier studies, average sewer prices remained higher than water prices. Figure 1 shows the average fixed and volumetric elements of water and sewer charges in 2017, 2019, 2021, and 2023. Over this period of time, the average monthly fixed sewer price—that is, the minimum fee for service that customers pay regardless of volume of water used—rose 54%, from $23.78 in 2017 to $36.54 in 2023. The average volumetric sewer charge, or price based on

Mean Monthly Fixed and Volumetric Prices for US Residential Water and Sewer Service, 2017–2023



Volumetric prices are calculated at 6,200 gallons monthly, reflecting typical indoor usage for a family of four. Post-stratification weights are applied to calculate averages.

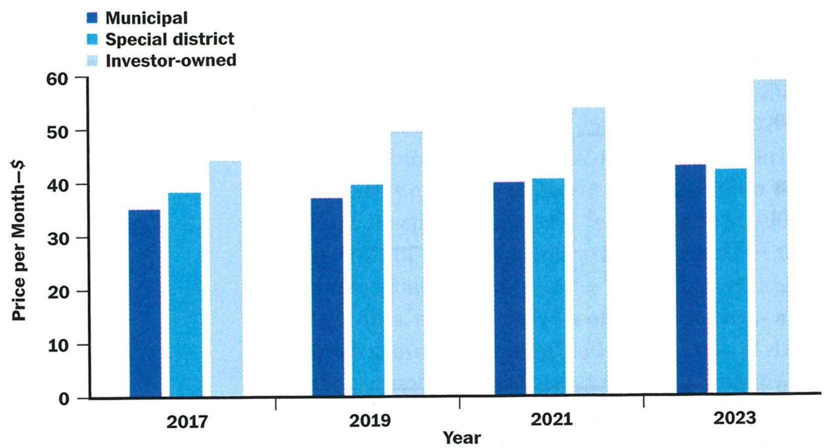
Figure 1

monthly water usage, was $14.25 in 2023, a 27% *decrease* since 2017.

Turning to drinking water, the most notable trend that emerges is that fixed water prices have outpaced volumetric prices since 2017. Monthly water volumetric prices at 6,200 gallons rose 11% from 2017 to 2023, from $19.15 per month to $21.31. Meanwhile, fixed water prices rose from $16.84 to $22.92—a 36% increase over six years. The financial appeal of fixed prices for utility management is clear: fixed prices generate reliable revenue from year to year regardless of water demand. However, the increased reliance on fixed prices carries troubling implications for affordability, as discussed subsequently.

There are also differences in average residential monthly water bills between the three types of organizations; Figure 2 depicts the weighted average price trends for monthly residential water bills for municipal, special district, and investor-owned utilities. Municipalities have historically charged the lowest average prices, but municipal water and sewer prices have increased 22% since 2017 and are now effectively equal to special districts. Special district prices have increased the least of the three types, rising just 10% since 2017 from $38.34 a month to $42.15. As in earlier studies, investor-owned utility prices were significantly higher than municipal or special district utilities. Moreover, monthly bills for investor-owned water utilities grew the most in recent years, rising 33% from $44.24 in 2017 to $58.92 in 2023.

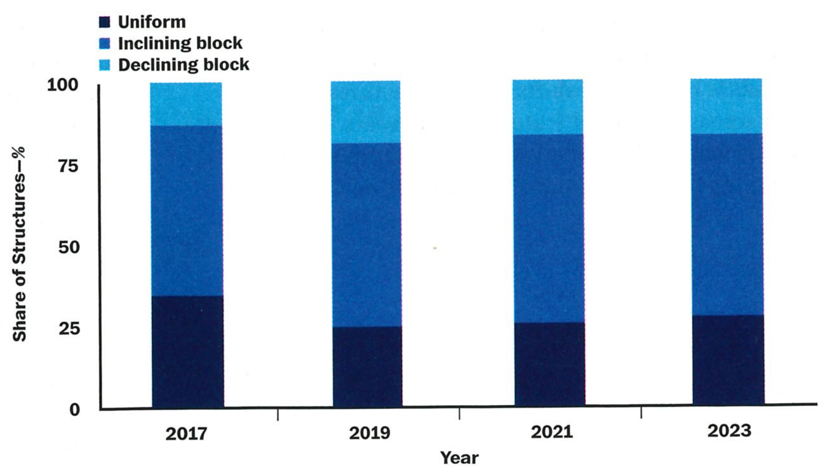
Mean Monthly Prices for Residential Water Service by Utility Ownership, 2017–2023



Volumetric prices are calculated at 6,200 gallons monthly, reflecting typical indoor usage for a family of four at 50 gpd. Post-stratification weights are applied to calculate averages.

Figure 2

Water Rate Structures Used by US Utilities, 2017–2023



Post-stratification weights are applied to calculate proportions.

Figure 3

Changes in Rate Structure

Most water utilities in the United States employ a periodic fixed charge in conjunction with one of three basic volumetric price structures:

- Uniform rates—customers are charged the same price per unit of water regardless of volume consumed.

Mean Unit Price Ratio at 85,000 Gallons (UPR_{85k}), 2017–2023

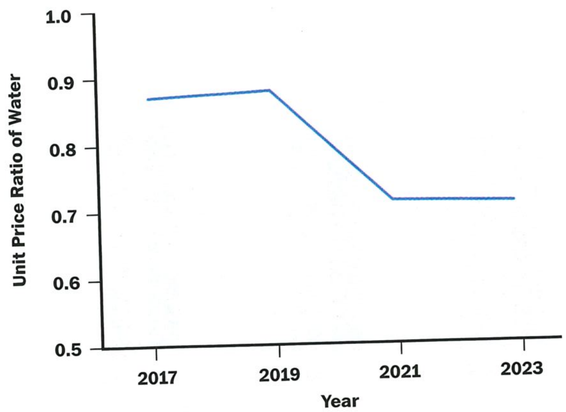


Figure 4

- Inclining block rates—unit prices increase with volume consumed.
- Declining block rates—customers are charged less per unit of water as their consumption increases.

Figure 3 illustrates the proportion of utilities employing each of these structures from 2017 to 2023.

Some subtle but notable shifts in rate structures have occurred across the United States in recent years. In 2017, 34% of water utilities had uniform structures, 51% used inclining block rates, and 13% employed declining

No comprehensive, nationally representative, publicly available data set on water and sewer rates in the United States currently exists.

block rates. In 2019, uniform structures dropped to 24% of utilities but have been growing again by 1% on average every year. Declining blocks filled the void, rising to 19%, where they have relatively remained. By 2021, inclining block rates peaked at 58% of all utilities, but in 2023 both inclining and declining blocks had lost a percentage point each to uniform rates.

Regressive Rates

Despite the growing use of inclining block rates, the past six years reveal a troubling trend in pricing that contributes to affordability problems. In general, inclining blocks with low fixed charges and inclining block volumetric charges bolster affordability by ensuring that essential indoor water service is available at relatively low total prices (Patterson & Doyle 2023, AWWA 2022, Chappelle & Hanak 2021, Rothstein et al. 2021). This kind of *progressive* pricing shifts revenue burdens away from the most conservative customers and toward high-volume customers (Switzer 2019), but introduces a degree of revenue risk (Chesnutt et al. 1996). The national data indicate that water and sewer rates have become less progressive and more regressive since 2017.

We measured and illustrated rate progressivity with a unit price ratio (UPR). The UPR is a ratio of the average unit price of water at basic consumption levels to the average unit price of water at excessively high volumes. The present analysis gauges excessive use at 85,000 gallons per month (UPR_{85k}), based on documented excessive water use by celebrities who infamously used 85,000 gallons per month in Beverly Hills during the height of a drought in California (Tait 2016). The UPR_{85k} is the ratio of the unit price of water and sewer prices at 85,000 gallons to the unit price of the same service at 6,200 gallons per month. Total fixed and volumetric charges are used to develop the unit prices of water at the two usage levels.

A UPR_{85k} value of 1.0 indicates that an excessively high-volume customer and a conservative residential four-person household pay identical unit prices for water. Values less than 1.0 indicate regressive rates (the excessive user pays a lower unit cost than a conservative user), and values greater than 1.0 indicate progressive rates (the excessive user pays a higher unit cost than a conservative user).

Figure 4 shows that water and sewer rates generally have become more regressive over the past six years, presumably spurred by the COVID-19 pandemic. In 2017, the mean UPR_{85k} for utilities was 0.874, meaning that for every dollar that conservative single-family residential customers spent per unit of water, high-volume users spent about $0.87 per unit. Average UPR_{85k} rose to 0.883 in 2019 but took a steep drop to 0.715 in 2021, with further decline to 0.711 in 2023. High-volume customers now pay substantially less per unit of water and sewer service relative to their conservative neighbors. These more regressive prices shift greater revenue burdens in the form of higher fixed fees to more conservative customers, even as those customers use less water, instead of using higher volumetric fees that would more greatly affect excessive water users.

Another way of viewing this trend in rate structures is through first-gallon prices (Teodoro & Saywitz 2020). The first-gallon price combines the fixed charges for water and sewer service with the volumetric price that applies to the first unit of water consumed. In 2017 the mean monthly first-gallon price was $30.16, but it jumped to $40.02 in 2019. While the increase in price slowed from 2019 to 2023, at $44.36 in 2021 and $47.82 in 2023, first-gallon price rose 59% from 2017 to 2023. In 2023, first-gallon prices became 50% of an average monthly bill for a single-family residential customer for the first time. In contrast, first-gallon prices were about 38% of a total bill in 2017.

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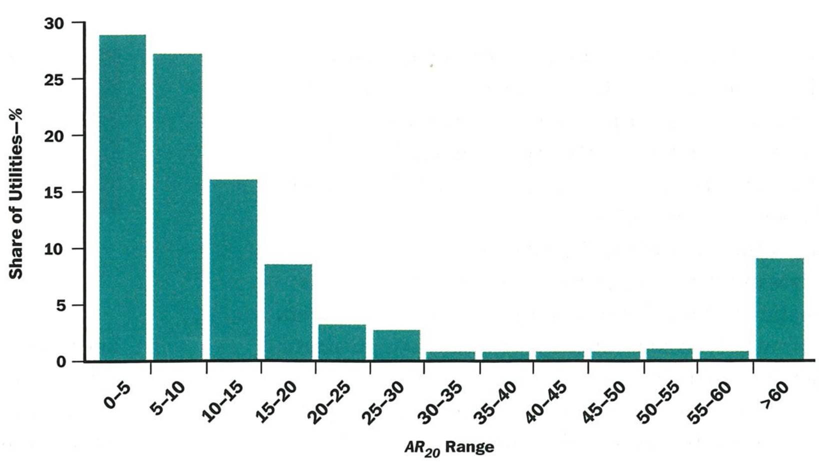
Although fixed prices provide generally stable revenue, the rapid rise in the first-gallon price indicates that recent price increases have affected relatively conservative customers more than high-volume users. Since average water consumption correlates positively with income (Burger et al. 2020, Ruijs et al. 2008), rate structures that shift burdens to conservative customers and away from high-volume customers also tend to exacerbate affordability problems (Patterson & Doyle 2023). As Figure 1 indicates, these first-gallon prices change are driven mainly by increases in fixed prices.

Affordability

Increasing prices and more regressive rate structures combined with broader economic factors have worsened water and sewer affordability in the United States over the past six years as measured with AR_{20}, which again is the basic water and sewer costs as a share of discretionary income at the 20th percentile of household income. Average incomes for households at the 20th percentile rose from $22,105 in 2017 to $27,826 in 2023—a 26% increase. However, over the same period, mean monthly essential expenditures other than water for those households grew 39%, from $854 to $1,190. These trends in general inflation have sapped low-income households' capacity to pay for water and sewer services, even as their incomes have risen.

Figure 5 shows the unweighted distribution of AR_{20} values for sampled US water and sewer utilities in 2023. More than half of sampled utilities' AR_{20} values are 10.0 or lower, indicating that low-income households pay less than 10% of their discretionary income on basic water and sewer service. The distribution of AR_{20} is highly skewed: 19.4% of the communities in the data set have values greater than 20.0, with 9% having an AR_{20} of greater than 60.0. This long "tail" at the right-hand side of Figure 5 drove a startling increase in national average AR_{20} from 2017 to 2023. From 2017 to

2023 Distribution of AR_{20} Values



AR_{20} is the basic water and sewer service price as a percentage of discretionary income for a household at the 20th income percentile.

Figure 5

Median AR_{20}, 20th Percentile Income, Median Monthly Water Bill by Utility Service Population, 2017–2023

Stratum—AR_{20} *population served*	2017	2019	2021	2023
100,001–250,000	7.0	9.6	8.8	8.2
50,001–100,000	7.6	9.0	6.4	6.3
10,001–50,000	6.9	10.1	10.1	8.6
3,301–10,000	9.2	12.3	13.1	12.2
Cells contain median AR_{20} value within each sample stratum.				
Stratum—Income 20th Percentile *population served*	**2017 $**	**2019 $**	**2021 $**	**2023 $**
100,001–250,000	20,085	21,312	24,108	24,462
50,001–100,000	24,559	24,140	29,433	33,105
10,001–50,000	20,669	22,492	25,535	26,303
3,301–10,000	18,707	20,299	22,500	23,459
Cells contain median income at the 20th percentile within each sample stratum.				
Stratum—Median Monthly Water Bill *population served*	**2017 $**	**2019 $**	**2021 $**	**2023 $**
100,001–250,000	70	83	86	89
50,001–100,000	72	77	82	90
10,001–50,000	67	78	83	88
3,301–10,000	63	82	91	93
Cells contain median monthly water bills within each sample stratum.				

Table 1

2019, the affordability ratio for lower-income households rose from 10.6 to 12.6. AR_{20} spiked to 25.6 in 2021, driven in part by fluctuating expenses and incomes associated with the COVID-19 pandemic. Although average AR_{20} dropped slightly in 2023 to 24.7, it remains well above the 2017 value.

Inspection of median AR_{20} values for utilities of different sizes over the same period suggests somewhat less dramatic changes in affordability. Table 1 shows median AR_{20} from 2017 to 2023 for each of the four sample strata. Although median AR_{20} increased substantially over the six-year period in three of the four strata, these changes indicate a gradual erosion of affordability rather than a staggering collapse. Moreover, as in earlier studies, median AR_{20} values indicate that the most serious affordability problems emerge in utilities that serve populations of less than 10,000. Taken together, these results indicate that low-income water and sewer customers across the United States face increasing pressures but that a small minority of utilities face severe affordability challenges. Utilities with severe affordability challenges are disproportionately small and/or serve populations with very low incomes.

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The case of Troy, Ala., provides a useful illustration of how local economic conditions can generate significant affordability challenges, even where rates are quite low. In

2023, the City of Troy's Utilities Department provided water and sewer services to a population of about 22,000. At $46.15 a month, at 6,200 gallons for water and sewer combined, Troy's rates were less than half of the national average. However, according to the ACS, the 20th percentile annual income in Troy was just $13,960, or $1,163 per month. Even with essential monthly expenditures estimated at a modest $1,088, a low-income, four-person household in Troy had just $75 in discretionary funds available to pay its water and sewer bill and any other costs. The resulting AR_{20} value of 61.5 indicates a severe affordability problem in Troy, but one driven mainly by low incomes and a rising cost of living rather than water or sewer prices.

Measuring affordability with *HM* yields a somewhat different picture since average minimum wages have increased roughly in tandem with water and sewer prices in much of the United States. As shown in Figure 6, most utilities have *HM* values of less than 8.0, indicating that monthly water and sewer prices are less than or roughly equal to a typical 8-hour work day's worth of labor at minimum wage. The national average minimum wage increased 24% from $8.18 in 2017 to $10.15 in 2023. Consequently, *HM* increased just 5% from 2017 to 2023, from 9.6 hours of minimum wage labor required to pay a monthly bill to about 10.0 hours today, even as water and sewer prices increased. While Figure 6 shows that the distribution of *HM* is skewed, its "tail" of extreme values is not as long as the distribution of AR_{20} in Figure 5.

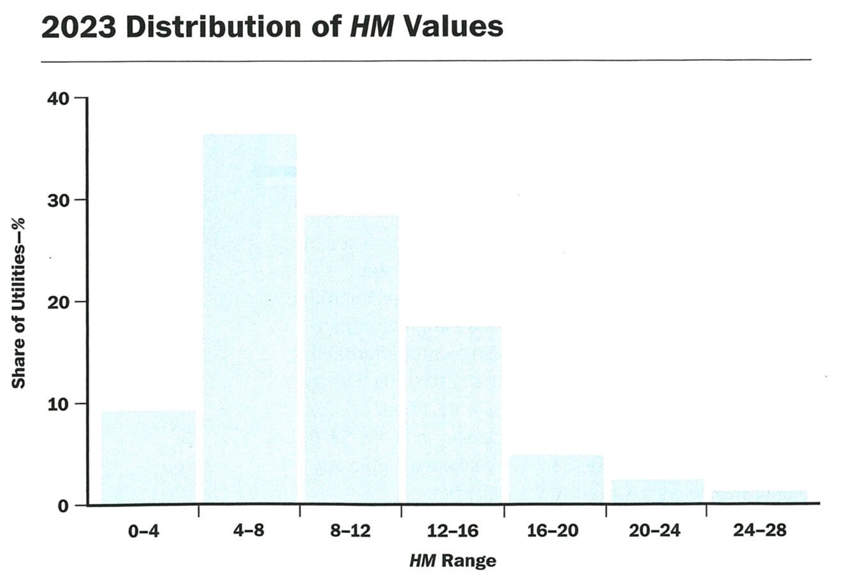
These *HM* results indicate that the troubling affordability suggested by 2023's average AR_{20} cannot be solely or even mainly attributed to utility prices. Rising water and sewer prices and more regressive rate structures contribute to affordability problems. However, the extreme affordability problems that some utilities now face are likely driven as much or more by rising costs of living and lagging income growth among lower-income households.

Meeting the Challenge of Affordability

Data on prices, rate structures, incomes, and household expenses combine to reveal worsening water and sewer affordability in the United States over the past six years, which is driven by several factors. Monthly water and sewer bills have increased significantly and have become more regressive on average, as utilities rely more on fixed and first-gallon prices to raise revenue. These pricing trends reduce customers' ability to manage their own expenses and place ever greater pressure on conservative customers—who often also have lower incomes. Utilities' pricing and financial management policies thus can contribute directly to deteriorating affordability.

Greater efficiency, a return to more progressive pricing, and income-qualified assistance programs can all improve affordability.

At the same time, difficult economic conditions for low-income households have contributed as much or more to US water and sewer affordability problems. Although working class incomes have increased over the past six



HM **is the price of basic monthly water and sewer service expressed in hours of labor at local minimum wage.**

Figure 6

years, inflation for essential expenses like housing, health care, food, and home energy have sapped low-income households' capacity to pay for water and sewer services. These macroeconomic factors are largely beyond utilities' control.

Ensuring that essential water and sewer services are affordable for every customer is a strategic challenge. Multiple layered, complex factors contribute to the water sector's affordability problems; it is a complicated challenge that demands a comprehensive strategy. Greater efficiency, a return to more progressive pricing, and income-qualified assistance programs can all improve affordability. Above all, affordability requires continued dedication to safe, resilient, and sustainable water and sewer utilities.

A commitment to drinking quality pays off in affordability for customers who can drink from their taps with confidence and avoid spending orders of magnitude more for bottled water (Teodoro et al. 2022). Effective sanitary sewers prevent costly illnesses and allow people to fish and swim without fear. Despite their rising prices, excellent drinking water and sewer systems continue to provide remarkable value to the communities that they serve.

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