

DEFINING & MEASURING WATER AFFORDABILITY

A LITERATURE REVIEW



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This report provides a review of the definition and measurement of water affordability. Water affordability does not have any one generally accepted definition or method of measurement. Rather, the definition and measurement varies depending on the purpose of the water affordability assessment. A history of the meaning and measurement of water affordability for EPA Clean Water Act, Safe Drinking Water Act and State Revolving Loan Fund, and Customer Assistance Programs is provided. A review of the criticisms of traditional water affordability measures and suggested improvements from relevant experts is also included. Illinois-Indiana Sea Grant, the Metropolitan Planning Council and Elevate Energy collaborated on this report as part of a larger initiative to research and explore the extent to which communities in the northeastern Illinois region are facing challenges to water affordability, and identify opportunities to address these concerns.

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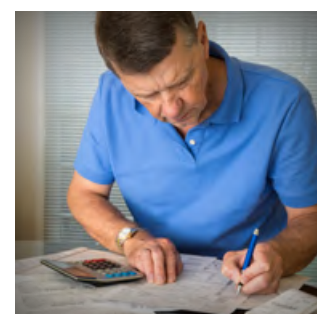
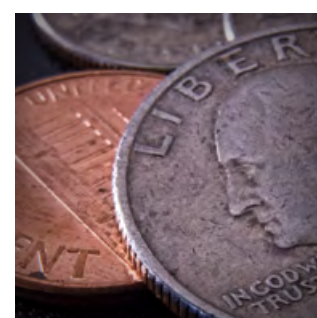
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Introduction

Concern over water service affordability has grown in recent years as water bills escalate at a faster pace than the overall cost of living.¹ While the cost of water has been rising over the past decade, the ability of consumers to pay for water service has declined.² Ability-to-pay, or residential water affordability, refers to the capacity of customers to pay water rates that reflect the full costs of providing water service. At the same time, concern over community ability-to-finance has been growing due to a widening gap between needed and actual water system infrastructure investment. Taken together, escalating water costs, reduced ability-to-pay, and the widening infrastructure investment gap have translated into an increased focus on the issue of defining, measuring, and addressing water affordability.

This review examines the definition and measurement of water affordability through a chronological search and presentation of the regulatory and research literature.³ Because the bulk of the research addresses wastewater costs, wastewater affordability is considered along with drinking water affordability. Customers typically receive bills reflecting these two separate charges—water service and wastewater (or sewer) service—though the bill is typically combined to a single amount due. Particular attention is given to the method and data used in constructing water affordability measurements.



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1 Beecher, J. A. (2015). IPU Research Note: Trends in Consumer Price Index (CPI) for Utilities through 2016. Institute for Public Water Utilities, Michigan State University.

2 Hughes, J. (2014). *Defining a resilient business model for water utilities*. Denver, CO: Water Research Foundation.

3 Teodoro, M. P. (2018). Measuring household affordability for water and sewer utilities. *Journal - AWWA*, 110(1), 13–24. doi: 10.5942/jawwa.2018.110.0002

Defining Water Affordability

Reasons for measuring water affordability include compliance with federal water regulations, eligibility for State Revolving Funds (SRF) and other grants, and customer assistance program (CAP) design. Water affordability does not have one generally accepted definition or method of measurement. Rather, the definition and measurement varies depending on the purpose of the water affordability assessment. At the federal level, measuring water affordability is required to assess the impact of complying with U.S. Environmental Protection Agency (EPA) Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) standards. The primary definition of water affordability used in the CWA and SDWA assessments is: the financial capability of the community to pay for CWA and SDWA compliance costs. In determining eligibility for grant and loan programs, such as SRF, discretion is given to states to assess affordability. Water affordability assessments are also used to develop CAPs. In this context, water affordability is defined as whether the most vulnerable populations can pay for essential water services. Because these definitions are typically conflated in the water affordability literature, measurements for all these definitions are included in this review.

Measuring Water Affordability

EPA CLEAN WATER ACT AFFORDABILITY ANALYSIS

The CWA affordability assessments are used to determine the impact of complying with combined sewer overflow (CSO) control, and provide flexible implementation schedules for burdened communities.⁴ The affordability measure includes the residential indicator (RI), to measure the ability of community system users to cover compliance costs, and the financial capability indicator (FCI), to measure the ability of the community system to access financing for necessary investments to comply with the CWA. States are encouraged to submit additional measurements to EPA.

Determining the value of RI requires performing a calculation that uses data from both the utility and the U.S. Census. It is calculated as the average cost per household for wastewater treatment

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4 U.S. Environmental Protection Agency (1995) *Interim Economic Guidance for Water Quality Standards–Workbook*; U.S. Environmental Protection Agency, Office of Wastewater Management, Municipal Support Division. (1997). *Combined sewer overflows: guidance for financial capability assessment and schedule development*. Washington, D.C.

and CSO control divided by median household income.⁵

EQ.1 Residential Indicator (RI) = $\frac{\text{Annual Wastewater and CSO Control Costs per Household (CPH)}}{\text{Annual Median Household Income (MHI)}} \times 100$

The RI is expressed as a percentage, and is interpreted in relation to a 2% threshold (Table 1).

Table 1: Interpretation of the Residential Indicator

Financial Impacts	Residential Indicator (CPH as % MHI)
Low	Less than 1% of MHI
Mid-Range	1–2% of MHI
High	Greater than 2% of MHI

The financial capability indicator (FCI) is a composite of six variables measuring community debt burden, socioeconomic condition, and financial management (Table 2). These variables are assigned a numeric score based on a classification scheme, and then aggregated and compared to national benchmarks to assess a systems financial capability (Table 3).

Table 2: Financial Capability Indicator Benchmarks (EPA 1997)

Indicator	Strong	Mid-Range	Weak
Bond Rating	AAA–A (S&P) Aaa–A (Moody's)	BBB (S&P) Baa (Moody's)	BB–D (S&P) Ba–C (Moody's)
Overall Net Debt as a Percent of Full Market Property Values	Below 2%	2%–5%	Above 5%
Unemployment Rate	More than 1% below the national average	±1% below /above the national average	More than 1% above the national average
Median Household Adjusted	More than 25% above adjusted national MHI	±25% of adjusted national MHI	More than 25% below adjusted national MHI
Property Tax Revenues as a Percent of Full Market Property Value	Below 2%	2%–4%	Above 4%
Property Tax Collection Rate	Above 98%	94%–98%	Below 94%

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⁵ Current wastewater costs, including annual operations and maintenance expenses, excluding depreciation; annual debt service (principal and interest); plus projected wastewater and CSO control costs.

Table 3: Numeric FCI Scores

Benchmark	Score
Weak	1
Mid-Range	2
Strong	3

Together, RI and FCI form the EPA Financial Capability Method (FCM) to determine the burden of system compliance with CSO controls and determine if flexibility in meeting the control is warranted (Table 4). For example, the indicator is used to create the community implementation schedule—communities with lower financial capability (higher financial burdens) have longer implementation schedules.

Table 4: Burden Level Using the Financial Capability Metric (EPA 1997)

Permittee Financial Capability Indicators (Socioeconomic, Debt and Financial Indicators)	Residential Indicator (Cost Per Household as a % of MHI)		
	Low (Less than 1%)	Mid-Range (1%–2%)	High (More than 2%)
Weak (Less than 1.5)	Medium	High	High
Mid-Range (1.5–2.5)	Low	Medium	High
Strong (More than 2.5)	Low	Low	Medium

EPA SAFE DRINKING WATER ACT

Turning to drinking water, water affordability assessments are used for the SWDA to determine the impact of Maximum Contaminant Level (MCL) regulations on small community water suppliers (serving a population of 10,000 or less). Since small systems often have disproportional cost burdens, doing an affordability assessment helps determine whether a community water system can apply for a variance so that meeting the MCL is more affordable.⁶ Evaluating the affordability of implementing the best avail-

6 U.S. Environmental Protection Agency, Office of Water. (1998). *Information for states on developing affordability criteria for drinking water*. Washington, D.C.

able technology (BAT) to meet SDWA regulations is performed at the federal level, but discretion is given to states to develop the affordability criteria in assessing alternatives to BAT and in administering SRF to help communities achieve the standard.⁷

The SDWA National Level Affordability Criterion has two components: household ability-to-pay; and municipal ability-to-finance. The residential household indicator is calculated as:

EQ.2 *Affordability Threshold* =
$$\frac{\text{Total Annual User Charges (AUC)}}{\text{Annual Median Household Income (MHI)}} \times 100$$

The resulting ratio is used as an affordability threshold. The threshold is expressed as a percentage, with the affordability threshold value defined as values that are 2.5% or lower. When the affordability threshold is 2.5% or less, meeting the MCL regulation is considered affordable. When the affordability threshold is greater than a 2.5%, further (ability-to-finance) analysis is triggered to determine the ability of small systems to apply for variances in meeting the MCL.

The U.S. Environmental Protection Agency (1998) also notes that any number of justifiable variations of this ratio are possible, such as including both the water and wastewater charge in the numerator, and using alternate income measures (mean income, poverty level income) in the denominator. The ratio can also be considered in the context of other community socio-economic measures (poverty rate, unemployment, etc.).⁸ The agency gives discretion to states to develop affordability criteria that may be stricter than the suggested federal threshold for ability-to-pay.

The financial capacity of a water system is assessed based on five indicators: ratio of revenues to expenditures; ratio of net income to revenues; ratio of assets to liabilities; debt-service coverage; and a composite financial health indicator. The complete SDWA affordability analysis framework is presented in Table 5.

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 7 U.S. Environmental Protection Agency, Office of Water. (1998). *Information for states on developing affordability criteria for drinking water*. Washington, D.C.

8 An issue in using many of these measures is the potential for a mismatch between service area boundaries (see previous note) and political boundaries (census tracts and counties).

Table 5. EPA Framework for Affordability Analysis (Source: EPA 1998)

	Focus	Level of Analysis	Selected Indicators
Category	Household Affordability	Households	<ul style="list-style-type: none"> › Ratio of user charges to income › Ratio of user charges to income relative to income levels › Percentage rate increase (rate shock)
	Financial Capacity	Water system	<ul style="list-style-type: none"> › Ratio of revenues to expenditures › Ratio of net income to revenues › Ratio of assets to liabilities › Debt-service coverage capacity › Composite indicators of financial health › Market test for goods and services (non-community systems)
	Access to Private Capital	System (or parent entity) and private capital markets	<ul style="list-style-type: none"> › Credit and bond ratings › Debt and debt capacity › Market test
	Eligibility for Public Capital	System (or parent entity) and public capital markets	<ul style="list-style-type: none"> › Credit and bond ratings › Priority rankings › Eligibility test
	Fiscal Conditions	Relevant local government	<ul style="list-style-type: none"> › Debt as a percentage of market property › Tax revenues as a percentage of market property values › Property tax collection or delinquency rate › Local expenditures per resident › Opportunity costs associated with water system expenditures
	Socio-Economic Conditions	Service territory	<ul style="list-style-type: none"> › Median household income › Percent below the poverty level › Percent unemployment › Composite indicators of distressed communities

STATE-LEVEL AFFORDABILITY GUIDELINES

In addition to determining the ability of systems to comply with federal regulations, water affordability assessments are also used by EPA to prioritize funding and determine grant eligibility. Both the Clean Water and Drinking Water SRFs provide states with low-cost financing, subsidize community water investment, and assist systems most in need, based on state affordability criteria. The Water Resources Reform and Development Act of 2014 requires that states establish affordability criteria for receiving SRF funds. Illinois adopted affordability criteria in 2017, and revised it in 2018, as follows⁹:

- › Service population of 30,000 or less (unless median household income is not higher than 70 percent of the state average).
- › MHI of the service population is less than or equal to the statewide MHI.
- › Score is at least 21 points based on median household income, population, unemployment, and service population as follows:

Table 6: Illinois Scoring of MHI as Percentage of Statewide MHI

Points	MHI as % of Statewide MHI
0	Above 100%
5	95-99.99%
10	90-94.99%
15	85-89.99%
20	80-84.99%
25	75-79.99%
30	70-74.99%
35	65-69.99%
40	60-64.99%
45	55-59.99%
50	50-54.99%
55	45-49.99%
60	0-44.99%

9 Illinois Environmental Protection Agency, Bureau of Water, Infrastructure Assistance Section. (2017). *Water pollution control loan program: 2018 intended use plan*. Retrieved from <https://www2.illinois.gov/epa/Documents/iepa/grants-loans/state-revolving-fund/2019-wpc-intended-use-plan.pdf> [35 Ill. Adm. Code Part 365 "Procedures for Issuing Loans from the Water Pollution Control Loan Program"].

Table 7: Illinois Scoring of Service Population

Points	Service Population
5	20,000-30,000
10	15,000-19,999
15	10,000-14,999
20	5,000-9,999
25	2,000-4,999
30	1,000-1,999
35	0-999

Table 8: Illinois Scoring of Additional Criteria

Points	Additional Criteria
1	Unemployment rate is greater than the state average by one percentage point or more
4	Decrease in service population is greater than 5% in the five years from the date of the loan application

In addition to SRF, funding sources for clean water and drinking water in Illinois include: the U.S. Department of Agriculture Rural Development; Department of Commerce Economic Development Administration; National Rural Water Assistance Partnership; CoBank (rural water and wastewater lending); Water Infrastructure Finance and Innovation Act program; and in Illinois, the Illinois Department of Commerce and Economic Opportunity and Community Development Assistance Program.¹⁰ These grant and loan programs may have their own water affordability eligibility criteria.

UTILITY AND CUSTOMER ASSISTANCE PROGRAM WATER AFFORDABILITY GUIDELINES

Community water systems have flexibility in how they define and measure affordability when designing CAP programs, subject to any relevant state laws.¹¹ Therefore, the definition and measurement of water

10 Environmental Finance Network. (2017). <http://efcnetwork.org/funding-sources-by-state/>

11 Berahzer, S.I., Hughes, J., & Riggs, E. (2017). *Navigating legal pathways to rate-funded customer assistance programs*.

affordability varies from community to community depending on the CAP program objectives. The first step in determining if the community needs an assistance program is to gather information, such as poverty measures, late and delinquent bill rates, and the number of low-income households.¹² Designing affordability programs requires a local assessment of: water affordability, including customer socio-economics (unemployment, low-income households, households below the poverty level, households receiving public assistance, etc.); financial capacity (financial ratios); consumer water use and delinquency rates; and other factors to establish program eligibility criteria (AWWA 2014)¹³. Communities can use internal data from the utility accounting and billing system, including uncollectable accounts, late payments, delinquent accounts, aged accounts receivable, financial data, and anecdotes from customer service (AWWA, 2014). Many locally-defined water affordability grant criteria have been developed across the U.S. For example, Illinois American Water and The Salvation Army have an H2O Help to Others Program™ for which customers are eligible if they are at risk of losing access to water and they meet The Salvation Army basic needs criteria.

WATER AFFORDABILITY MEASUREMENT ALTERNATIVES

The EPA affordability guidelines have been widely criticized since their publication.¹⁴ Some key criticisms of RI and the affordability threshold indicators include: the use of median income, which masks the impact on lower-income water users; incomplete measure of costs; and an arbitrary or subjective threshold. Central concerns of FCI include: the community financial health measure does not reflect the utility's financial condition; bond ratings for smaller utilities are not available; and it does not include long-term debt obligations. Communities can, however, make some adjustments to the EPA guidelines to better reflect local conditions. In 2002, the Environmental Economics Advisory Committee of the EPA Science Advisory Board (SAB) reviewed the water affordability criteria.¹⁵ While SAB found the EPA approach to be efficient and practicable, the review also noted the method's limitations.¹⁶ Recommendations include:

12 American Water Works Association. (2014). *Thinking outside the bill: a utility managers guide to assisting low-income water customers (2nd ed.)*. Denver, CO.

13 American Water Works Association. (2017). *Principles of water rates fees and charges: manual of water supply practices M1 (7th ed.)*. S.I.

14 Rubin's criticisms include: 1) low correlation between median household income and measures of poverty, and 2) water costs should not be considered in isolation, but rather, as part of an overall household bundle of goods and services. Rubin, S. National Rural Water Association. (2001). *Affordability of Water Service*. Duncan, OK: U.S.

15 U.S. Environmental Protection Agency, Office of the Administrator, Science Advisory Board. (2002). *Affordability criteria for small drinking water systems: an EPA Science Advisory Board report*. Washington, D.C. Noting the fact that the variance rule has never been triggered may mean the threshold is too high.

16 From an economic viewpoint, this comes down to an issue of property rights. EPA (2002)—See *Previous Note*.

- › Consider system consolidation options to take advantage of cost efficiencies of scale.
- › Consider measures other than median income to more accurately reflect disadvantaged or poor households.
- › Consider use of a threshold lower than 2.5%. Three options are:
 - » Keep the EPA formula, but use a lower income percentile (10th or 25th).
 - » Consider whether a certain percentage of small systems (10 or 25%) fall below the affordability threshold and allow those communities to apply for variances.
 - » Base the threshold on a measure of dispersion (such as standard deviation).

The committee noted that the impact of reducing the income threshold may also reduce water service levels, resulting in higher morbidity and mortality (via reduced water quality).¹⁷ The committee concluded that the EPA water affordability criteria work as a screening tool, but that final decisions regarding compliance technology affordability should be made at the regional or local level, due to the heterogeneity of small systems across the U.S.

In 2007, the Environmental Finance Advisory Board (EFAB) provided comments to EPA on FCM, recommending improvements to both RI and FCI.¹⁸ For RI, EFAB recommended that rather than using costs, household expenditures (calculated as actual rate structures at an average consumption level of 5,000 to 6,000 gallons monthly) should be used. If, however, costs continue to be used instead of household expenditures, EFAB recommended expanding the definition of costs to include full service provision costs, and use of a composite RI that also considers costs by income quintile. The advisory board suggested that debt metrics beyond bond rating be considered for FCI, including collection rate and bad debt ratio at the utility level, instead of property taxes. Finally, EFAB noted that EPA needs to coordinate its multiple affordability policies (CSO, Small Drinking Water, Drinking Water SRF and Clean Water SRF).

The Environmental Protection Agency (2014), attempting to improve on FCM, developed the Financial Capability Assessment Framework. One suggestion to improve the RI variables was to include not only sanitary sewer overflow and CSO control costs, but also stormwater control costs. While the framework ultimately retained the core 1997 guidance on water affordability metrics, communities were

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17 This occurs when the median households would have been willing to pay for a higher level of water quality, and variances defer implementation of clean water technologies. The committee recommends that a calculation of cost-effectiveness of the 2.5% affordability threshold be compared to those in other public sector goods (transportation safety policy, for example) to make the affordability threshold less arbitrary.

18 U.S. Environmental Protection Agency, Environmental Financial Advisory Board. (2007). *Analysis and recommendations on: Combined sewer overflows: guidance for financial capability assessment and schedule development*. Washington, D.C.

encouraged to submit additional metrics in their financial capability assessment, including for both RI and FCI (see Table 9 for a complete list). According to the National Academy of Public Administration, concerns over changing the financial capability assessment framework included that: by increasing the data collection and analysis burden, smaller utilities are disadvantaged relative to larger ones; the EPA workload to negotiate current consent decrees is increased; and CSO controls already passed into law need statutory amendments.¹⁹

The Environmental Financial Advisory Board (2014), in reviewing the 2014 framework, made several recommendations.²⁰ For the RI analysis, the board recommended that EPA: include cost of living and income-based transfer payments; include all water charges (wastewater, drinking water, stormwater), other utility charges, and other dedicated expenditures; account for the housing cost burden; and consider impacts on non-residential water users. For the FCI analysis, the board recommended focusing on utility, rather than community metrics, and taking a more expansive view of financial health.

A brief prepared by the U.S. Conference of Mayors, American Water Works Association (AWWA), and Water Environment Federation provides an overview of EPA's guidance for determining the affordability of CWA and SDWA regulations, a critique of this method, suggestions, and a tool for calculating alternative water affordability measures.²¹ Suggested improvements to the RI measure include examining income quintiles, household types, smaller geographic units, poverty measures, and other economic indicators (unemployment, households on public assistance, households meeting Home Energy Assistance program requirements, customers eligible for water affordability assistance programs, households with high housing costs, and other household expenditure burdens). Recommended actions to improve FCI measures include: consider gross taxable resources (rather than just property); expand the unemployment measure; consider declines in community revenues; and account for trends in long-term liabilities (such as pensions).

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19 Czerwinski, S.J., Fretwell, E., Fosler, R. S., Lindsey, G., & Pagan, M.A. (October 2017). *Developing a new framework for community affordability of clean water services: Report by a panel of the National Academy of Public Administration for the Environmental Protection Agency.*

20 U.S. Environmental Protection Agency, Environmental Financial Advisory Board. (2014). *Analysis and recommendations on: Draft financial capability assessment framework.* Washington, D.C. Retrieved from https://www.epa.gov/sites/production/files/2014-10/documents/financial_capability_assessment_framework.pdf

For example, the AR-20 method used in Davis, J. P., & Teodoro, M. P. (2014). *Financial capability and affordability.* In *Water and wastewater financing and pricing* (4th ed., pp. 443–465). Boca Raton, LA: CRC Press. doi: <https://doi.org/10.1201/b17255>

21 U.S. Conference of Mayors, American Water Works Association, & Water Environment Federation. (2013). *Assessing the affordability of federal water mandates: An issue brief.* Retrieved from <https://www.awwa.org/Portals/O/awwa/government/Affordability-IssueBrief.pdf>

The National Association of Clean Water Agencies (NACWA) (2013) also argued for reform of FCM.²² After critiquing the FCM method, NACWA presents an integrated planning-based FCA framework. It includes three improvements to the EPA framework—water quality project prioritization, cash-flow forecasting, and burden analysis. The water quality prioritization calls for including a greater range of costs and benefits in project evaluation; the cash-flow forecasting suggests using historic and projected data; and the burden analysis recommends that group incomes (low-income for example) be considered.

The Pacific Institute (2013) examined several alternative affordability measures using data from two regions in California.²³ The first affordability measure used by Pacific Institute is called the Percent of Median Household Income plus Water Replacement Cost, Water System Scale. This measure considers not only the monthly water bill, but also any averting expenditure household purchases of bottled or vended water.²⁴ A second measure used by Pacific Institute is called the Percent Median Income, Census Block Group Scale. This measure uses census block group level data to disaggregate household water bills and median household income at the census block group scale. A third alternative used by Pacific Institute for measuring water affordability is called the Number of Households that Spend More than 2% of Annual Income on Drinking Water Services. This measure uses data from the five-year American Community Survey (ACS) on the number of households in income brackets (to estimate the number of households), then divides the estimated household water bills for an average amount of water use by 2% (to determine the income threshold at which water bills were exactly 2% of household income). A fourth water affordability measure used by Pacific Institute is called the Number of Households that Spend More than 2% of Annual Income on Drinking Water Service Plus Replacement Cost. The study concluded that the geographic scale used to measure income in the affordability metric matters; although performing the water affordability assessment at varying scales requires geospatial matching of census tract data to water service areas.²⁵ The study did not consider wastewater costs or

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22 National Association of Clean Water Agencies. (2013). *The evolving landscape for financial capability assessment Clean Water Act negotiations and the opportunities of integrated planning*. Retrieved from <https://www.nacwa.org/docs/default-source/news-publications/White-Papers/2013-05-31affordability-whitepaper.pdf?sfvrsn=2>

23 Christian-Smith, J., Balazs, C., Heberger, M., & Longley, K. (2013). *Assessing water affordability: A pilot study in two regions of California*. Pacific Institute. Retrieved from <https://pacinst.org/wp-content/uploads/2013/08/assessing-water-affordability-1.pdf>

24 These averting expenditures occur when households perceive the municipal water supply to not be safe, and replace consumption of municipal water with purchased bottled or vended water. Using data from California, the researchers found the average household replacement cost is \$28.91.

25 Due to spatial mismatch between census tracts and service areas, population weighting was used to estimate the number of households in each income rate. This was accomplished by: 1) joining the ACS data to the census block group GIS layer using block group FIPS as the ID, 2) Disaggregating median household income by census block group, 3) intersecting census block groups and water service area boundaries to calculate the percent of each block group intersecting the water system service area, and 4) calculating population-weighted average for the water system.

ability-to-finance measures.

In 2016, the Senate Appropriations Committee directed EPA to work with the National Academy of Public Administration (NAPA) to update how the agency conducts analysis of community water affordability.²⁶ The academy used existing EPA affordability guidelines as the baseline for their analysis, conducting a comprehensive literature review as well as stakeholder interviews and surveys, which yielded 22 recommendations.²⁷ Key recommendations related to improving the RI criteria were to include all water costs, use low rather than median household income, determine the systems proportion of vulnerable users, and avoid arbitrary thresholds. To improve the FCI criteria, NAPA suggested focusing on operational efficiency, debt burden, and managerial effectiveness, and expanding socioeconomic components.

Mumm (2017) critiqued FCM and presented results from a case study in Omaha, Nebraska that used the Weighted Average Residential Index developed by Stantec.²⁸ This measure examines income by census tract and by income level. Billing data helps determine water bills by census tract, while U.S. Census data on 16 income ranges is used to examine burden by different income levels. The number of households for each income range is inferred for each census tract from U.S. Census data. Finally, the weighted average for each census tract and for the entire service area is calculated. The study concluded that this method helps water providers better understand the geography of affordability and where to target customer assistance programs. Hughes (2014) noted that the distribution of poverty may not be consistent throughout the census tract and so this method may still mask households facing affordability issues in census tracts.

Irvin (2017) critiqued FCM, noting that using MHI masks the actual affordability burden of low-income households.²⁹ Irvin recommended using either the AWWA guideline on the 20th percentile of income

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26 Czerwinski, S.J., Fretwell, E., Fosler, R. S., Lindsey, G., & Pagan, M.A. (October 2017). *Developing a new framework for community affordability of clean water services: Report by a panel of the National Academy of Public Administration for the Environmental Protection Agency.*

27 Economics and Statistical Analysis Branch, Office of Science and Technology, Office of Water (1995). *Interim economic guidance for water quality standards: workbook, Interim economic guidance for water quality standards: workbook.* Washington, D.C.

- *Combined sewer overflows: guidance for financial capability assessment and schedule development.* (1997).
- *Integrated Municipal Stormwater and Wastewater Planning Approach Framework.* (May 2012).
- *Financial Capability Assessment Framework for Municipal Clean Water Act Requirements.* (November 2014).

28 Mumm, J., Theiler, J., Baker, A., & Malesky, C. (2017). Enhanced affordability analysis of combined sewer overflow long-term control plans—Omaha’s CSO! Program. *Proceedings of the Water Environment Federation*, 2017(2), 862–868. doi: 10.2175/193864717821495203

29 Irvin, D. (2017, August 31). *Is Percent MHI the Best Way to Measure Affordability?* Retrieved from <http://efc.web.unc.edu/2017/08/31/percent-mhi-best-way-measure-affordability/>

as an alternative measurement, or the federal poverty threshold. Irvin illustrated this poverty threshold measurement by conducting an analysis of 3,428 households, using pricing data, assuming a water consumption level of 5,000 gallons, and \$24,600 income, which represents the poverty guideline for a household family of four. He compared the MHI water affordability measure to the poverty line water affordability measure, concluding that MHI misstates water affordability.

Teodoro (2018) criticized the FCM water affordability measure and introduced two alternative water affordability measurements.³⁰ The first alternative metric is the Affordability Ratio (AR), which takes the ratio of the household combined water and sewer bill to disposable income for low-income customers (20th percentile). Teodoro conducted a regression analysis to estimate essential household expenditures in the disposable income calculation. The second alternative metric is the Hours of Labor at Minimum Wage, calculated as the ratio of the household combined water and sewer bill to the minimum wage.

The National Consumer Law Center (2014) recommended considering the customer's ability to pay both the current bill, as well as past due bills and the cost to reconnect when water or sewer services are terminated, as well as considering the rates of disconnection and reconnection.³¹ Aqua Publica suggested tracking consumers that are behind in payments, for example, customers failing to pay their water bill after a second notice reminder, as a ratio to the total number amount of consumers.³² Secondly, the group suggested directly surveying customers to ascertain what they consider unaffordable. The third recommendation was to distinguish customers who are in economic hardship—unable to pay the water utility—as opposed to those that choose not to continue paying the bill.

Rockowitz, et al. (2018) surveyed a sample of 413 low-income households in the Detroit metropolitan area.³³ The survey included 35 questions, concentrating on three main themes: low-income customers' experiences with water accessibility, water and sewer billing, and water shut-offs. Respondents were also asked to estimate what they believed they could afford to pay for water. According to the survey, respondents were currently spending 10% of their monthly household income on water bills. Survey respondents indicated they could afford to pay 7% of their income on water, two-thirds of what they were

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30 Teodoro, M. P. (2018). Measuring household affordability for water and sewer utilities. *Journal - AWWA*, 110(1), 13–24. doi: 10.5942/jawwa.2018.110.0002

31 Wong, D. R. (2014). *Review and recommendations for implementing water and wastewater affordability programs in the United States*. Boston, MA: National Consumer Law Center.

32 European Association of Public Water Operators. (2016). *Water affordability: Public operators' views and approaches on tackling water poverty*. Retrieved from https://www.aquapublica.eu/sites/default/files/document/file/ape_water_affordability_final_0.pdf

33 Rockowitz, D., Askew-Merwin, C., Sahai, M., Markley, K., Kay, C., & Reames, T. (2018). *Household Water Security in Metropolitan Detroit: Measuring the Affordability Gap*. Retrieved September 13, 2018, from <https://poverty.umich.edu/10/files/2018/08/PovertySolutions-PolicyBrief-0818-r2.pdf>

paying. This water affordability gap was measured using survey responses and comparing them with the federal standard of 4.5% of monthly household income, resulting in an estimate of a water affordability gap of \$45.08. According to the survey, 94.3% of low-income customers cut back on other essential household expenses (rent, transportation, medical care, fresh produce, or school supplies, for example) to better afford their water bill. The survey found that 80% of respondents received some form of customer assistance to pay for their water, but still paid more than the EPA water affordability threshold of 4.5% of their income. That is, even with the assistance, water customers were still not within the EPA water affordability guidelines.

A summary of water affordability analysis methods and data is provided in Table 9. At the time of this writing, the EPA water affordability guidelines are being revisited.³⁴

Conclusion

United Nations Resolution 64/292 recognized clean drinking water as a human right, but did not offer a definition of, or method of measuring, water affordability.³⁵ The National Coalition for Legislation on Water Affordability defined water affordability as the cost of provision that does not impede people from meeting other basic needs or human rights.³⁶ There is, however, currently no one generally accepted definition of water affordability. It varies depending on the purpose of the water affordability assessment: at the federal level it is used to evaluate the impact of CWA or SDWA regulations to address CSO issues; at the state level, it is used to administer grant programs such as SRF or USDA, and to calculate which water systems should receive funds; and at the local level, it is used to design community-specific CAPs to address what should be done in a community when households cannot pay their bills.

While the EPA measurement of water affordability has been widely criticized, it continues to be broadly used and accepted, in both its original form (water bills as a percentage of MHI) and with variations (such as using income quintiles, income by census tract, disposable income instead of MHI). Affordability researchers generally agree that no one single metric can or should be used in measuring water affordability, rather, a variety of quantitative and qualitative data should be

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34 Raucher, R., Clements, J., Rothstein, E., Mastracchio, J., & Green, Z. (2019). *Developing a new framework for household affordability and financial capability assessment in the water sector*. Report prepared for The American Water Works Association, National Association of Clean Water Agencies, and Water Environment Federation.

35 Hughes, J. (2014). *Defining a resilient business model for water utilities*. Denver, CO: Water Research Foundation.

36 National Coalition for Legislation on Affordable Water. (n.d.). Retrieved from <http://affordablewaternow.org/>

considered. The proposed, but not passed, Water Resources Development Act of 2016 (S. 2848 (114th)) defined affordability as “whether an individual customer or household can pay the bill without undue hardship or unreasonable sacrifice in the essential lifestyle of spending patterns of the individual or household.” Local economic conditions, essential community investments, percent of low-income households in the service area, the impact of rate increases from infrastructure investments on low-income customers, and other factors should be considered in making an affordability determination.³⁷ It seems clear, therefore, that water affordability measures need to be expanded beyond the EPA metric to be meaningful at the local or community level.

Table 9: Summary of Affordability Analysis Methods and Data

Data	Data Source	Notes/supplemental metrics
EPA (1997)		
$\text{Residential Indicator} = \frac{\text{Annual Wastewater and CSO Control Costs per Household}}{\text{Annual Median Household Income}} \times 100$		
Wastewater and CSO Control Costs	Water utility financial reports	Affordability threshold is 2%
Median Household Income	U.S. Census Bureau ACS	
Financial Capability Indicator (FCI)		
Debt Indicators <ul style="list-style-type: none"> Bond rating Overall net debt as a percent of full market property values 	Municipal bond reports from rating agencies Municipal financial statements (state auditor’s office) State assessor’s office	Net debt to property values: comparison of debt level to real property value available to support debt
Socioeconomic Indicators <ul style="list-style-type: none"> Unemployment rate Median household income 	Bureau of Labor Statistics U.S. Census Bureau ACS	
Financial Management Indicators <ul style="list-style-type: none"> Property tax burden Property tax collection rate 	State assessor’s office Community financial statements Levied property taxes—assessed value times property tax rate Property tax revenues—annual community financial statements	Property tax revenues as a percent of full market property value

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 37 Water Resources Development Act of 2016 (2016 - S. 2848). (n.d.). Retrieved from <https://www.govtrack.us/congress/bills/114/s2848>

EPA (1998)		
$\text{Affordability Threshold} = \frac{\text{Total Annual User Charges}}{\text{Annual Median Household Income}} \times 100$		
Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = monthly bill for average water use * 12 = (monthly base charge + average monthly consumption (unit charge))*12. Supplemental metric: include com- bined water and wastewater bill
Monthly water consumption	Assumed value—consult expert or local knowledge on average use	
Median household income	U.S. Census Bureau ACS	Affordability threshold is 2% and using alternate income measures in the denominator (mean income, poverty level income). The ratio can also be considered in the context of other community socio-economic measures (poverty rate, unemploy- ment, etc).
Financial Capability Indicator		
Ratio of revenues to expenditures Ratio of net income to revenues Ration of assets to liabilities Debt-service coverage Composite financial health indicator	Community and utility financial statements U.S Census Bureau of Labor Statistics	See Table 5.
EFAB (2007)		
$\text{Residential Indicator} = \frac{\text{Full Cost of Water}}{\text{Income by Quintile \& by Poverty Rate}} \times 100$		
Full water costs	Water utility financial reports Capital improvement plans	Supplemental metrics: projected water costs and income; poverty rate and Income distribution
Income by quintile Poverty rate	U.S. Census Bureau ACS	
Financial Capability Indicator		
Utility bill collection rate Bad debt ratio	Water utility financial records	Collect information at the utility level instead of property tax or bonding information.

EPA (2014)

$$\text{Residential Indicator} = \frac{\text{SSO,CSO Control Costs and Stormwater Costs per Household}}{\text{Annual Median Household Income}} \times 100$$

SSO, CSO, Stormwater Control Costs	Water utility financial records	Affordability threshold is 2% Supplemental metrics:
Median household income	U.S. Census Bureau ACS	<ul style="list-style-type: none"> • Disaggregate income (quintile, geography or other) • Income distribution that determined low income rate structures • Poverty rates and trends • Water rates (sewer, and storm-water fees) as a percent of disaggregate income measure, over time • Water use disaggregated by socio-economic factor (customer classes, type of dwelling unit) • Percent of households who own versus rent
Financial Capability Indicator (FCI)		
See EPA (1997)	See EPA (1997)	Supplemental metrics: <ul style="list-style-type: none"> • Population trends and projections • Unemployment data and other labor market indicators • Rate or revenue models • Rate studies • Data on late payments, disconnection notices, service terminations, uncollectable accounts, or revenue collection rates • Historic rates increases and other sources of revenue • State or local legal restrictions on property taxes, other revenue, debt levels • Other financial obligations • Factors affecting bond rating • Financial plans and financial metrics • Information on stressors (natural disasters, municipal bankruptcies, etc.)

EFAB (2014)

$$\text{Residential Indicator} = \frac{\text{Full Cost of Water}}{\text{Income by Quintile, Income by Census Tract}} \times 100$$

Full water costs	Water utility financial records Capital Improvement Plans	<p>Supplemental metrics:</p> <ul style="list-style-type: none"> • Historic trends and projections of costs and income • Poverty rate • Income distribution • Cost of living differences • Housing cost burden (renters, owners) • Non-residential user impacts
Income by quintile Poverty rate	U.S. Census Bureau ACS	
Income by census tract	U.S. Census Bureau ACS	
Financial Capability Indicator (FCI)		
<ul style="list-style-type: none"> • Days of cash on hand • Days of working capital • Debt ratio • Debt per customer • Total annual operating revenues • Number of customers • Top ten customers as percent of total revenue • Overall debt service coverage • Maximum annual debt service coverage • Combined average annual utility bill as percentage of MHI 	Water utility financial records	<p>Notes and supplemental metrics:</p> <ul style="list-style-type: none"> • Bond ratings should not be used as many smaller systems do not have bond ratings. • Unemployment rate: Analyze on an absolute rather than relative basis. • Overall net debt should also include system revenue debt and other debt (unfunded pension liabilities, etc.). • Consider the systems revenue collection rate. • Include wage taxes, sales taxes, as well as all utility system user charges. • Include extraordinary considerations (municipal bankruptcies, natural disasters, etc.). • Include broader list of water and wastewater capital investment requirements.

USCM/AWWA/WEF (2013)

$$\text{Household Affordability Ratio (Percent)} = \frac{\text{Total Annual User Charges for Drinking Water}}{\text{Average Household Income of disaggregate group}} \times 100$$

Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	<p>Calculation of annual user charges (water bills) = monthly bill for average water use * 12 = (monthly base charge + average monthly consumption (unit charge))*12</p> <p>Supplemental metric: include combined water and wastewater bill</p> <p>Supplemental metrics:</p> <ul style="list-style-type: none"> • Non-discretionary expenses as % of income by quintile • Poverty rate, supplemental poverty measures • High housing cost burden • Percentage of the population eligible for the Low Income Home Energy Assistance
Monthly water consumption	Assumed value: can consult expert or local knowledge on average use	
Income by quintile Income for poor, elderly, or renters Income for poor areas	U.S. Census Bureau ACS	
Financial Capability Indicator		
<ul style="list-style-type: none"> • Local revenue trends • Total long term debt obligations (as a percent of total property value) • Legal debt ceiling • Measures of revenue collection (such as current delinquency rates, the agency's ability to enforce collection, and likelihood of recovering these costs) • Socio-economics (unemployment, poverty, high housing costs) 		

NACWA (2013)		
$\text{Household Affordability Ratio (Percent)} = \frac{\text{Projected Water Bill}}{\text{Income by Quintile}} \times 100$		
Projected water bill	Utility financial forecasts	Supplemental metrics: burden on sub-populations
Income by quintile	U.S. Census Bureau ACS	
Financial Capability Indicator		
Forecasted revenue and costs Projected new revenue and debt service Historic trends in late accounts Income distribution Trends in poverty and unemployment		
Pacific Institute (2013)		
$\text{Household Affordability Ratio (Percent)} = \frac{(\text{Monthly bill for average water use+replacement costs}) \times (12)}{\text{Median Household Income of All Customers}} \times 100$		
Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = Monthly bill for average water use * 12 = (Monthly Base Charge + Average Monthly Consumption (Unit Charge))*12.
Monthly water consumption	Assumed value	
Expenditures per month for replacement water supplies	Previous research studies (Moore, et al 2011)	Note: replacement costs are assumed
Median household income	U.S. Census Bureau ACS	
$\text{Household Affordability Ratio (Percent)} = \frac{(\text{Monthly bill for average water use}) \times (12)}{\text{Median Household Income of Block group}} \times 100$		
Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = Monthly bill for average water use *12 = (Monthly Base Charge + Average Monthly Consumption (Unit Charge))*12.
Monthly water consumption	Assumed value	
Median household income by block group	U.S. Census Bureau ACS	
Census block group boundaries	U.S. Census Bureau ACS	
Water system boundaries	Water utility staff, previous studies (Provost and Pritchard 2013)	Because census block groups and water service areas do not typically have the same boundaries, it is necessary to perform spatial weighting to assign ACS data to the water system.

$\text{Household Affordability Ratio (Percent)} = \frac{(\text{Monthly bill for average water use}) * (12)}{2\%} \times 100$		
Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = Monthly bill for average water use * 12 = (Monthly Base Charge + Average Monthly Consumption (Unit Charge))*12.
Monthly water consumption	Assumed value	
Number of households in a block group that fall within income ranges	ACS 5-year estimates (2007–11)	“Household income data” is proxied by the ACS counts of households in income ranges (up to \$10,000; \$10,000–\$15,000; etc.). The RI is compared to each income range to determine the number of households that spend more than 2% of annual income on water service.
Census block group boundaries	U.S. Census Bureau ACS	
Water system boundaries	Water utility staff, previous studies (Provost and Pritchard 2013)	Because census block groups and water service areas do not typically have the same boundary, it is necessary to perform spatial weighting to assign ACS data to the water system.
$\text{Household Affordability Ratio (Percent)} = \frac{\text{Monthly bill for average water use+replacement costs} * (12)}{2\%} \times 100$		
Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = Monthly bill for average water use * 12 = (Monthly Base Charge + Average Monthly Consumption (Unit Charge))*12.
Monthly water consumption	Assumed value	
Expenditures per month for replacement water supplies	Previous research studies (Moore, et al 2011)	Note: replacement costs are assumed
Number of households in a block group that fall within income ranges	ACS 5-year estimates (2007–11)	“Household income data” is proxied by the ACS counts of households in income ranges (up to \$10,000; \$10,000–\$15,000; etc.). The RI is compared to each income range to determine the number of households that spend more than 2% of annual income on water service
Census block group boundaries	U.S. Census Bureau ACS	
Water system boundaries	Water utility staff, previous studies (Provost and Pritchard 2013)	Because census block groups and water service areas do not typically have the same boundaries, it is necessary to perform spatial weighting to assign ACS data to the water system.

Mumm (2017)

$$\text{Household Affordability Ratio (Percent)} = \frac{\text{Average Water Bill by Census Tract}}{\text{Income by Census Tract, by range}} \times 100$$

Note: Once the calculation is completed by each income range, the weighted average for the entire census tract is calculated; once the calculation is completed for each census tract, the weighted average for the entire service area is calculated.

Water bills	Water Utility Billing Data	
Number of households in a block Group that fall within income ranges	ACS 5-year estimates (2007–11)	Midpoint of ACS counts of households in income ranges (up to \$10,000; \$10,000-\$15,000; etc.) is used.
Income	U.S. Census Bureau ACS	

Irvin, D. (2017)

$$\text{Household Affordability Ratio (Percent)} = \frac{\text{Monthly bill for average water use}*(12)}{\text{Poverty Line Annual Income}} \times 100$$

Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	Calculation of annual user charges (water bills) = Monthly bill for average water use * 12 = (monthly base charge + average monthly consumption (unit charge))*12
Monthly water consumption	Assumed value	
Poverty thresholds	U.S. Department of Health & Human Services https://aspe.hhs.gov/poverty-guidelines	

Teodoro, M. (2018)

$$\text{Household Affordability Ratio (Percent)} = \frac{\text{Household Combined Water and Sewer Bill}}{\text{Disposable Income}} \times 100$$

Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances 5/8 meter assumed	CAP program impacts not included.
Monthly water consumption	Assumed value, per capita (50 gpcd)	
Number of people per household	Assumed to be 4	
Income	U.S. Census Bureau ACS	
Essential expenses	Bureau of Labor Statistics 2015 Consumer Expenditure Survey Regression-based estimates— variables included in the regression: household size, single family home, education (high school graduate, college graduate), married, race, income, homeowner, urban.	Less water and sewer expenses; includes taxes, housing, food, medicine, health care, home energy If the utility lacks the expertise to do regression analysis, local data or knowledge can be used.
Disposable income	Calculated	Income less essential expenditures

$$\text{Hours of Labor at Minimum Wage (HM)} = \frac{\text{Household Combined Water and Sewer Bill}}{\text{Minimum wage}}$$

Water rates (monthly base charge, unit charge)	State regulatory commissions, water utilities, ordinances	
Monthly water consumption	Assumed value	
Minimum wage	Bureau of Labor Statistics	

Rockowitz, et al. (2018)

Self-assessed ability to pay	Survey of utility customers	
Water affordability gap	Survey of utility customers	Calculated as the difference between the current bill and what the bill would be if the federal standard of 4.5% of monthly's household income was met

