Appendix B – Supporting Information

Residential Indoor

Table A1. Current Federal, State, and Efficiency Scenario Residential Indoor Fixture Standards.

Jurisdiction/Scenario	Private Use Bathroom Faucet (gallons per minute)	Toilet (gallons per flush)	Showerhead (gallons per minute)
Federal	2.2	1.6	2.5
WaterSense	1.5[1]	1.28	2.0
Leading Edge	0.8	0.79	1.0
California	1.2	1.28	1.8
Colorado	1.5	1.28	2.0
Georgia	1.5	1.28	Federal
Hawaii	1.2	Federal	1.8
Illinois	1.5	1.28	2.0
Maine	1.2	1.28	1.8
Maryland	1.5	1.28	2.0
Massachusetts	1.5	1.28	2.0
Nevada	1.5	1.28	2.0
New Jersey	1.5	1.28	2.0
New York	1.2	1.28	1.8
Oregon	1.2	Federal	1.8
Rhode Island	1.5	1.28	2.0
Texas	Federal	1.28	Federal
Utah	1.5	Federal	2.0
Vermont	1.5	Federal	2.0
Washington	1.2	1.28	1.8
Washington D.C.	1.5	1.28	2.0

[1] In December 2024, the EPA proposed to modify the water efficiency criteria for residential bathroom faucets from 1.5 to 1.2 gpm (https://www.epa.gov/watersense/bathroom-faucets).

Table A2. Current Department of Energy Standards with Manufactured On or After Dates for Residential Clothes Washers and Dishwashers.

Dishwasher	May 30, 2013 (GPC)	April 23, 2027 (GPC)	Clothes Washer	January 1, 2018 (IWF)	March 1, 2028 (WER)
Standard	5.0	3.3	Top-loading, compact	12.0	0.29
Compact size	3.5	3.1	Top-loading, standard	6.5	0.57
			Front-loading, compact	8.3	0.71
			Front-loading, standard	4.7	0.77

In each scenario, fixture performance was converted to end-use GPCD values using fixture use rates and durations, derived from Flume data. End-use GPCD values, for each efficiency scenario, were then scaled across households for the same geographies used to develop current-day water demand estimates to obtain a statewide estimate of total efficiency savings. Existing levels of efficiency in various geographies were considered by only applying efficiency scenarios to geographies with average fixture performance exceeding the corresponding fixture performance for each efficiency scenario. Figure A2 shows the comparison of end-use performance between the median of current-day water demand estimates and the three efficiency scenarios, by end-use. We assumed a threshold of less than 100 gallons per household per day to evaluate low flow leaks, or the leakage volume attributed to persistent and/or recurring leaks and not including large volume intermittent leak events, in accordance with previous research (DeOreo et al. 2016).

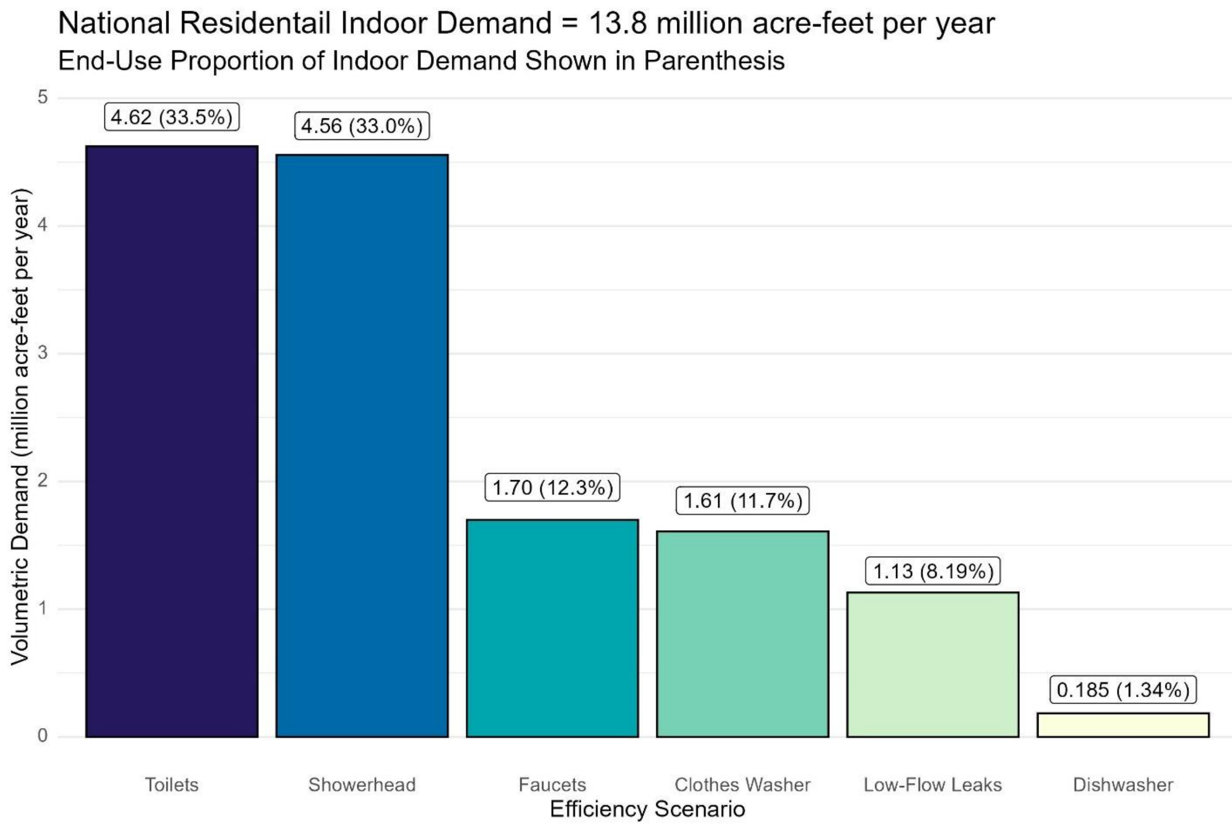

Figure A1. National Baseline Residential Indoor Volumetric Demands by End-Use, with Proportion of Total Indoor Demand for Each End-Use Shown in Parentheses.

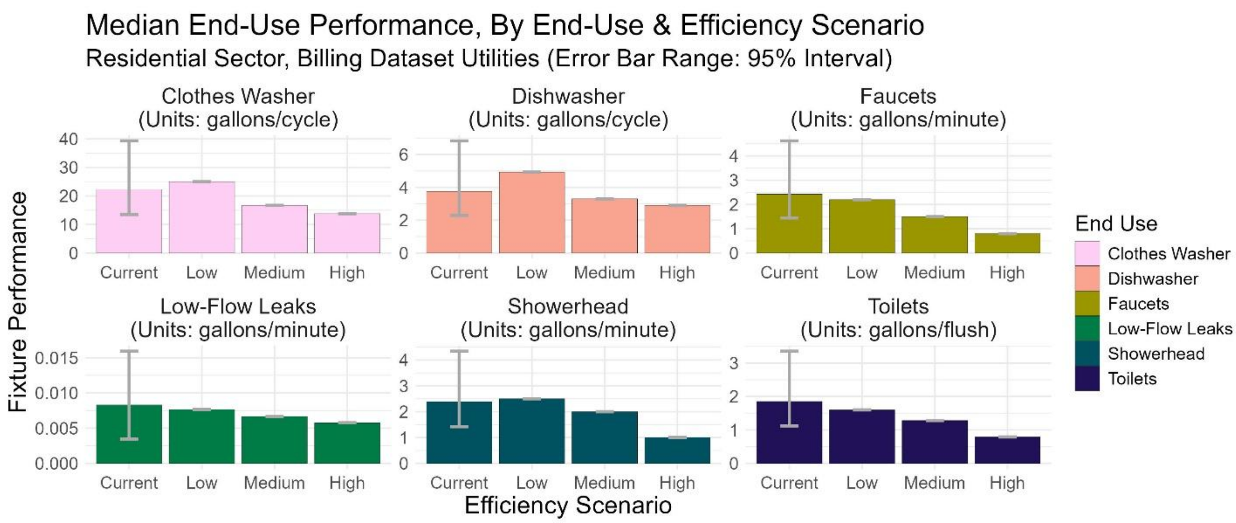

Figure A2. Comparison of end-use performance for median current-day water demand estimate and efficiency scenarios, by end-use.
Note: Error bars for the Baseline scenario indicate the 95% interval of estimated values across geographies.

Residential Outdoor

For a warm-season turf grass landscape, an ETAF of 1.0 represents an average irrigation system efficiency of 60% or an outdoor water use volume that is equal to the average monthly ET_{net} of the landscape (a cool-season turf grass landscape with the same distribution uniformity and water demands, would have an ETAF of 1.33). This relationship is shown in Eq. 1 , which we used to define the current-day and efficiency scenario ETAF values that would drive water use savings.

$ETF_{geo} = \frac{D_{actual}}{D_{required}} = \frac{D_{actual}}{ET_{net} * LA * \left(\frac{PF}{IE}\right) 0.623}$	Eq. 1

where,

- ETF_{geo} is the monthly ET Adjustment Factor for the geography of interest
- D_{actual} is observed monthly outdoor water demands, in gallons
- $D_{required}$ is the estimated supplement water needs of the landscape, in gallons
- ET_{net} is the net evapotranspiration (difference of potential evapotranspiration and precipitation)
- LA is the total landscape area, in square feet
- PF = Landscape Plant Factor, or the area-weighted average Plant Factor of landscape plantings
- IE = Irrigation system efficiency, as percentage
- 0.623 is a factor to convert into gallons

To estimate the resulting efficiency savings produced by each scenario, we re-arranged Eq. 1 in conjunction with the scenario ETAF value and assumed no changes to landscape area, to estimate the resulting outdoor water use volume and compared these volumes to their corresponding current-day outdoor water demand estimates. We first estimated the average and total single-family landscape area using data from the 2019, 2021, and 2023 American Housing Surveys (AHS), reported household landscape area from the Flume dataset, and additional sources with state-level estimates of average lot size (U.S. Census Bureau 2020; 2022; 2024; Flume Data Labs 2024; Pacheco 2022; Wasson 2024). Following the assumption used in the Flume Dataset, which was informed by landscape area to lot size statistics collected by Flume, we assume that the average ratio of irrigated landscape area to total lot area is approximately 40% (Flume Data Labs 2024).

We followed the same geospatial aggregation approach that was used to estimate current-day water demand, starting first with CBSAs in the AHS data, then the Flume Dataset for additional CBSAs not found in the AHS data, and an average of the state-level index values in areas for state-level remainders and CBSAs where AHS and Flume data were not available. Figure A3 shows the comparison of relevant landscape variables, broken out by geographic scale, for reference.

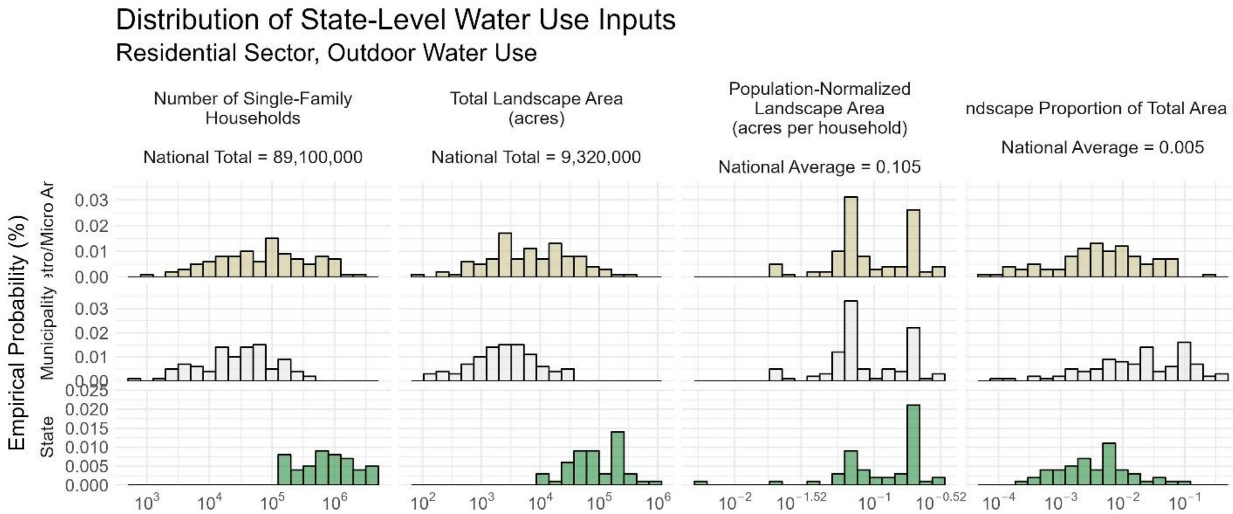

Figure A3. Summary of Residential Landscape Characteristics and Inputs, By Scale of Geography Used in Analysis

To facilitate the analysis, we assumed that outdoor water use occurs solely on single-family landscapes, and these landscapes are comprised of cool- and/or warm- season turf grass. We used the Oregon State University PRISM Climate Group's Plant Hardiness Zone map overlaid with Turf Grass Climate Region data to inform the appropriate season turf at the US Zip Code level and assigned corresponding monthly turf grass plant coefficients at this scale (USDA et al. 2023; Harivandi et al. 2009)[2]. By treating all existing landscapes as fully comprised of turf lawn as a simplifying assumption, our analysis does not account for communities with alternative plant selections or lack of landscaping overall. This assumption does not affect the interpretation of the efficiency potential presented in this report, since we do not report any household-level estimates. By aggregating results to the state and national levels, our estimates reflect average landscape efficiency performance and we assume savings are solely driven by changes to households with less water-efficient landscapes, as opposed to all households equally. In this fashion, the resulting landscape area and ETAF estimates should be interpreted in terms of "turf grass lawn-equivalents" which represent that amount of turf grass landscape that would produce equivalent current-day and efficiency scenario water use.

We then estimated the average monthly Net ET, using average historical monthly ET and precipitation data for years 1961 – 1990 provided the International Water Management Institute and summarized to the US Zip Code scale by the US EPA's WaterSense Program (IWMI 2024). We aggregated these average monthly net ET estimates to the appropriate corresponding analysis geography to estimate average monthly ETAF for the current-day period. With these estimates of outdoor water use, landscape characteristics, and net ET, we applied Eq. 1 to then estimate the current-day ETAF value for each analysis geography

[2] Plant Hardiness Zones 1 and 2 are considered too cold for reliable landscape growth and were not included in this analysis. Turf Grass Climate Zones were mapped to Plant Hardiness Zones based on visual inspection of maps for both data sources.

(net ET and effective plant factor derived from estimated outdoor water use are illustrated in Figure A4 for reference).

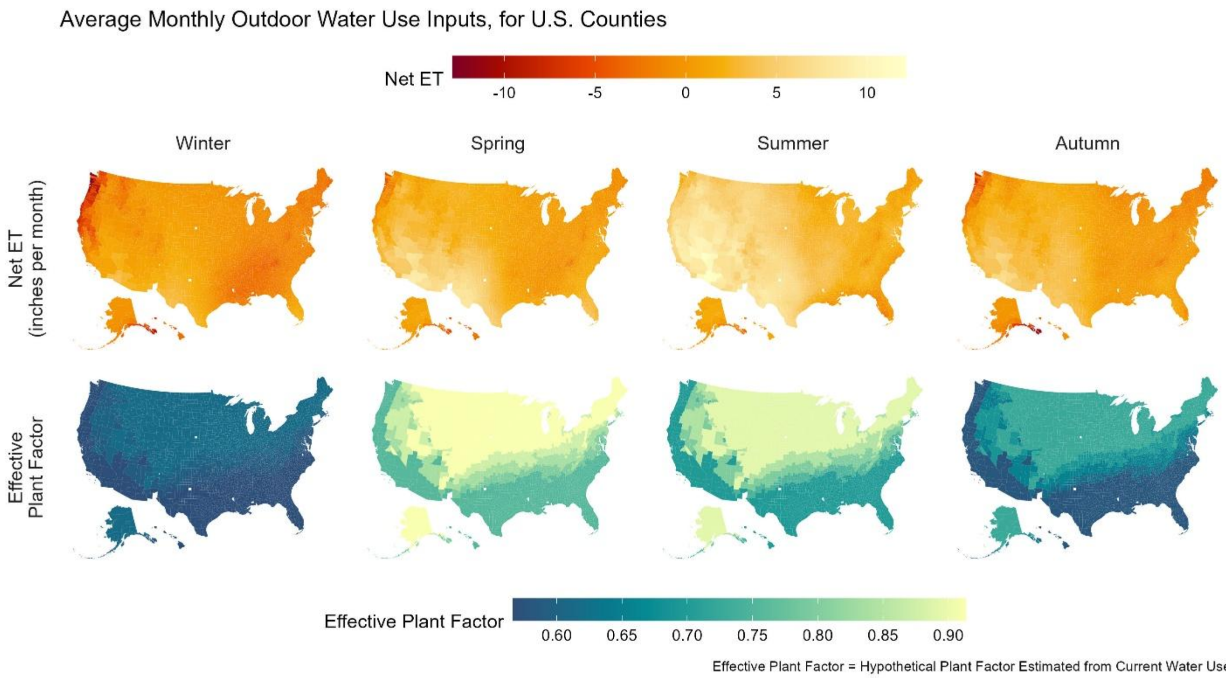

Figure A4. Outdoor Water Use Input Variables (Net ET and Effective Plant Factor) and Resulting Baseline ET Adjustment Factor by Zip Code, As Seasonal Averages.

We developed outdoor water efficiency scenarios to reflect increasingly aggressive but achievable ETAF values that could be achieved by adjusting one or more of: outdoor watering behaviors and/or aesthetic preferences, landscape plant factor (via alternate plant selection), and irrigation system efficiency (up to a maximum of 100%).

Commercial, Industrial, and Institutional

The CII sector does not exhibit the same regional clustering in WUI seen for Residential per capita demands. We find significant variability in WUI estimates across subsectors and across states (**Error! Reference source not found.** and Figure A5). The Food Service subsector has the highest WUI value across all states, though this sector is not the largest user of water (Figure A6). Conversely, we find that only 17 states have both the highest water demands and largest gross building floor area attributed to the same subsector. Further, we find that 24 states both have the highest water use and most employees are attributed to the same subsector.

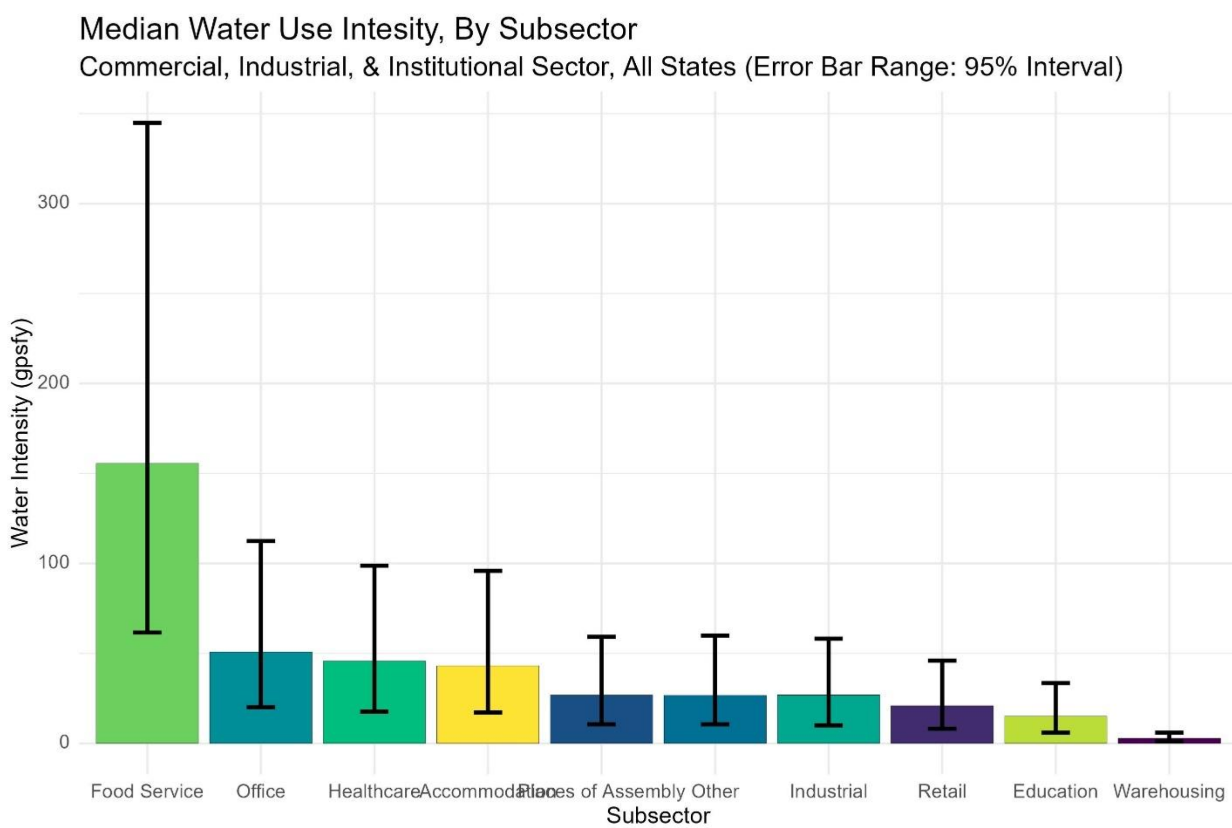

Figure A5. State-Level Current-Day Water Intensity Estimates as gallons per square foot per year (gpsfy), by Subsector.
Note: Chart columns represent median water intensity values across states with 95% range across states representated by error bars.

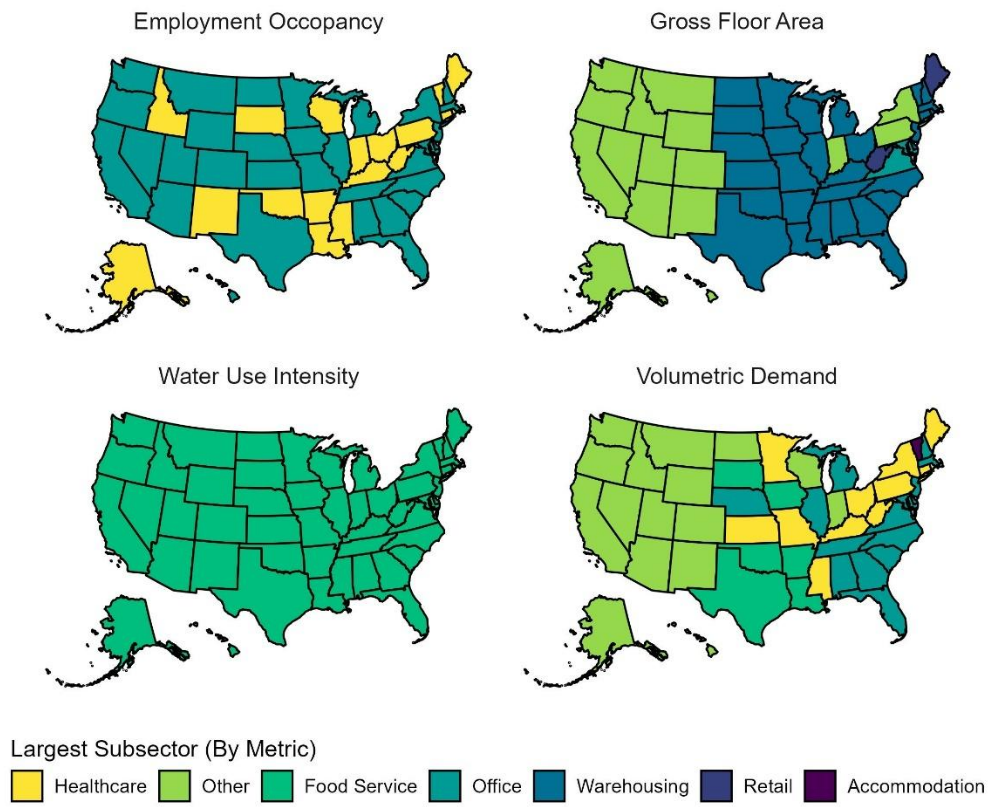

Figure A6. Predominant CII Subsector Within Each State, In Terms of CII Water Use Input Variables (Employment Occupancy, Gross Floor Area, Water Use Intensity, and Volumetric Demand).

These discrepancies of predominant subsector between water demand inputs and estimated water demand volumes, point to the complicated and highly variable nature of CII water use and could suggest that blanket approaches to improve CII water use efficiency might not be appropriate (also evidenced by the lack of comprehensive efforts to characterize and predict CII water use thus far). While our analysis is a useful first step in better understanding successful strategies for CII water efficiency that can be applied more broadly, there is a clear need for additional research to identify additional potential input variables (e.g. sales/production levels) and benchmarking metrics to evaluate and realize greater CII water use efficiency.

Utility Water Loss

For the distribution system losses, we relied on the Water Loss Dataset containing water loss audit data collected for over 4,000 water providers across the United States, across 15 states. The spatial coverage of the Water Loss dataset was limited to primarily southern and east coast states, with a large gap in state-level representation for the Mountain – West, Pacific-West, and the northern half of the Midwest Census Regions (**Error! Reference source not found.**). To overcome these data limitations, we assumed that state-level per capita estimates of current and unavoidable real water losses for these regions as the average values of states within the same Census Division (or Census Region if no aggregated data exists at the Division-level). While this assumption simplifies the analysis process and potentially obscures more granular patterns of Utility Water Loss demands, the resulting estimates provides a preliminary national assessment of distribution system loss efficiency potential that should be further refined and improved. Future research efforts should build upon these estimates as data for additional states becomes available.

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