State of California
State Water Resources Control Board

Standardized Regulatory Impact Assessment of Proposed *Making Water Conservation a California Way of Life* Regulation

March 10, 2023

For the California Department of Finance in accordance with
Senate Bill 617, Chapter 496, Statutes of 2011

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Abbreviations

AVR—Annual Volumetric Reporting
CII—Commercial, Industrial, and Institutional
DIM—Dedicated Irrigation Meter
DOF—Department of Finance
DWR—Department of Water Resources
DWR IDs—Department of Water Resources Identification Numbers for Urban Retail Water Suppliers
eAR—Electronic Annual Report
ET_o—Reference Evapotranspiration Value
GPCD—Gallons per Capita per Day
LEF—Landscape Efficiency Factor
MAF—Million Acre Feet
PWS IDs—Public Water System Identification Numbers
SRIA—Standardized Regulatory Impact Assessment
State Water Board—California State Water Resources Control Board
Supplier—Urban Retail Water Supplier
UWMP—Urban Water Management Plan
WUCOLS—Water Use Classification of Landscape Species
WUE—Water Use Efficiency

Summary

Assembly Bill (AB) 1668 and Senate Bill (SB) 606 of 2018 directed the California State Water Resources Control Board (State Water Board or Board) to adopt standards for urban retail water suppliers (suppliers) for the efficient use of water and performance measures for commercial, industrial, and institutional (CII) water use. Staff's proposed regulation, the *Making Water Conservation a California Way of Life* regulation, would require suppliers to calculate and comply with "urban water use objectives" based on efficiency standards for a subset of urban water uses (residential indoor and outdoor use, irrigation of CII landscapes with dedicated irrigation meters (DIMs), and real water losses); implement CII performance measures; and submit annual progress reports. The proposed efficiency standards become more ambitious overtime, reaching their final, lowest values in 2035.

The State Water Board will, in the near term, post the proposed regulation analyzed here and begin the formal rulemaking process. If, during the rulemaking process, updates are made to the proposed regulation, the potential economic impacts of the final regulation may differ from what is presented here. The Board will update the economic analysis as required.

While the proposed regulation gives suppliers great flexibility in their choice of compliance pathways, to estimate possible impacts associated with the proposed regulation, State Water Board staff have assumed that suppliers would meet their water use objectives through some combination of conservation measures, including, for example, providing water-efficient appliance and fixture rebates and providing incentives to support the transition from lawns to more California-friendly (i.e., lower water-using) landscapes. We assumed that suppliers would comply with the proposed regulation by making investments from 2025 to 2040 and that a substantial portion of such investments would occur in the earlier part of that period. In contrast, the benefits of the proposed regulation are projected to be greater in the later part of that period. Because the assumed residential water use efficiency measures and CII performance measures will yield enduring and cumulative water savings, significant benefits will continue beyond 2040.

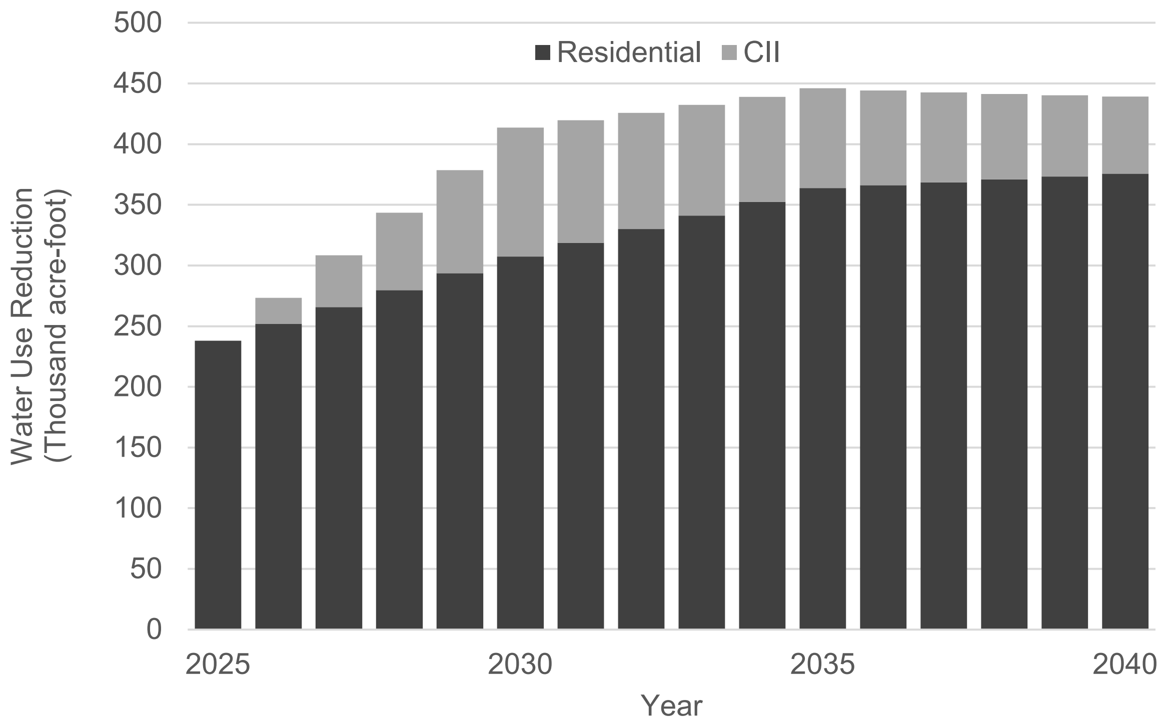
There are many ways to assess the impacts of a proposed regulation as complex as this one. We considered how making different assumptions about key factors affects our projections. Examples of assumptions made:

- Staff assumed suppliers will not use variances to reduce their compliance obligations. Variances could not be incorporated in this assessment because data for variances are not currently available. This assessment therefore very likely overestimates the costs, and benefits, of the proposed regulation.
- Staff assumed suppliers pass on to their customers the impacts of the proposed regulation; this includes reduced revenue (suppliers may sell less water), increased costs (suppliers are assumed to expand their water conservation programs), and increased benefits (suppliers will not have to produce or purchase as much water or fund costly new sources of supply). Staff did not assume suppliers would use any particular rate structure to pass aggregate benefits and costs to customers. Note: there may be

cases where a supplier could change its rate structure in ways that would encourage efficient water use, which could reduce or eliminate the supplier's need to use water conservation programs to comply with the proposed regulation.

As shown in the graph below, staff estimated that the proposed regulation would save approximately 235,000 acre-feet of water in 2025 (compared to the assumed 2025 baseline water use) and increased amounts in subsequent years, reaching almost 440,000 acre-feet of water saved in 2040 (compared to the assumed 2040 baseline water use). The total cumulative amount of water savings in the 2025-2040 period would be approximately 6.3 million acre-feet. Most of the estimated water savings (approximately 80 percent) would come from the assumed residential water use efficiency measures, and the remainder (approximately 20 percent) from CII performance measures.

Figure 1: Projected residential and commercial, industrial, and institutional water use reduction due to proposed regulation



The proposed regulation would apply to 405 suppliers, which collectively provide water for approximately 95 percent of the state's population. Many of these suppliers are projected to be in compliance with their objectives without specific additional efforts, i.e., even in the absence of the proposed regulation. About half of California residents are customers of those suppliers.

In the 2025-2040 period, quantified benefits of the proposed regulation are estimated to exceed the quantified costs. Assuming a discount rate of 3 percent, State Water Board staff estimate present discounted values of $15.6 billion for the quantified benefits and $13.5 billion for the quantified costs.[1]

The table below breaks these estimates down. Of the parties listed in the table, urban retail water suppliers are the only ones on which the proposed regulation imposes obligations; the other parties may be affected indirectly, based on suppliers' compliance paths. Suppliers would incur aggregate costs of almost $9.9 billion and accrue benefits of approximately $10.6 billion from 2025 to 2040.[2] Local wastewater management agencies would incur costs of $2.5 billion; benefits for these agencies could not be quantified. Residential customers would incur costs of $1.0 billion and accrue benefits of almost $5.1 billion. Urban forestry and landscape management agencies would incur costs of approximately $100 million; benefits for these agencies could not be quantified.

Table 1: Projected costs and benefits of the proposed regulation from 2025 to 2040

Entity Type	Cost ($ million)	Benefit ($ million)
Urban retail water suppliers	9,857	10,555
Wastewater management agencies	2,495	not quantified
Residential customers	1,004	5,080
Urban forestry and landscape management agencies	103	not quantified
Total*	**13,459**	**15,635**

**Potentially important benefits could not be estimated. These include, for example, the benefits of reduced overall pressure on the limited water resources that many sectors in California compete for, reduced need for emergency water conservation when there is a severe drought, increased volumes of water that suppliers could store for their future use, improved water quality, and improved soils (and therefore potentially more carbon sequestration).*

Most of the estimated benefits originate from reduced water purchases or reduced water production (compared to the assumed future baseline) by the affected suppliers. The estimated benefits also originate from reduced water use (compared to the assumed future baseline) by residential customers (reduced water use by CII customers, although also a benefit, could not be quantified). A smaller fraction of the estimated benefits originates from savings associated with smaller residential energy bills and from suppliers' having to do less stormwater-related work. As discussed later in this assessment, some potentially important benefits are assumed but their economic impact could not be quantified with sufficient detail.

The table below provides a breakdown of the 2025-2040 estimated costs of the proposed regulation. Most of the estimated costs originate from the implementation of residential water use efficiency measures, approximately $5.8 billion from 2025 to 2040 or 43 percent of total

[1] A discount rate of 3 percent is assumed for all present discounted value calculations in this assessment and is generally consistent with the U.S. EPA's guidelines for discounting future benefits and costs (U.S. EPA 2017).
[2] This summary does not distinguish privately-owned suppliers from publicly-owned suppliers. The distinction is accounted for in the remainder of the SRIA. Privately-owned suppliers are analyzed in the Direct Costs of Proposed Regulation section, and publicly-owned suppliers are analyzed in the Fiscal Impacts on Local Governments section.

estimated costs, and revenues that would be lost by suppliers (and, to a lesser extent, no wastewater management agencies), approximately $4.7 billion or 35 percent. The estimated cost of wastewater infrastructure improvements and other related infrastructure projects during that period is approximately $1.6 billion or 12 percent of total estimated costs.

Table 2: Projected cost impacts of the proposed regulation from 2025 to 2040

Cost Impact Description	Cost ($ million)
Residential water use efficiency measures	5,799
Lost revenues (assuming no rate changes)	4,686
Wastewater infrastructure improvement	1,568
Wastewater operations and maintenance	793
Commercial, institutional, and industrial performance measures	476
Urban tree inventory and forestry management plans	77
Program creation and reporting	35
Public education and outreach	26
Total	**13,459**

Staff also considered two alternative approaches to the proposed regulation. Alternative 1, which assumes less stringent water use standards, would be expected to save about 65 percent of the water saved under the proposed regulation at approximately 73 percent of the projected cost for the proposed regulation. Alternative 2, which assumes more stringent water use standards, would be expected to save about 113 percent of the water saved under the proposed regulation at approximately 110 percent of the projected cost for the proposed regulation.

Introduction

Framework of Proposed Regulation

On May 31, 2018, Governor Brown signed two bills, Senate Bill (SB) 606 (Hertzberg) and Assembly Bill (AB) 1668 (Friedman). Referred to as the 2018 conservation legislation, these bills reflect the dedicated work of many water suppliers, environmental organizations, and members of the Legislature. Added by the 2018 conservation legislation, Water Code section 10609 et seq. required the Department of Water Resources (DWR) to provide recommendations on and the State Water Resources Control Board (State Water Board or Board) to adopt standards for the efficient use of water, variances for unique uses that can have a material effect on water use, performance measures for commercial, industrial, and institutional (CII) water use, and guidelines and methodologies that identify how each urban retail water supplier (supplier) will calculate an urban water use objective. The proposed regulation, the *Making Water Conservation a California Way of Life* regulation, would require suppliers to comply with urban water use objectives, implement the adopted CII performance measures, and submit annual progress reports.

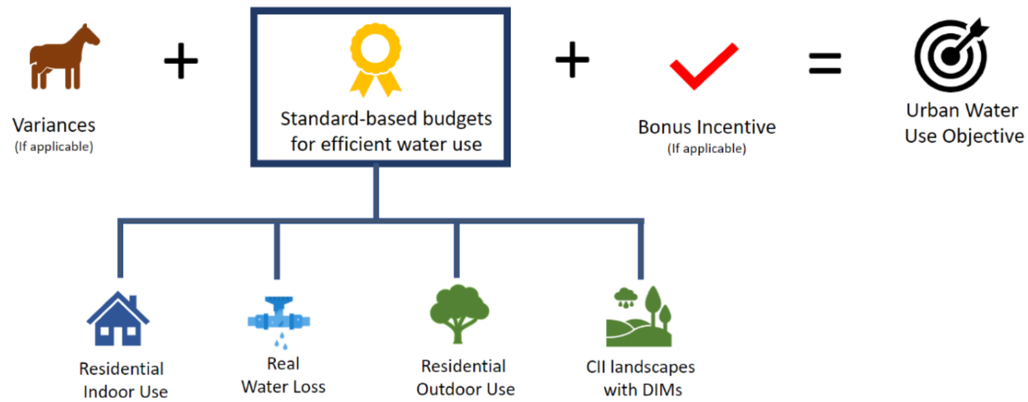
Urban Water Use Objective

A supplier's urban water use objective is a retrospective estimate of aggregate, efficient water use for the previous year, based on adopted water use efficiency standards and local service area characteristics for that year. As shown in Figure 2, a supplier's water use objective equals the sum of standard-based budgets for:

- Residential indoor use
- Residential outdoor use
- CII landscapes with dedicated irrigation meters (DIMs), which are submeters that supply water for only outdoor irrigation
- Real water losses

When applicable, the urban water use objectives will also include variances (for example, for water use associated with livestock), and a bonus incentive for potable recycled water use.

Figure 2: How a supplier calculates its urban water use objective



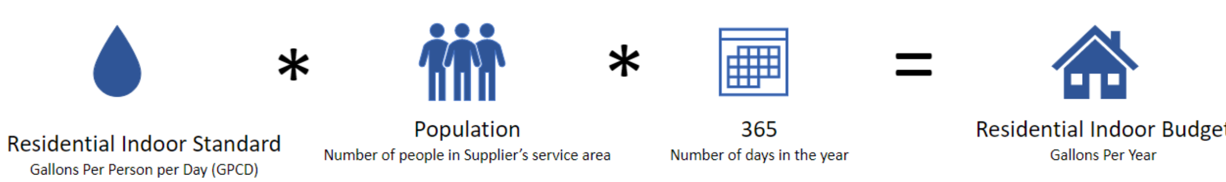
The proposed regulation does not set every component needed to calculate a supplier's urban water use objective. The bonus incentive cap, for example, was established by the 2018 conservation legislation (Wat. Code, § 10609.2.). That legislation also set the standard for efficient residential indoor use (Wat. Code, § 10609.4.), which was then lowered in 2022 based on joint recommendations from DWR and the State Water Board (SB 1157). As shown in Table 3, the residential indoor standard lowers over time.

Table 3: Residential indoor standard as defined in Water Code Section 10609.4

	Residential Indoor Standard (GPCD)
Through December 31, 2024	55
From January 1, 2025, through December 31, 2029	47
January 1, 2030, onwards	42

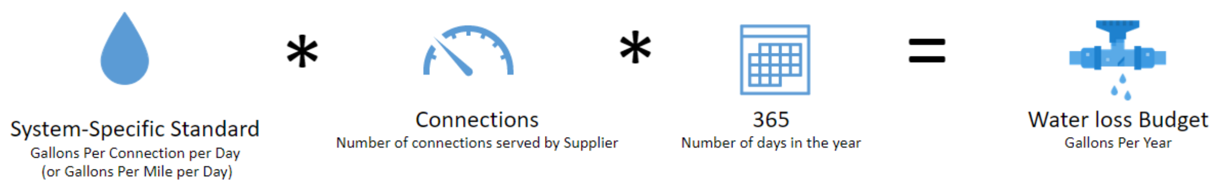
The standard for residential indoor water use — along with unique service area data — would be used to calculate an efficient residential indoor use budget. Specifically, the efficient residential indoor use budget would be calculated by multiplying the standard by the supplier's service area population, and by the number of days in the year (Figure 3).

Figure 3: How a supplier would calculate its Residential Indoor Budget



A separate State Water Board regulation established system-specific standards for water losses (Cal. Code Regs., tit. 23, §§ 980-986). A supplier will calculate its annual water loss budget by multiplying their system-specific standard (State Water Board 2022b), by the number of days in the year, and, depending on the units associated with the standard, by either the number of total service connections or the length of the distribution system, in miles (Figure 4). Suppliers that own and operate multiple systems will calculate an annual water loss budget by summing the estimated efficient water loss budgets associated with each system.

Figure 4: How a supplier would calculate its Water Loss Budget



The proposed regulation would set the standard for residential outdoor water use and the standard for CII landscapes with DIMs, using Landscape Efficiency Factors (LEF). The LEF is a factor used to indicate the amount of water a supplier may need to deliver to maintain healthy and efficient landscapes across its service area. A higher LEF value would correspond to higher water-using, less efficiently irrigated landscapes; a lower LEF value would correspond to lower water-using, more efficiently irrigated landscapes. Under the proposed regulation, the long-term standard (2035 and onwards) for residential outdoor water use would be a LEF of 55%; for CII landscapes with DIMs, the long-term standard would be a LEF of 45%. Table 4 summarizes what the residential outdoor standard and the standard for CII landscapes with DIMs would be under the proposed regulation.

Table 4: Outdoor standards under the proposed regulation

	Landscape Efficiency Factor
Through September 30, 2030	
Residential outdoor	80%
CII DIM landscapes	80%
From October 1, 2030, to September 30, 2035	
Residential outdoor	63%
CII DIM landscapes	63%
October 1, 2035, onwards	
Residential outdoor	55%
CII DIM landscapes	45%

The standards for outdoor use — along with suppliers' unique service area data — would be used to calculate efficient outdoor use budgets. For example, a supplier's efficient residential outdoor water use budget would be calculated by multiplying the standard by the square footage of residential irrigable irrigated landscape area, by net evapotranspiration, and by a conversion factor of 0.62 (Figure 5). The square footage of residential irrigable irrigated landscape area, reference evapotranspiration, and effective precipitation values will be provided by DWR, unless a supplier has produced alternative data that are, in terms of quality and accuracy, demonstrably equal or superior to what has been provided by DWR.

Figure 5: How a supplier would calculate its Residential Outdoor Budget

- Net evapotranspiration (Net ET_o) is equal to reference evapotranspiration (ET_o) minus effective precipitation (EP).
- Reference evapotranspiration (ET_o) is a standard measurement of environmental parameters that affect the water use of plants. ET_o is expressed in inches per year and is an estimate of the evapotranspiration of a large field of four- to seven-inch tall, cool-season grass that is well watered. It varies from year-to-year and throughout the state. For example, in Sacramento, in 2019 and 2020, ET_o was 55.1 inches per year and 58.5 inches per year, respectively; in, San Francisco in 2019 and 2020 it was 40.1 inches per year and 40.9 inches per year, respectively.
- Effective precipitation (EP) is the portion of total precipitation that becomes available for plant growth. For example, in Sacramento, in 2019 and 2020, EP was 6.7 and 2.1 inches, respectively; in, San Francisco in 2019 and 2020 it was 7.6 and 2.2 inches, respectively. Consistent with DWR's recommendation, effective precipitation would be modeled effective precipitation using Cal-SIMETAW, a daily soil-water balance model, and capped at 25% of total precipitation.

"Irrigable Irrigated" and "Irrigable Not Irrigated" Areas

Relevant to the regulatory framework are the standards themselves and the irrigation status of the landscapes that the standards would be applied to. In making its recommendations per the 2018 conservation legislation, DWR analyzed residential outdoor water use in California, estimating residential landscape area for every supplier in California and categorizing residential landscapes based on irrigation status. This was a huge and novel undertaking. DWR categorized residential landscapes as follows:

- *Irrigable Irrigated (II)* landscape areas include healthy vegetation, somewhat unhealthy vegetation (e.g., brown lawns), and non-vegetative features, such as the rows between irrigated trees and features on or between vegetated areas (e.g., mulch, rocks, gravel, or weed blocking fabric; patches of bare earth; cars or other movable vehicles; and trampolines or other movable solid objects).
- *Irrigable Not Irrigated* area includes very unhealthy vegetation (e.g., brown or leafless plants) and areas that are not currently being irrigated, but were irrigated in the past or may be irrigated in the future.

- *Not Irrigated (NI)* areas refer to residential landscapes that are not being irrigated and are unlikely to be in the foreseeable future (e.g., undeveloped or less developed areas; or hardscapes that cannot grow plants or hold water).

In its recommendations to the State Water Board, DWR proposed that the residential outdoor standard be applied to all II area and 20 percent of INI area in a supplier's service area. DWR refers to the 20 percent of INI as an "INI buffer." Under the proposed regulation, a supplier would calculate their residential outdoor water use budget by applying the standard to Irrigable Irrigated area, plus up to 20 percent of the area categorized by DWR as INI, if the supplier demonstrates those INI areas have come under irrigation.

Process for Incorporating the Standard for CII Landscapes with Dedicated Irrigation Meters

Under the proposed regulation, suppliers would have until 2028 to measure the irrigable irrigated area of CII landscapes with Dedicated Irrigation Meters (DIMs). While being required to show annual progress, suppliers would, for those landscapes they have not measured, continue to report "landscape irrigation" water associated with CII landscapes with DIMs to the State Water Board via the already-required electronic Annual Report (eAR). Starting in 2028, suppliers would use the standard to calculate efficient water use budgets for CII landscapes with DIMs.

Water use data associated with CII landscapes with DIMs are not currently available and therefore could not be incorporated into this analysis. For that reason, this analysis may overestimate or underestimate costs and benefits.

Special Landscape Areas

DWR's Model Water Efficient Landscape Ordinance (MWELO) defines Special Landscape Areas (SLAs) as areas with edible plants, areas irrigated with recycled water, and water features that use recycled water. MWELO assigns SLAs an efficiency factor of 100%.
Under the proposed regulation, all residential landscapes and all CII landscapes with DIMs would be subject to the outdoor standards or, if considered an SLA, be granted a LEF of 100%.

Under the proposed regulation, residential SLAs are those used for growing edible plants and areas irrigated with recycled water.

Under the proposed regulation, SLAs for CII landscapes with DIMs would be the same as defined under MWELO, with the following additional landscape types classified as SLAs: bioengineered slopes ponds for recreation or for sustaining wildlife; public swimming pools; ecological projects that do not require a permanent irrigation system; mine-land reclamation projects; existing plant collections, botanical gardens, and arboretums; low-impact development projects; and cemeteries built before 2015.

For both residential areas and CII landscapes with DIMs, areas planted with non-functional turf would not be considered SLAs.

Variances

The proposed regulation would establish variances for unique uses of water, along with the process suppliers would follow to request variances. In addition to the variances recommended by DWR, the State Water Board staff proposal includes two additional variances:

- A variance for new, climate appropriate trees.
- A variance for pools, spas and other water features, starting in 2030.

Water use data associated with variances are not currently available and therefore could not be integrated into this analysis. Because variances will be used to help suppliers comply with the proposed regulation, this analysis very likely overestimates the costs and water savings associated with the proposed regulation.

Process for Including Additional II Area, SLAs, and Variances

The proposed regulation would establish a process suppliers would follow to annually request approval to include additional II area beyond that calculated by DWR, SLAs, and variances. The supplier would be required to provide information quantifying and substantiating each request (e.g., demonstrating that the amount of water requested was delivered by the supplier for the requested use) and a description of efforts to prioritize water for existing trees.

Bonus Incentive

The State Water Board staff's proposed accounting method would incorporate potable reuse water loss and surface water augmentation or groundwater recharge, as appropriate. The bonus incentive would be calculated annually using the following annual data:

- Total groundwater recharge or total reservoir augmentation.
- Loss factor for evaporation and seepage.
- Total basin production or waste discharge to reservoir.
- Individual water supplier groundwater basin production or percent apportionment.
- Total potable water entering the supplier's distributing system.
- Residential metered and potable DIM deliveries.
- Total potable use.

Performance Measures

Under the proposed regulation, suppliers will be required to carry out several CII performance measures. Performance measures are actions to be taken by urban retail water suppliers that would result in increased water use efficiency by CII water users. They will not affect process water. Under the proposed regulation, there are three CII performance measures:

1. Suppliers will be required to install DIMs on or employ in-lieu technologies for the landscapes of CII customers that a) do not have a DIM and b) the supplier estimates to have used more than 500 million gallons of water.

2. Suppliers will be required to classify their CII customers according to the broad classification categories used by the U.S. Environmental Protection Agency's ENERGYSTAR Portfolio Manager tool.

3. Suppliers will be required to offer BMPs to their CII customers that meet specific criteria.

    a. For customers that own or manage a building that is considered a "disclosable building" under the California Energy Commission's "Benchmarking" regulation (Cal. Code Regs., tit. 20, § 1681, subd. (d)), the supplier would provide annual water use data in a format compatible with ENERGYSTAR's Portfolio Manager tool.

    b. For customers that the supplier has determined to be in the top 20 percent of water use, relative to other customers within their specific CII classification category (e.g., lodging), the supplier would design and implement a conservation program that includes at least one BMP (e.g., educational bill inserts) from five discrete BMP categories (e.g., Outreach, Education, and Technical Assistance). The proposed regulation stipulates the BMPs categories and the specific BMPs within each category.

    c. For customers the supplier has determined to be in the top 2.5 percent of water use, relative to all its CII customers, the supplier would design and implement a conservation program that includes at least two BMPs from each of the BMP categories.

Outreach and Public Input

Prior to the State Water Board initiating the formal rulemaking process for the proposed regulation, DWR engaged in studies and investigations to inform the recommendations that it provided to the Board; these studies and investigations included collaboration with, and input from, stakeholders. Public engagement included in-person public meetings throughout 2019 and the creation of three working groups to inform the recommendations for guidelines and methodologies for water use efficiency standards, variances, and performance measures. These subgroups met multiple times from 2020 to 2022 and were able to share feedback and comments. In addition, DWR participated in numerous meetings with stakeholders to solicit information and gather additional input to support the research and to inform the development of the Urban Water Use Efficiency Recommendation Package (DWR 2022).

Additionally, State Water Board staff and contractors engaged with stakeholders in developing the methods and gathering the data used in this assessment.

The methods developed and data used to estimate economic impacts (see Appendices) were presented at several water use efficiency working groups and committees for California water supplier associations including the Association of California Water Agencies (ACWA), the California Water Efficiency Partnership (CalWEP), and regional water authorities throughout the state. Contractors supporting the development of the analysis gathered feedback from the industry on the estimation approach and then revised accordingly. Finally, suppliers throughout the state participated in semi-structured interviews in 2021, organized with assistance from regional water management organizations.

In 2021, professionals at wastewater collection, treatment, and reuse facilities were contacted. One part of the outreach involved detailed discussions with approximately twenty industry professionals and wastewater system managers about the operational challenges in the industry. A second part included an online collection response system that gathered responses from agencies with forty to seventy agencies responding depending on the topic. We wanted to learn about their experiences during the drought of 2011 to 2017 to better understand how they would respond to the proposed regulation. This industry participation greatly aided our modeling of the impact of reduced influent and increased concentrations in wastewater facilities and systems.

The model and data proposed to be used to estimate how the forthcoming efficiency standards may impact wastewater collection, treatment, and reuse facilities were presented at virtual stakeholder meeting in May 2022. The methods used to evaluate the efficiency standard and develop the impact model were also presented as part of two statewide public webinars in December 2021. We gathered feedback from industry professionals, other interested parties, and the public.

In accordance with Water Code section 10609.2, State Water Board staff evaluated potential impacts on local wastewater management, developed and natural parklands, and urban tree health from long-term efficiency standards. As part of the work to evaluate potential impacts to parklands and urban trees, State Water Board staff held one public workshop in December 2021 and a second in May 2022. The public workshops were attended by suppliers, park districts, tree organizations, landscapers, environmental nonprofits, and environmental justice organizations.

Baseline

To estimate the impacts of the proposed regulation, a baseline condition must be established. This baseline is the reference point for determining whether additional actions would be needed to comply with the regulation as well as the limits to those actions given costs and potential water savings through efficiency and conservation.

Urban Water Supply Sector

The analysis assumes the proposed regulation would apply to 405 suppliers in the state (DWR 2021b; State Water Board 2019). In 2015, DWR collected data from 432 distinct suppliers. However, some of these suppliers have multiple service territories with unique designations as distinct public water systems. Additionally, some of the suppliers on DWR’s list are wholesalers and would not be subject to the objectives established by the proposed regulation.[3] The 432 suppliers correspond with over 530 unique water systems as tracked by the U.S. Environmental Protection Agency. In 2020, these suppliers provided water for approximately 95 percent of the state's population.

The suppliers in California include both public and private entities. Public suppliers include municipal agencies, special-purpose and irrigation districts, municipal water districts, and counties, while private suppliers include investor-owned utilities and nonprofit mutual water companies (Dobbin and Fencl 2021; Pincetl et al. 2016). Public suppliers' actions can be subject to public approval by elected officials or the public through requirements such as Articles XIII C and D of the California Constitution (commonly referred to as Proposition 218 (1996)). Another type of public entity, special districts, are governed by a board of directors that is elected or appointed. Alternatively, privately owned systems like investor-owned utilities (IOUs), are regulated by the California Public Utilities Commission (CPUC). IOUs must seek approval for rate increases and other actions from the CPUC, including balancing the benefits of new investments with the fiscal impacts to ratepayers (Pincetl et al. 2016; Teodoro and Zhang 2017).

Suppliers invest in both water supply and water demand management strategies to provide reliable water for residents and customers. Current habits of water supply and use in California's cities have evolved over time but also reflect past decision-making and expectations. Early in the twentieth century, California's developing cities built large-scale infrastructure systems to transport water across long distances. Today, many suppliers obtain water from multiple sources, including local surface water, groundwater, recycled water, and inter-basin imports, as well as through temporary or permanent transfers and agreements. Strategies that suppliers have used to increase reliability in recent decades included diversifying supplies and, especially in Southern California, investing in demand management and new large water storage projects (Dixon et al. 1998; MWD 2020; Quinn 1990). Starting in 1991, during a 5-year drought (1987–1992), suppliers institutionalized demand management actions as part of local and statewide policies.

Most of today's typical urban water use efficiency and conservation actions used by suppliers were developed by the California Urban Water Conservation Council (CUWCC) following a 1991 Memorandum of Understanding between water agencies and nonprofit and industry groups (CUWCC 1991). Best management practices included residential, commercial, industrial, and institutional measures that suppliers could take to build conservation programs. By 1998, the California Water Plan highlighted 14 urban water conservation best management practices developed by CUWCC and used a portion of them in support of forecasting water demand through 2020. The 14 urban water conservation BMPs are listed below. Appendix A characterizes current water use efficiency programs.

1) Water audit programs for single-family residential and multifamily residential customers
2) Residential plumbing retrofit

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[3] Some suppliers operate in both a wholesale and retail capacity. Suppliers with both operations may have to meet water use objectives under the proposed regulation for their retail operations.

3) System water audits, leak detection and repair
4) Metering with commodity rates for all new connections and retrofit of existing connections
5) Large landscape conservation programs and incentives
6) High-efficiency washing machine rebate programs
7) Public information programs
8) School education programs
9) Conservation programs for CII accounts
10) Wholesale agency assistance programs
11) Conservation pricing
12) Conservation coordinator
13) Water waste prohibition
14) Residential ultra-low-flush toilet replacement programs

Urban Water Use

The water use baseline used in this document was derived from an analysis of data from technical literature, data the State Water Board collected through monthly and annual reporting by suppliers, the Department of Finance (DOF), tax assessor information for parcels in California derived from a commercial dataset (LandVision), U.S. Census tract data, reports and documentation from water authorities and suppliers, and documentation gathered during outreach efforts. With these data, a multi-step estimation procedure was used to estimate residential water demand currently and through 2040. Appendix B provides details. The accuracy of the water demand projections is limited by the short period of available detailed statewide data (2013–2019) on supplier demand.

Per capita water use is a standard measure of efficiency. In California, per capita water use has, for the most part, been declining over the last few decades. It has declined steeply during drought and rebounded slightly during times when the rains returned. In 2000, average statewide total urban water use was 199 gallons per capita per day (GPCD) and it had dropped to 164 GPCD by 2013 (DWR et al. 2017). By 2015, in response to the last drought emergency, it had dropped to 129 GPCD. Since then, California has experienced some rebound, peaking at 137 GPCD in 2020 (the beginning of the hot, dry conditions associated with the current drought) and had dropped to 130 GPCD by the end of 2022 data (State Water Board 2022a). Between 2013 and 2022, Californians have stepped up in big and small ways to save water, reducing water use by over 20 percent.

Urban retail water suppliers report urban water deliveries to the State Water Board and water losses to DWR. Water deliveries are reported to the State Water Board via the electronic Annual Report (eAR) according to the following categories: single-family and multi-family residential; commercial, industrial, and institutional; landscape irrigation; and other. Residential water deliveries and deliveries to CII landscapes with DIMs would be affected by the standards and are relevant to the calculation of urban water use objectives. For the purposes of this analysis, staff assumed the single-family and multi-family residential deliveries reported via the eAR represent the entirety of residential deliveries and that landscape irrigation deliveries represent CII landscapes with DIMs; the remaining eAR categories are considered “excluded demands.”

Water losses are reported to DWR via the Water Loss Audit Reporting Program according to the following categories: real water loss;[4] apparent water loss;[5] and authorized, unbilled water loss. Real water loss is relevant to the calculation of the proposed urban water use objectives. The remaining water loss categories are considered “excluded demands.” Total urban water use includes all urban water deliveries and all water losses. Information about the excluded demands is presented to contextualize the prospective impacts of the proposed regulation.

Table 5: Urban water use categories included and excluded from the urban water use objective

Included in Objective	Excluded from Objective
Residential water use (single- & multi-family)	CII indoor use
CII landscapes with DIMs	CII outdoor use, not associated with a DIM
Real water losses	Other
	Apparent water losses
	Authorized, unbilled water losses

The proposed regulation would affect urban water use in two primary ways: by setting efficiency standards that will be used to calculate each supplier’s urban water use objective, and requiring each supplier to achieve its urban water use objective; and by establishing and requiring CII Best Management Practices (BMPs). The efficiency standards are set for each broad category of urban water uses (e.g., residential indoor water use, residential outdoor water use) included in the urban water use objective while the CII BMPs will affect some of the use types excluded from the objective (specifically, CII indoor water use and the water used on CII landscapes that are not associated with DIMs).

Next, we describe the baseline conditions used forecast future use and evaluate the impact of the proposed regulation.

Residential Indoor and Outdoor

In estimating baseline residential indoor conditions, i.e., what indoor residential water use would be absent the regulation, we relied on the data and analyses completed for the Indoor Residential Water Use Report (DWR 2021a) and forecasted future use, as explained in Appendix D. To forecast future residential indoor use, we considered ongoing natural (i.e.,

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[4] “Real loss” means the volume of annual leakage due to physical leakage, not including apparent losses, reported in the annual audit as “current annual real loss.” Real loss has three components: reported, unreported, and background leakage.

[5] “Apparent loss” means losses in customer consumption attributed to inaccuracies associated with customer metering, systematic data handling errors, plus unauthorized consumption (theft or illegal use of water), as reported in the annual audit as “apparent losses.”

passive) conservation, as well as population growth.[6] To take natural conservation into consideration, we estimated current and future saturation for each supplier.

Saturation of a fixture or appliance in a region or sector refers to the fraction of efficient fixtures and appliances that exist within a market, such as, for example, the percentage of 1.2 Gallon Per Flush (GPF) toilets that have already replaced the older models using 3.5 or even 6 GPF. Estimates of current and future saturation were informed by available data and literature, including existing fixture efficiency standards (state and federal), and residential water use estimates; geographic boundaries for each supplier and tax assessor data were used to estimate and corroborate the number of residential households as well as the number and performance of the indoor fixtures and appliances within a supplier's service area. An end-use model incorporated the data to estimate average per capita water use for each supplier.

In estimating baseline residential outdoor conditions, i.e., what outdoor residential water use would be without the regulation, we first estimated, for each supplier, current residential outdoor use and then forecasted future use. To estimate current outdoor residential use, we subtracted current indoor use from current total residential water use. To forecast future residential outdoor use, we considered the steady declines in use that would take place because of *business-as-usual active conservation* as well as a *net-adaptation effect.*

- *Business-as-usual active conservation*: this refers to the suite of programs (education and outreach, residential and commercial water audits, rebates, etc.) that result in outdoor water savings during non-drought years. The associated rate of decline in outdoor per capita water use is assumed to be 0.3 percent per year.

- *Net adaptation effect*: given that climate change is increasing the frequency and intensity of droughts in California, the analysis also took into consideration the investments suppliers and local governments make to further incentivize activities, such as turf replacement, during drought emergencies and that these investments under most circumstances result in permanent water savings (e.g., actions taken by suppliers and their customers during recent drought years have led to the large and lasting decrease in per-capita water use observed since 2013). The associated rate of per capita decline in water use is assumed to be 0.5 percent per year. As described in Appendix B, these rates of decline are based on an analysis that used supplier turf rebate data to estimate the area of turf replaced, during both drought and non-drought years. This area was then inserted into the Model Water Efficiency Landscape Ordinance equation to estimate average statewide savings (in gallons) and percent per year reductions.

Taking into consideration both business-as-usual active conservation and the net-adaptation effect, each supplier's per capita outdoor residential water use was assumed to decline at an average rate of 0.8 percent per year.

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[6] "Natural" or passive conservation refers to water use reductions due to plumbing codes and turnover given the expected lifetime of fixtures and appliances.

The forecasted indoor and outdoor per capita residential water use rates were multiplied by projected population and the number of days in the year to calculate, for each supplier, the future volume of water that the residential sector would use in the absence of the proposed regulation. The table below shows the annual average percent change in residential water use that the analysis assumes will occur through 2035, even in the absence of the proposed regulation.

Table 6: Baseline annual percentage change in suppliers' water use from 2020 to 2035

	GPCD: Average Change	GPCD: Median Change	Volume: Average Change	Volume: Median Change
Indoor residential	-0.88%	-0.91%	-0.37%	-0.70%
Outdoor residential	-0.78%	-0.78%	-0.26%	-0.62%
Total residential	-0.84%	-0.85%	-0.33%	-0.64%

CII Landscapes with DIMs

The staff assumed that what suppliers have reported as "landscape irrigation" deliveries in the eAR represents water use associated with CII landscapes with DIMs. In estimating future water use of CII landscapes with DIMs, the model assumes that the volume of "landscape irrigation" deliveries would decrease at rate of approximately 0.5 percent per year from the 2019 deliveries.

CII Indoor and Outdoor, Unassociated with DIMs

Staff assumed that what the suppliers have reported as "commercial and institutional" and "industrial" deliveries in the eAR represent water use associated with indoor CII water use plus CII outdoor use unassociated with DIMs. In estimating future CII water use, absent the regulation, the model assumes that the volume of "commercial and institutional" and "industrial" deliveries would decrease at rate of approximately 1 percent per year from the 2019 deliveries.

Water Loss

The proposed regulation does not set water loss standards. State Water Board staff, for the purposes of this analysis, assumed all water losses remain constant, on a volumetric basis.

Other

We assumed that the water deliveries suppliers have reported as "other" (which can include water uses such as firefighting, street cleaning, and line flushing) in the eAR would remain constant, on a per capita basis.

Table 7 summarizes, for each sector, the assumed annual changes used to forecast the future baseline.

Table 7: Assumed annual changes, by sector, used to forecast future water use

Sector	Assumption
Indoor residential	Depends on each supplier**
Outdoor residential	0.80% decline in use per person
CII landscapes with DIMs*	0.5% decline in total volume
CII indoor and outdoor, unassociated with DIMs*	0.5% decline in total volume
Other	No change assumed
Water loss	No change assumed

** To ensure the model best reflected reported water use data, volumetric values were multiplied by the ratio of the 2020 model value and the reported 2019 value. If the model value deviated significantly from reported use, the resulting adjustment effectively brought the model value closer to the reported use value.*
*** See Appendix B.*

Impact of Proposed Regulation on Urban Water Use

In this section, we describe the water savings that would be associated with proposed regulation. We describe what savings would be associated with meeting the urban water use objective and with carrying out CII performance measures. As explained in the *Framework of Proposed Regulation* section, the objective is equal to the sum of standard-based budgets for residential indoor use, residential outdoor use, CII landscapes with DIMs, and real water losses. When applicable, the objective will also include variances and a bonus incentive for potable recycled water use. The proposed regulation would also establish performance measures for CII water use. Estimated water savings were based on the performance measure that would establish a threshold to convert CII mixed-use meters to DIMs (or to employ in-lieu technologies). Under the proposed regulation, a supplier would be required to install DIMs on or employ in-lieu technologies for CII large landscapes that have mixed-use meters and are estimated to apply 500,000 or more gallons per year to their landscapes.

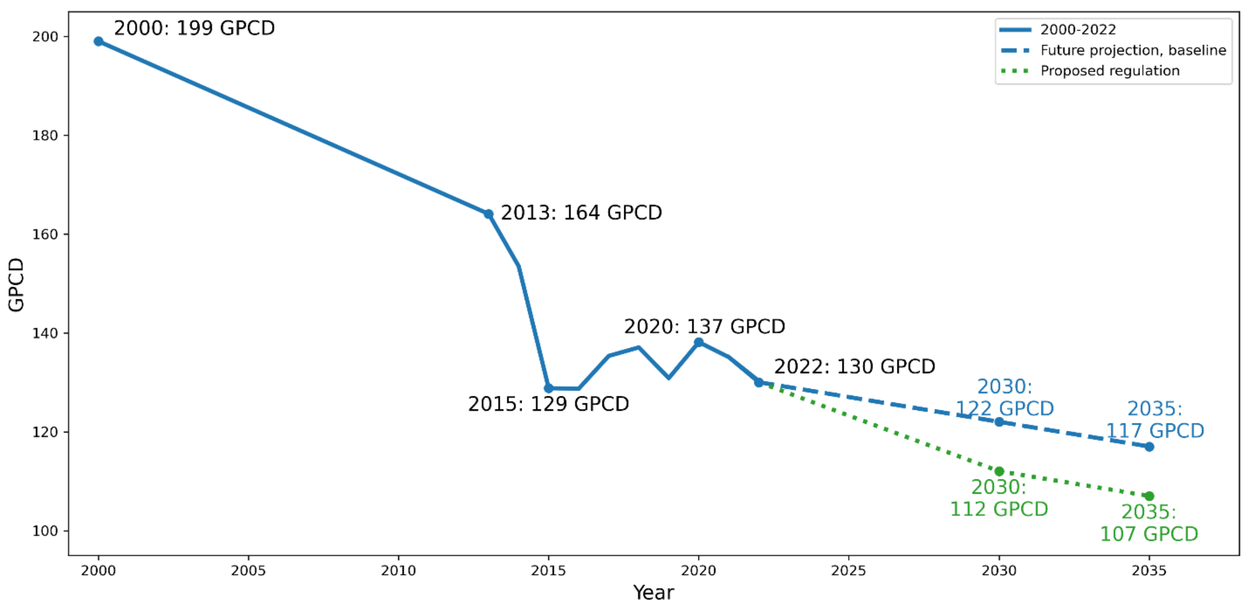
The following pages present the water savings associated with the proposed regulation. Looking at total urban water use helps to contextualize these savings. For this reason, staff has provided information about historic and future *total* water use. Absent the proposed regulation, average statewide total urban water use is forecasted to decline from a modeled baseline of 136 GPCD in 2020 to 117 GPCD in 2035. Without accounting for variances, the proposed regulation could significantly increase urban water use efficiency, bringing average total statewide water use to 107 GPCD in 2035. For context, urban water use trends in two affluent and industrialized nations – Australia and Denmark – provide useful examples. Total urban water use in Australia averaged 100 GPCD in 2020, with residential water use accounting for a little over half of total use in most metropolitan areas (Bureau of Meteorology 2022). In Denmark, total urban water use averaged 42 GPCD in 2021, with residential water use accounting for a little over two-thirds of total use (DANVA 2022).

Table 8 and Figure 6 show the historic and future baseline as well as what average total GPCD would be under the proposed regulation (for 2030 and 2035). The table also shows the average annual change from 2020 and the GPCD savings associated with proposed regulation.

Table 8: Current and forecasted statewide urban water use, in gallons per capita daily

	Statewide Urban Water Use (GPCD)	Change per Year from 2020	Savings from Residential Sector (GPCD)	Savings from CII Sector (GPCD)
Historic reference level:[7] 2020	136	-	-	-
Future reference level: 2030	122	- 1.0%	-	-
Proposed regulation: 2030	112	- 1.8%	7.5	2.5
Future reference level: 2035	117	- 0.9%	-	-
Proposed regulation: 2035	107	- 1.4%	8.2	1.8

Figure 6: Past and forecasted statewide urban water use per person per day, with and without proposed regulation



In 2000, statewide water urban use averaged 199 GPCD, according to the 20×2020 Water Conservation Program report (DWR et al. 2013). With the passage of the Water Conservation Bill of 2009 (SBx7 7), the State sought to reduce per capita water use by 20 percent by 2020. Between 2000 and 2013, average statewide per capita water use decreased from 199 GPCD to 164 GPCD. Between 2013 and 2015, emergency conservation regulations resulted in average statewide water use dropping from 164 GPCD to 129 GPCD, a 21 percent savings in two years

[7] The 2020 modeled baseline GPCD of 136 GPCD was informed by 2017-2019 averaged Electronic Annual Report data, and is therefore 1 GPCD lower than the reported 2020 value of 137 GPCD.

(State Water Board 2022a). Since then, California has experienced some rebound, peaking at 137 GPCD in 2020 (the beginning of the hot, dry conditions associated with the current drought) and again dropped by the end of 2022, averaging 130 GPCD (State Water Board 2022a).

While urban water use has rebounded since the 2015 low, the long-term trend is clear: Californians are taking strides to use water more efficiently, indoors and outdoors. Between 2013 and 2022, per capita urban water use decreased by over 20 percent, savings equating to an average decline of 2.3 percent per year. By 2035, the proposed regulation could, without accounting for variances, result in average GPCD declining at a rate of 1.4 percent per year. It could, in other words, help maintain the annual pace of change realized over the last decade.

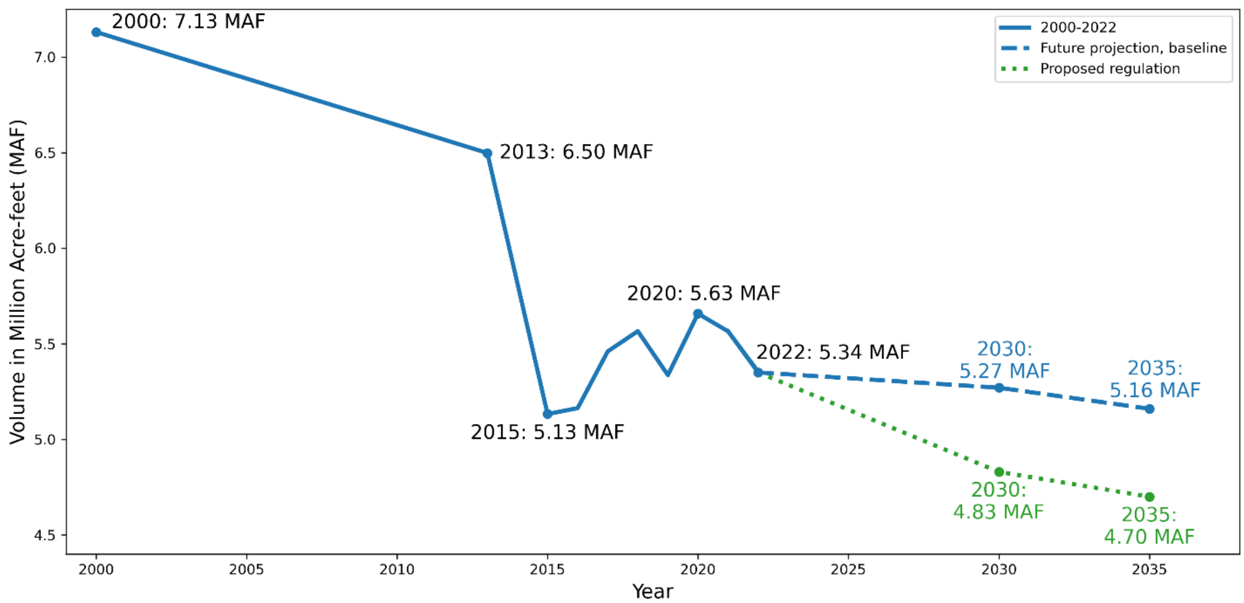
Per capita water use is a standard measure of efficiency and, for that reason, trends in GPCD have been discussed in the paragraphs above. Also relevant is the total volume of water consumed by the urban water sector. Volumetric trends are summarized below. Table 9 and Figure 7 show, in million acre-feet (MAF), current and forecasted statewide total urban water use as well as what it could be under the proposed regulation. The table also shows the average annual change and the MAF savings associated with proposed regulation.

Table 9: Current and forecasted statewide urban water use

	Statewide Urban Water Use (MAF)	Change per Year from 2020	Savings from Residential Sector (MAF)	Savings from CII Sector (MAF)
Historic reference level:[8] 2020	5.57	-	-	-
Future reference level: 2030	5.27	- 0.5%	-	-
Proposed regulation: 2030	4.83	- 1.3%	0.33	0.11
Future reference level: 2035	5.16	0.5%	-	-
Proposed regulation: 2035	4.70	- 1.0%	0.38	0.08

[8] The 2020 modeled baseline volume of 5.57 MAF was informed by 2017-2019 averaged electronic Annual Report data, and is therefore 60,000 AF lower than the reported 2020 volume of 5.63 MAF.

Figure 7: Historic, current, and forecasted statewide urban water use, total water use, with and without proposed regulation



The analysis of impact of the proposed regulation reflects the data of 385 water agencies, which are assumed to collectively serve a population of over 39 million Californians in 2035 (95 percent of the state's projected 2035 population). Based on the analysis, the proposed regulation would result in no water use reductions or modest water use reductions for most urban retail water suppliers in California. Seventy-two percent of suppliers (274 suppliers), serving about half of the state's population, would have to reduce water use by some amount to comply with their 2035 objective. Of these suppliers, about half would have to reduce water use by less than 10 percent. About a third of suppliers, representing 14 percent of Californians served by suppliers, would have to reduce water use by 20 percent or more. Table 10 shows how the proposed regulation, when only considering objective compliance, might impact suppliers in 2035.

Table 10: Suppliers and service population, by degree of potential impact of the proposed regulation, considering compliance with the objective only

Impact Category	Percent of Suppliers in Category	Percent of Service Population in Category
No reductions in water use	28%	48%
Reductions of 10% or less	32%	24%
Reductions of 10% to 20%	19%	13%
Reductions of 20% to 30%	12%	10%
Reductions of more than 30%	9%	4%

When considering compliance with both the objectives and the CII performance standard requirements, the proposed regulation would result in almost all (379) agencies reducing water deliveries by some amount, relative to the assumed 2035 reference level. For most suppliers, those reductions would be associated with carrying out the CII performance standards and would be relatively small. For example, 47 percent of suppliers would see water delivery reductions of 5 percent or less.

We used census data to assess the possible impacts of the proposed regulation on different demographic groups. Suppliers serve approximately 95 percent of the state population and the population served by suppliers has a similar racial and ethnic composition as the entire state. An exception is Native Americans: approximately 1.7 percent of the state population is Native American while 0.4 percent of the population served by suppliers is Native American. Likewise, the degrees to which different demographic groups live in areas served by suppliers that may need to reduce water use (i.e., impacted areas) are generally comparable. Approximately 41 percent of the white population served by suppliers resides in impacted areas; the figures are 42 percent for the Hispanic population, 36 percent for the African American population, 40 percent for the Native American population, and 33 percent for the Asian American and Pacific Islander population.

Alternatives to Proposed Regulation

As discussed above, the proposed regulation would set the standard for residential outdoor water use and the standard for CII landscapes with DIMs; it would establish variances for unique uses and the process suppliers would follow to request and receive those variances; and it would establish methods to calculate volumetric budgets for every component of each supplier's overall water use objective. Appendix C describes the methods that suppliers would use to calculate their urban water use objectives. The proposed regulation would also establish performance measures for CII water use.

Two alternatives to the proposed regulation were evaluated by staff. The parameters for each are summarized in Table 11 and compared to those of the proposed regulation. These parameters include the proposed standards, which are Landscape Efficiency Factors (LEF), as well as the irrigation status of the landscapes that the proposed standards would be applied to. More specifically:

- The LEF is a factor used to indicate the amount of water a supplier may need to deliver to maintain healthy and efficient landscapes across its service area; LEF is applied to net evapotranspiration and the supplier's *irrigable irrigated landscape area*. A higher LEF value would correspond to higher water-using, less efficiently irrigated landscapes; a lower LEF values would correspond to lower water-using, more efficiently irrigated landscapes.
- Implementing the directives of the 2018 conservation legislation, DWR analyzed residential outdoor water use in California, estimating residential landscape area for every supplier in California and categorizing residential landscapes based on irrigation status. This was a huge and novel undertaking.

- *Irrigable Irrigated (II)* landscape areas include healthy vegetation, somewhat unhealthy vegetation (e.g., brown lawns), and non-vegetative features, such as the rows between irrigated trees and features on or between vegetated areas (e.g., mulch, rocks, gravel, or weed blocking fabric; patches of bare earth; cars or other movable vehicles; and trampolines or other movable solid objects).
- *Irrigable Not Irrigated* area includes very unhealthy vegetation (e.g., brown or leafless plants) and areas that are not currently being irrigated, but were irrigated in the past or may be irrigated in the future.
- *Not Irrigated (NI)* areas refer to residential landscapes that are not being irrigated and are unlikely to be in the foreseeable future (e.g., undeveloped or less developed areas; or hardscapes that cannot grow plants or hold water).

In its recommendations to the State Water Board, DWR suggested that the residential outdoor standard be applied to II area and 20 percent of INI area. DWR refers to this 20 percent as the "INI buffer." Under the proposed regulation, the standard would apply to Irrigable Irrigated area and, up to 20 percent of the area categorized by DWR as INI, provided a supplier can demonstrate that previously unirrigated areas have come under irrigation.[9]

Table 11: Parameters for the proposed regulation, Alternative 1, and Alternative 2

	Alternative 1		Proposed Regulation		Alternative 2	
	LEF	**INI Buffer?**	**LEF**	**INI Buffer?**	**LEF**	**INI Buffer?**
Now through 2030						
Residential outdoor	80%	Yes	80%	No	80%	No
CII DIM landscapes	80%	n/a	80%	n/a	80%	n/a
2030 through 2035						
Residential outdoor	63%	Yes	63%	No	55%	No
CII DIM landscapes	63%	n/a	63%	n/a	45%	n/a
2035 onwards						
Residential outdoor	63%	Yes	55%	No	55%	No
CII DIM landscapes	63%	n/a	45%	n/a	45%	n/a

LEF = Landscape Efficiency Factor, INI = irrigable, not irrigated.

Under the proposed regulation, the outdoor residential water use standard would be an LEF of 80 percent until 2030, when it would decline to an LEF of 63 percent. The residential outdoor standard would then decrease to an LEF of 55 percent in 2035. Under the proposed regulation, the standard for CII landscapes with DIMs would be an LEF of 80 percent until 2030, when it would decline to an LEF of 63 percent. The standard for CII landscapes with DIMs would decrease to a LEF of 45 percent in 2035.

[9] While DWR recommended that 20 percent of INI be automatically included for all suppliers, the proposed regulation does not include this buffer automatically. Staff propose a process for suppliers to substantiate and request a buffer, of up to 20 percent of INI.

In evaluating the impacts of the proposed regulation, as well as the two alternatives, staff assumed no changes to the indoor residential standard, which is set in statute as 55 GPCD until 2025, 47 GPCD from 2025 to 2030, and 42 GPCD after 2030. Under all three scenarios, it was assumed that suppliers would claim the recycled water bonus they would be eligible for. Data from Annual Volumetric Reports (AVR), eAR, and Urban Water Management Plans (UWMPs) were used to estimate supplier-specific potable recycled water production.

For performance measures associated with the outdoor landscapes of CII properties, we evaluated the number of affected properties in the suppliers' service areas. The proposed regulation would require CII landscapes estimated to consume 500,000 or more gallons per year (the threshold under the proposed regulation) to install a dedicated irrigation meter or implement "in-lieu" technologies. Under Alternative 1, the threshold would be 1,000,000 gallons per year (and thus far fewer landscapes affected); under Alternative 2, the threshold would be 250,000 gallons per year (and thus far more landscapes affected).

Assumptions Regarding Compliance with Proposed Regulation

State Water Board staff assumed that, for compliance, some suppliers would need to take actions to reduce their residential water use, reduce the water use of CII landscapes with DIMs, and adhere to CII performance measures, which include abiding by a classification system and implementing some BMPs. As noted previously:

- For residential water use, suppliers can choose from several types of indoor and outdoor water use efficiency measures.
- For CII landscapes with DIM, it is proposed that suppliers use a specific CII standard to calculate an efficiency budget that would be integrated into their objective. For those CII customers that have water use exceeding the threshold, suppliers would choose from several outdoor efficiency measures. For all CII customers, suppliers would need to adhere to BMPs that increase the efficiency of water use (except for "process water" use).[10]
- The proposed regulation incorporates compliance with the State Water Board's water loss regulation associated within production and distribution systems, and does not assume or require reductions in water loss beyond those required by the water loss regulation.

[10] "Process water" means water used by industrial water users for producing a product or product content, or water used for research and development. Process water includes, but is not limited to continuous manufacturing processes, and water used for testing, cleaning, and maintaining equipment. Water used to cool machinery or buildings used in the manufacturing process or necessary to maintain product quality or chemical characteristics for product manufacturing or control rooms, data centers, laboratories, clean rooms and other industrial facility units that are integral to the manufacturing or research and development process shall be considered process water.

Numerous options exist for suppliers to reduce water consumption to achieve compliance. Urban water conservation programs in California include incentives for increased indoor fixture efficiency and outdoor water conservation, education, targeted messaging programs for acute demand reductions such as during drought, and community-based efforts that engage local nonprofits. Appendix B contains a summary of current water use efficiency program characteristics. Changes to water rate structures – for example, establishing budget-based rates – could also in some cases reduce water use while still meeting revenue requirements. For example, the Eastern Municipal Water District adopted budget-based rates and reduced water residential water demand by 18 percent (Baerenklau et al. 2013). A case study looking at water districts in Orange County also showed that implementing budget-based rates have led to greater household savings. For the Moulton Niguel Water District, a 1 percent increase in price corresponded to a 2.4 percent decrease in water demand (Harmon et al. 2021).

Existing research and industry literature have focused on evaluating the cost-effectiveness and water savings potential for technological options using experiments, modeling, and data analysis to estimate results. Less work has been done on evaluating effects of programs and strategies that are not technology-based, such as public education. In our outreach efforts, many suppliers indicated that they would likely continue to emphasize technology-based and landscape-based efficiency programs. For these reasons, to estimate benefits and costs of the proposed regulation, we focus on strategies and incentives with available data. This does not negate the value of programs that focus on education and behavior or of conservation pricing. It demonstrates, however, that further empirical studies are needed in these areas to quantify outcomes across communities of varying sociodemographic and economic standing.

Variances, special landscape areas (SLAs), and the bonus incentive are additional potential accommodations for suppliers, as these recognize heightened water use that is due to specific uses or, in the case of the bonus incentive, give credit for investments in specific technologies. At the time of writing, supplier-specific information on variances and SLAs was not available and therefore were excluded from the analysis. For this reason, the estimated costs and benefits of the proposed regulation may be overstated. Suppliers that include variances and SLAs in their objective would not be required to reduce water to the degree assumed by this analysis.

For values of the potable recycled water bonus incentive, we relied on reported data for suppliers' existing and projected potable recycled water use, obtained from State Water Board's Annual Volumetric Reporting data and DWR's Urban Water Management Plans. Due to a number of factors, including the cap on the bonus incentive and the significant cost and time associated with adding new potable recycled water production, all of which make such development unlikely during the period of regulatory implementation, plus a lack of clarity on how such new potable reuse would adjust a supplier's objective, we do not consider in this analysis the possibility that a supplier will increase potable recycled water use to increase its objective.

Residential Water Use Cost Minimization

As discussed, suppliers will have extensive flexibility in how they comply with the proposed regulation. We assumed that suppliers would use the water use efficiency measures that minimize compliance costs. This is a more conservative approach than assuming suppliers would have the information needed to—or would seek to—maximize net benefits. Suppliers generally operate at cost of service and the semi-structured interviews held with suppliers indicate that suppliers will work to reduce compliance costs.

State Water Board staff and contractors modeled the water savings from various water use efficiency strategies, and we combined the modeled savings with market prices and rebate historical data to estimate costs that suppliers would incur to meet the residential water use objectives.

The modeling approach reflects that suppliers differ in many dimensions. For example, one supplier may have a significant amount of older housing stock with significant potential for water conservation from new low-flow toilet upgrades. Once we estimate the number of toilet replacements needed, we multiply that number by the average market price of a new low-flow toilet (including installation cost) to obtain total cost of toilet replacement in that supplier's service area. Another supplier, however, may have fewer older, higher water using fixtures, and their most relevant low-cost water conservation strategy may be to incentivize outdoor water use reductions through landscape conversions. For this scenario we multiplied the potential water savings by the price per square foot of landscape conversion and obtained the total cost of landscape conversion in that supplier's service area. The least-cost modelling approach takes supplier-specific attributes into account. In the least-cost approach, therefore, suppliers minimize their costs through an optimal, supplier-specific mix of available water use efficiency measures.

The process used to estimate the reasonably knowable and available lowest cost for suppliers to achieve residential water use reductions was adapted from the American Water Works Association (AWWA) M52 manual (2006). State Water Board staff:

- Developed a baseline estimate of water use that represents current demand and demand through one year after the first year of full implementation of the regulation
- Identified a set of water use efficiency measures based on applicability to the objective and baseline
- Determined a water use efficiency profile for supplier for the measures listed in the step above
- Derived water savings associated with each measure for each supplier
- Calculated the set of efficiency measures with the lowest cost that reduce residential indoor and outdoor water use to levels that comply with the proposed regulation
- Identified the benefits to customers and utilities

- Identified capital projects that may be delayed or downsized by reductions in water demand
- Calculated the avoided costs resulting from capital project delays or reductions
- Determined cost savings associated with reduced operations and maintenance (O&M) needs, energy use reductions, and other related cost savings associated with reductions in water use and wastewater flows
- Combined the avoided capital costs and O&M cost savings into marginal costs
- Computed benefits by combining water savings and marginal costs

Detailed descriptions of the least-cost modelling approach and underlying data analyses are provided in Appendices B and E. The accuracy of resulting estimated of costs and benefits of water use reductions relies on accurate estimates of water savings, their related costs, and the benefits resulting from the water savings. Maddaus (1996) and Maddaus Water Management, Inc. (2000) developed a framework to evaluate potential conservation that considers region-specific demographics, land use, and water-use behavior, all of which are important in analyzing effective water use efficiency measures. Following this guidance, we assembled data from sources of census tract data and parcel-level data, and information on other supplier attributes, to estimate impacts across all suppliers. The main datasets used in this assessment and respective sources are:[11]

- Population estimates and inflation forecast - Department of Water Resources' Urban Water Management Plan data and California Department of Finance data
- End-use modeling water efficiency estimates - parcel-level county assessor data
- Residential indoor, residential outdoor, CII DIM water use estimates and projections - State Water Board's electronic Annual Report (eAR) data
- Efficiency measures, rebates, and projections - eAR data and State Water Board's outreach (stakeholder data)
- Agency attributes - eAR data
- Water loss - State Water Board data, DWR data
- Variances and recycled water use - eAR data and State Water Board data
- Climate and drought effects - climate models, water use data and scientific literature

While we implemented the modeling at the supplier-level and used supplier-specific characteristics to model current and future water use demand, determining the costs associated

[11] More generally, data used in this SRIA come from public data sources, data reported by suppliers as part of monthly and annual compliance with statewide regulations, wastewater data for collection and treatment systems collected by the State Water Board, public and private sector data for urban landscapes and trees, economic, population, and inflation data for California collected or estimated by DOF. Data and data sources are described in more detail in the Appendices.

with water use efficiency measures for every supplier was not possible. Instead, we estimated the costs and benefits for suppliers for which there were available data. This list of suppliers with available data totaled 391 agencies representing in 2022 approximately 34.6 million people, or 89 percent of the total statewide population potentially affected by this regulation. The omission of the suppliers without available data, however, should not materially affect the findings in this assessment.

CII DIM Landscapes and CII Performance Measures

In California, standards and guidelines for water demand management on CII landscapes have been developed over the past decades. The strategies being considered for CII landscapes as part of AB 1668 and SB 606 reflect many of the previously developed recommendations and guidelines. As described above, AB 1668 and SB 606 incorporate the water demand of CII landscapes in two ways. First, there would be a specific standard for CII landscapes with DIMs that is part of the supplier's water use objective. Second, the regulation would include several performance measures that direct suppliers to improve the efficiency of water use in the CII sector.

These performance measures would direct suppliers to categorize CII customers according to a uniform, statewide classification system as well as to implement various best management practices. Such best management practices would primarily focus on improving the efficiency of outdoor water use and include actions such as installing DIMs (or an equivalent or in-lieu technology)[12] on landscapes that exceed a certain threshold, completing water audits, and providing certain CII customers with their water use data in a format that empowers those customers to track and manage water consumption with U.S. EPA's ENERGYSTAR portfolio manager. As noted, process water will not be affected by the proposed regulation.

For several reasons, including data gaps, we did not estimate the cost associated with categorizing CII customers or with complying with the CII standard. Instead, for this assessment, a supplier's cost for the CII performance measures is assumed to be the sum of:

1) the cost associated with installing a DIM, or an equivalent or in-lieu technology, on properties that exceed a certain landscape area threshold, and also the costs associated with performing certain BMPs for those affected properties; and
2) the cost associated with suppliers carrying out the BMP to provide "disclosable buildings" with water use data in a format compatible with ENERGYSTAR portfolio manager.

[12] Equivalent technologies: technologies are functionally equivalent to dedicated irrigation meters in terms of accuracy and supplier accessibility. In-lieu technologies: technologies that can be used in-lieu of dedicated irrigation meters. These include but are not limited to those that are functionally similar to dedicated irrigation meters, such as sub-meters, as well as those technologies that also facilitate water savings such as audits, efficient irrigation devices, or irrigation budgets.

The CII baseline is characterized by (a) those suppliers already providing “disclosable buildings” with water use data in a format compatible with ENERGYSTAR portfolio manager; and (b) the set of current CII properties in the suppliers’ service areas that would meet or exceed a water use threshold. The CII baseline therefore is derived from an analysis of California land use data and water use data obtained from several sources.

There are already a handful of communities in California that require buildings of a certain size to report water and energy use through ENERGYSTAR portfolio manager (ESPM). Those communities include San Jose, Brisbane, and Los Angeles. In estimating the statewide costs associated with their 2018 Benchmarking Regulation, the California Energy Commission (CEC) specifically estimated the costs that energy utilities might incur in providing the owners of “disclosable buildings” with energy use data in a format compatible with ESPM. These statewide costs were estimated to be highest in the first year of implementation and would decrease in the following years (CEC 2018). We assumed that the costs associated with implementing the BMP in the proposed regulation that would require suppliers to provide “disclosable buildings” with water use data in a format compatible with ESPM would be akin to the energy utility costs estimated by the CEC. The difference is that the costs associated with the proposed regulation exclude those communities that already require “disclosable buildings” to report building water use.

Limited water user data exist for CII landscapes that already have dedicated irrigation meters. In December 2019, the California Water Efficiency Partnership (CalWEP) and the Alliance for Water Efficiency (AWE) published a report focused on lessons learned for CII landscape irrigation management (CalWEP and AWE 2019). Based on reported results from surveyed agencies, a large percentage of agencies had fewer than 25 percent of CII properties connected to existing dedicated irrigation meters. The majority of surveyed agencies had less than half of their CII properties connected to dedicated irrigation meters. A small set of interviewed agencies also reported wide variance in the number of CII properties with dedicated meters that also have developed water budgets to manage irrigation.

The eAR requires water systems to report to the State Water Board the number of service connections by meter type, which include “landscape irrigation” accounts, assumed to be DIMs, and the volume of water delivered to those metered service connections. Demand is tracked by month and year. Of all suppliers, 302 suppliers had water use data associated with “landscape irrigation.” This demand, however, can be associated with CII and residential customers.

To assess the number of affected properties for which DIMs would be required, we first estimated the number of CII properties meeting or exceeding the threshold within each supplier’s service area. The number of potentially affected properties within each suppliers’ service area that would meet or exceed a water use threshold was calculated by estimating, for each CII property, its landscape area and water use based on local climate conditions.

Information about the landscape area for affected CII properties within each supplier’s service area was estimated using a land use database, based on land use codes that are associated with commercial, recreational, industrial, transportation, communications, agricultural, and institutional parcels (codes 2000–7999 and 9001–9400). Vacant properties were not included as part of this analysis. The landscape area for CII properties was estimated by subtracting the building footprint of a property from the total lot area. The lot area was estimated using geographic information system (GIS) software for each parcel in the state, and the corresponding building size was extracted from Microsoft’s 2018 open-source spatial database of building footprints.

The current lack of data for existing DIMs, landscape area, and the variety of water sources that supply CII properties limits detailed evaluations of potential water savings from CII landscape irrigation management programs. Thus, an Excel-based tool was created to evaluate the number of affected properties by the landscape area, which in turn was used to calculate annual water demand using the maximum applied water allowance formula, according to California Code of Regulations, title 23, section 492.4. For all properties in a supplier’s service area, irrigation demand for CII properties was estimated by multiplying the land area by the supplier’s reference evapotranspiration, a coefficient of efficiency (0.8), and the conversion factor (0.62).

Major Regulation Determination

For a proposed regulation that meets the definition of “major regulation,” the State Water Board must submit a Standardized Regulatory Impact Assessment (SRIA) to the California Department of Finance as part of the rulemaking process. A major regulation includes any proposed rulemaking that will have an economic impact in an amount exceeding $50 million. “Economic impact” is defined as all costs and benefits (direct, indirect, and induced) of the proposed regulation on business enterprises and individuals located in or doing business in California. The impact is computed without regard to any offsetting benefits or costs that might result directly or indirectly from that adoption. In other words, the economic impact is the total sum of costs and benefits, rather than a “net” cost or benefit. To determine whether the proposed *Making Water Conservation a California Way of Life* regulation has an economic impact of over $50 million dollars, we calculated the economic impact for the suppliers and for the businesses and employees paid by suppliers.

The time horizon for determining whether a proposed regulation is “major” is any 12-month period between the date the major regulation is estimated to be filed with the Secretary of State through 12 months after the major regulation is estimated to be fully implemented. We assumed that the regulation will be filed with the Secretary of State in 2024 and fully implemented by the end of 2035. The proposed regulation will remain in effect and will benefit California beyond 2035. To account for that, this SRIA covers years 2025 through 2040. Significant benefits are expected to continue beyond 2040, but are not quantified. The 12-month period chosen for the major regulation determination was year 2025, the year in which estimated cost impact is greatest.

“Economic impact” is the sum of direct, indirect, and induced impacts. Direct impact of the proposed regulation is spending by the suppliers as they achieve water use efficiency objectives. This includes spending on various incentives and rebate programs to increase water use efficiency, such as the installation of low-flow toilets and clothes washers, implementing household leak detection programs, and funding installation of low-water-use landscapes on residential and CII properties. The dollar value of this spending has an impact on the economy and is revenue for the companies that make devices such as low-flow toilets and leak detection equipment. The companies that make toilets and monitoring equipment must subsequently purchase materials from their material or component suppliers, such as valves and electronic switches. This spending on materials from material or component suppliers is the indirect impact on the economy. Lastly, employees and owners at toilet and monitoring equipment companies, and employees and owners at the material and component suppliers, will receive more income and their families will likely use the extra income to purchase additional household items. This is the induced effect. The overall economic impact is measured by increased sales (the output effect) in the economy.

As analyzed in later sections of this assessment, the combined costs of program creation and reporting, residential water use efficiency measures, CII DIM performance measures, lost revenues, infrastructure improvement, and other types of impacts are estimated to be approximately $4.7 billion in 2025, while the combined benefits are estimated to be approximately $671 million in that year. To evaluate the sum of direct, indirect, and induced effects, we relied on the RIMS II model (described in the Economy-Wide Impacts section). RIMS II industries each have different multipliers in the model, converting new, direct spending into the industry into indirect and induced effects. Based on the application of these multipliers to the estimated costs and benefits, the proposed regulation is expected to increase the state's gross output by $4.1 billion in 2025. Therefore, the *Making Water Conservation a California Way of Life* regulation is a major regulation, and a SRIA is required.

Direct Costs of Proposed Regulation

Suppliers are the only parties on which the proposed regulation imposes obligations. However, as explained next, we assumed that both suppliers and their customers will incur expenses under the proposed regulation. More specifically, we assumed that suppliers would offer rebate and incentives programs to their residential customers, and that these customers would then take advantage of such programs and implement water use efficiency measures. We estimated these expenses from 2025, the first year of required milestones, to 2040. Thus, direct costs that suppliers will incur due to the proposed regulation are assumed to consist of:

a) costs associated with program creation and reporting
b) costs associated with the residential water use efficiency measures (mostly the cost of rebate and incentives programs)
c) costs associated with the CII performance measures
d) suppliers' lost revenues due to water saved through the residential water use efficiency measures and CII performance measures

Expenditures that their residential customers will potentially incur under the proposed regulation are the costs associated with the implementation of residential water use efficiency measures, which subsequently will be partially offset by the suppliers' rebates. Customers might also be affected indirectly: suppliers may choose to pass on some or all of their costs to them, likely in the form of higher (or lower) monthly water bills (compared to the assumed future baseline, i.e., water bills absent the proposed regulation). The analysis of that potential indirect impact is described in the Cost Pass-Through and Impacts on Water Bill section.

In this assessment, the direct costs incurred by privately-owned and publicly-owned suppliers are analyzed separately. This section analyzes direct costs incurred by privately-owned suppliers only. The Fiscal Impacts on Local Governments section analyzes direct costs incurred by publicly-owned suppliers.

Program Creation and Reporting Costs

As a result of the proposed regulation, suppliers likely will have to develop water reduction strategies, including rebate and other incentives programs. We assumed that the costs for a supplier to learn the new regulation and create a cost-minimizing plan to meet its water use objectives are one-time costs. We also assumed that there will be ongoing administrative compliance costs of reporting. As discussed in subsequent sections of this assessment, we assume that suppliers will ultimately pass on these costs to customers.

Consistent with water reduction strategies developed in the past, we assumed that suppliers would devote staff resources toward creating and implementing the new rebate and incentives programs. We estimated the one-time cost to a supplier for creating programs to be approximately $27,000 in the first year. This amount is based on one quarter of the annual work hours of a typical engineer.[13] Additionally, we estimated the annual administrative reporting costs per supplier as approximately $5,000, which is based on the annual cost of one eight-hour day each month for a typical engineer. These work-hour estimates for the general program cost and reporting costs were obtained based on outreach with suppliers across California and a review of conservation programs statewide.

The table below shows the general program cost and annual reporting costs across all privately-owned suppliers. The general program cost and reporting costs across all privately-owned suppliers are $2.3 million in 2025 and approximately $370,000 per year thereafter.

Note that all monetary values presented in this SRIA, including dollar amounts for the estimated costs, benefits, and statewide impacts of the proposed regulation, were adjusted to constant 2022 dollars unless noted otherwise. This adjustment relied on the Department of Finance's

[13] One-quarter time is 500 hours out of a 2,000-hour work year. The median California wage for a mechanical engineer is $53.99 per hour as reported by the Employment Development Department, State of California (2022).

most recent inflation forecast available at the time the SRIA was finalized, *US-CA-Inflation-Forecast-MR-2022-23* (DOF 2022c).

Table 12: Cost of water efficiency program creation and required reporting incurred by privately-owned suppliers

Year	Program Creation ($ million)	Reporting ($ million)	Total ($ million)
2025	1.94	0.37	2.32
2026	0	0.37	0.37
2027	0	0.37	0.37
2028	0	0.37	0.37
2029	0	0.37	0.37
2030	0	0.37	0.37
2031	0	0.37	0.37
2032	0	0.37	0.37
2033	0	0.37	0.37
2034	0	0.37	0.37
2035	0	0.37	0.37
2036	0	0.37	0.37
2037	0	0.37	0.37
2038	0	0.37	0.37
2039	0	0.37	0.37
2040	0	0.37	0.37

Residential Water Use Efficiency Measures

Suppliers will need to achieve water reductions to meet water use objectives beginning in 2025. As discussed above, suppliers' objectives become more restrictive through 2035 when they reach the strictest of the proposed standards for residential water use. Suppliers typically implement a variety of strategies to promote indoor and outdoor water use efficiency and conservation, but generally rely on a smaller set of primary tools to reduce indoor water use. These strategies tend to rely on technology-based approaches, yield more assured cost savings, yield the largest water savings per dollar invested, and emphasize important environmental and social goals.

Based on the findings from outreach with suppliers across California and a review of conservation programs statewide obtained from the eAR data, we directly modeled four strategies, i.e., water use efficiency measures that suppliers would undertake through rebate and incentive programs (see Appendix B). Semi-structured interviews completed with suppliers and review of conservation program data found that the biggest water use efficiency opportunities are in detecting leaks, replacing low-efficiency toilets and washing machines, and transitioning away from turf. In fact, the fixtures using the most water indoor are toilets, with 14.2 GPCD, and an upgrade to efficiency appliances across the board can translate to as much as a 35 percent decrease for indoor water use. Moreover, outdoor water use is approximately 50 percent of the total annual household water use. The most promising methods of outdoor water conservation are transitioning away from turf-dominant to California-friendly landscapes and increasing the efficiency of irrigation systems. Savings estimates for landscape conservation programs range from 20 percent water reduction for lower cost conservation programs to 50 percent for more effective programs.

Thus, consistent with our findings, the following four strategies were modeled in our least-cost analysis:

1) Suppliers would offer a rebate program so that households would install premium high efficiency toilets;
2) Suppliers would offer a rebate program for high efficiency clothes washing machines;
3) Suppliers would conduct home leak detection alerts that can capture losses from indoor and outdoor leaks;
4) Suppliers would promote conversion of lawn to California-friendly gardens.

The four-strategy approach is a reasonable modelling assumption. If more strategies were added to our least-cost analysis, then suppliers' costs would be expected to decrease, not increase, compared to under the above four strategies because suppliers would have additional options. Thus, the four-strategy approach yields conservative results as it might be overestimating suppliers' costs of residential water use efficiency measures.

The table below shows the relevant parameters for the four strategies that went into the least-cost analysis: water savings for each unit of water use efficiency measure, in gallons per year, and the cost, in dollars, incurred by a supplier for each unit of water use efficiency measure implemented. These parameters were derived from the Alliance For Water Efficiency's Water Conservation Tracking Tool (The Conservation Library), literature, and semi-structured interviews completed with suppliers.

The costs shown in the table for high-efficiency toilets and washers and turf conversion are the costs that we assumed suppliers would incur with rebate and incentives programs (suppliers would then pass them on to customers over time through higher water bills (relative to the assumed future baseline), which we analyze in the Cost Pass-Through and Impacts on Water Bill section). The costs shown in the table for leak detection and alerts (alerts would be sent by text, email, phone, mail, or door hanger to households with potential leaks) will be incurred entirely by the suppliers and no rebates or incentives would be necessary.[14] The full costs for the high-efficiency appliances and turf conversion, which will be incurred by residential customers before they receive suppliers' rebates, are discussed later in this section.

[14] We assumed that households who elect to participate in the programs will already have meters, which allow for the detection of potential leaks.

Table 13: Water savings and supplier costs of residential efficiency measures

Residential Measure	Water Savings		Supplier Cost	
High-efficiency toilet	7,356	gals/toilet/yr	$160	/toilet
High-efficiency washer	7,714	gals/washer/yr	$160	/washer
Leak detection & alerts	256	gals/home/yr	$1	/home
Turf conversion	36	gals/sqft/yr	$2	/sqft

Privately-Owned Suppliers

In our analysis, 33 of all privately-owned suppliers are assumed to achieve water reductions through residential water use efficiency measures. Table 14 shows the estimated direct costs that these suppliers will incur in the years 2025 through 2040 with the programs for the residential indoor and outdoor water use efficiency measures, namely, rebates for toilet replacement and clothes washer replacement, incentives for turf conversion, plus a leak alert program. It is assumed that suppliers will disburse the rebates and other incentives in the same year that their customers implement the residential water use efficiency measures. The Fiscal Impacts on Local Governments section describes the equivalent table for publicly-owned suppliers.

The estimated direct costs are shown for the four types of water use efficiency measures and were obtained directly from the least-cost analysis (see Appendix E).[15] The direct cost incurred by privately-owned suppliers with residential rebate and incentive programs is approximately $451 million in 2025, and ranges between $13 million and $35 million per year in the following years. Direct costs will be incurred mainly in the first years of the proposed regulation as this is when much of the water use efficiency measures are expected to be implemented. Costs with rebate programs for turf conversion are the most significant, totaling $348 million in 2025, and ranging between $12 million and $33 million per year in the following years.

[15] Unless noted otherwise, we assumed that all prices and costs in this assessment change with the rate of inflation, and so are in constant 2022 dollars.

Table 14: Cost of residential efficiency measures incurred by privately-owned suppliers

Year	High-Efficiency Toilet ($ million)	High-Efficiency Washer ($ million)	Leak Detection ($ million)	Turf Conversion ($ million)	Total ($ million)
2025	64.51	38.55	0.09	348.13	451.28
2026	0.87	0.82	0.00	27.93	29.62
2027	0.23	1.43	0.00	27.93	29.59
2028	0.23	1.42	0.00	27.92	29.58
2029	0.23	1.41	0.01	27.84	29.49
2030	0.23	1.41	0.02	27.76	29.42
2031	0.56	1.70	0.08	28.75	31.09
2032	0.56	0.68	0.01	32.75	33.99
2033	0.56	0.68	0.01	32.75	33.99
2034	0.54	0.51	0.02	33.16	34.22
2035	0.32	0.37	0.25	30.85	31.79
2036	0.23	0.15	0.00	12.97	13.35
2037	0.23	0.15	0.00	12.97	13.35
2038	0.23	0.15	0.00	12.97	13.35
2039	0.23	0.15	0.00	12.97	13.35
2040	0.23	0.15	0.05	12.30	12.73

As noted, much of the estimated costs are driven by turf conversion. This happens for two main reasons. First, landscaping upgrades in general, such as lawn conversion and irrigation upgrades, can be relatively expensive. Second, there are relatively more opportunities for residential outdoor water use efficiency programs, like turf conversion incentives programs, in the service areas of the suppliers analyzed than there are for toilet and clothes washer rebate programs. In fact, toilet and clothes washer programs are already widely used, and likely have already replaced many of the older toilets and washers in suppliers' service areas. Also, many older toilets and washers have already been replaced with more efficient devices in recent years through "natural" replacement of fixtures that reach the end of their effective lives. Residential outdoor water use efficiency programs, on the other hand, have been less widely used, leaving them as a likely source for greater shares of the water use reduction strategies, as reflected in the above results.

The reduction in water use (compared to the assumed future baseline), measured in acre feet, resulting from the residential efficiency measures is significant. Reduction in water use is obtained from the least-cost analysis and described in detail later in the Benefits of Proposed Regulation section.

Residential Customers

As noted, the proposed regulation applies to suppliers only. Customers who elect to participate in rebate and incentives programs their suppliers may offer will incur upfront costs associated with the implementation of the residential water use efficiency measures. For example, participating customers will pay for new low-flow toilets and installation costs before they receive the rebate from their supplier. In this section, we analyze the expenses that residential customers who elect to participate in the rebate and incentives programs will incur to implement the residential water use efficiency measures.

While the prior section focuses on privately-owned suppliers only, this section does not make such a distinction. Thus, it combines residential customers of both privately-owned suppliers and publicly-owned suppliers.

The table below shows the expenses that residential customers are assumed to incur per unit of residential water use measure, including installation costs, before any rebates from suppliers. The costs are based on actual market prices and wages (e.g., PG&E 2023; Cooley, H. and Phurisamban, R. 2016; EDD 2022). The table also shows the per-unit costs to residential customers after they receive the rebates. As noted, the costs for leak detection and alerts will be incurred entirely by the suppliers.

Table 15: Customer cost of residential efficiency measures

Residential Measure	Before Rebate		After Rebate	
High-efficiency toilet	$319	/toilet	$159	/toilet
High-efficiency washer	$909	/washer	$749	/washer
Leak detection & alerts	$0	/home	$0	/home
Turf conversion	$6	/sqft	$4	/sqft

The costs of the residential water use efficiency measures shown in the table do not account for the fact that many of the customers who elect to participate in the rebate programs for toilets, washers, and turf conversion most likely will be just “accelerating” the implementation of water use efficiency measures they would eventually take by some years. That is, at some point these customers would have implemented the efficiency measures (purchased and installed low-flow toilets, high-efficiency washers, replaced turf with California-friendly landscape) even in the absence of the rebate programs, but, under the programs, they will do so sooner.

For this type of customer, the rebate programs can have significant effects on water savings but little impact on the total costs that the customers incur (only on the timing of such costs). The earlier implementation of the measures have real effects on water savings because the sooner they are implemented, the more time there is for their long-lasting effects to accrue, and thus the greater is the total amount of water saved.[16] However, customers who “accelerate” the implementation of conservation measures will still incur the full costs associated with these measures (e.g., the price paid for low-flow toilets and installation) regardless of the availability of the rebate programs. The only difference is that with the rebate program these customers will incur such costs sooner (and of course receive a rebate later). This is in contrast with the other type of customer, those who would have never implemented the conservation measures in the

[16] To account for the water that would have been saved in the baseline by customers who “accelerate” the implementation of water use efficiency measures, the estimation of baseline water use incorporates historical replacement rates (rates at which water fixtures would be replaced in the absence of the proposed regulation, based on historical data. Appendix B provides further detail). The least-cost model relies on that estimated baseline water use.

absence of the rebate programs, and therefore would have never incurred those costs if it were not for the program.[17]

To account for the difference between these two types of customers, we adjusted the costs shown in the table above for toilets, washers, and turf conversion. We conservatively assumed that 60 percent of the customers who elect to participate in the rebate programs are of the type that accelerates the implementation of conservation measures in response to the suppliers' rebate programs, and the remaining 40 percent are of the type that would not have implemented the efficiency measure in the absence of the rebate programs.[18] Then, it can be shown that the *average* cost that customers will incur to implement an efficiency measure under the proposed regulation is 40 percent of the full cost shown in the table above.[19]

The table below shows the expenses incurred by all customers who elect to participate in the rebate programs, and accounts for the cost adjustment described earlier. As noted earlier, expenditures will be incurred mainly in the first years of the proposed regulation as this is when much of the water use efficiency measures are expected to be implemented. Before rebates, the upfront expenses incurred by customers with the residential water use efficiency measures is almost $4 billion in 2025, and ranges between $50 million and $300 million per year in the following years. The largest costs are for turf conversion: almost $3 billion in 2025, before rebates. After rebates are accounted for, expenses incurred by customers with the water use efficiency measures are almost $700 million in 2025, and range between $7 million and $51 million per year in the following years. Note that residential customers do not incur expenses for

[17] Or, more precisely, they would have not incurred such costs during the period analyzed (2025-2040).

[18] This assumption relies on existing studies about individuals' behavior in the context of rebate or other incentives programs, most of which are in the energy efficiency space (research on this particular type of behavior is scarce in the water use efficiency space). The studies typically document two types of behavior: (a) individuals who would have implemented the efficiency measure even in the absence of the rebate program, but, under the program, they do so sooner (these individuals are commonly referred to as "inframarginal" individuals); (b) individuals who would not have implemented the efficiency measure in the absence of the rebate program, but, under the program, they do (commonly referred to as "marginal" individuals). The studies show a relatively large proportion of inframarginal individuals. Sébastien and Aldy (2014) estimate that inframarginal individuals are 91 percent, 92 percent, and 73 percent of all individuals purchasing refrigerators, clothes washers, and dishwashers, respectively, through an energy efficiency rebates program. Boomhower and Davis (2014) find that for the same program, more than 65 percent would have purchased an appliance in the absence of rebates. Alberini, Gans, and Towe (2014) find evidence that rebate programs for energy-efficient heat pumps had between 50 percent and 89 percent of inframarginal participants.

[19] To illustrate, assume that 60 percent of the customers who participate in the rebate program are of the inframarginal type and 40 percent are of the marginal type. P = full cost of efficiency measure (and assume P is the same regardless of the availability of the rebate program, and constant in real term throughout the 2025-2040 period); R = suppliers' rebate; N = number of customers who elect to participate in the rebate program. Then, the inframarginal type spends $(P–R) under the rebate program, and $P in its absence. Thus, the cost of the proposed regulation for an inframarginal customer is $(–R) (a benefit). The marginal type spends $(P–R) under the rebate program, and $0 in its absence. Thus, the cost of the proposed regulation for a marginal customer is $(P–R). Therefore, the cost of the regulation for all customers participating in the rebate program is $(0.60 \times (-R) + 0.40 \times (P-R)) \times N = (0.40 \times P - R) \times N = 0.40 \times P \times N - R \times N$. It follows that, under the proposed regulation, the average cost of the efficiency measure incurred by customers (before rebate) is 40 percent of P.

leak detection and alerts. As mentioned earlier, the cost of leak detection and alerts programs will be incurred entirely by suppliers.

Table 16: Cost of residential efficiency measures incurred by customers across all suppliers

Year	High-Efficiency Toilet ($ million)	High-Efficiency Washer ($ million)	Leak Detection ($ million)	Turf Conversion ($ million)	Household Cost: Before Rebate ($ million)	Household Cost: After Rebate ($ million)
2025	356.21	646.32	0	2,987.94	3,990.48	693.26
2026	12.81	40.97	0	198.22	252.00	47.71
2027	6.93	28.12	0	242.37	277.42	48.30
2028	2.28	35.05	0	250.94	288.26	54.59
2029	1.25	25.27	0	269.09	295.61	51.96
2030	1.90	14.12	0	280.88	296.90	47.22
2031	3.18	32.13	0	190.27	225.58	44.12
2032	2.94	23.10	0	207.52	233.55	41.58
2033	4.28	16.45	0	211.94	232.66	38.14
2034	5.35	11.93	0	213.08	230.36	35.50
2035	3.95	6.85	0	187.88	198.68	29.45
2036	0.85	2.03	0	47.08	49.97	7.59
2037	0.85	2.03	0	47.06	49.94	7.59
2038	0.85	2.03	0	47.05	49.93	7.58
2039	0.85	2.03	0	46.69	49.57	7.53
2040	0.85	2.03	0	42.11	44.99	6.88

If an average of 38.9 million individuals are assumed to reside in the service areas of all suppliers in the 2025-2040 period, then, before rebates, the upfront expenses incurred by customers with the residential water use efficiency measures are approximately $102.6 per person on average in 2025, and range between $1.3 and $7.7 per person on average, per year, in the following years. These average upfront expenses per individual do not account for subsequent rebates to customers, suppliers' cost past-through, or the avoided water cost by households resulting from the implementation of the residential water use efficiency measures.[20] The combined impact of all these components on water bills, which on average will be net positive in the 2025-2040 period (compared to the assumed future baseline), is analyzed in the Cost Pass-Through and Impacts on Water Bills section.

CII Performance Measures

A supplier's cost for the CII performance measures is assumed to be the cost associated with installing a DIM (or an equivalent or in-lieu technology) on, and performing certain BMPs for, the

[20] Alternatives are available for making efficiency programs more accessible for low-income households. Suppliers can, for example, partner with retailers to provide vouchers for discounts on water efficient devices upon sale, rather than on a reimbursement basis. Vouchers have been used for many years by water utilities to incentivize water conservation and efficiency measures (Cooley et al., 2022).

properties that exceed the proposed water use threshold, and the cost associated with providing certain CII building owners with their water use data in a format that enables those customers to track and manage water consumption with U.S. EPA's ENERGYSTAR portfolio manager. We estimated supplier's costs associated with implementing the CII performance measures listed below. We assumed suppliers will:

- Install dedicated irrigation meters (or an equivalent or in-lieu technology), DIM tie-ins, and backflow devices for CII landscapes exceeding 500,000 gallons in annual water use;
- Pay fees to local governments for permits and backflow inspections for newly installed dedicated irrigation meters;
- Implement program and account management and parcel water budget development;
- Provide owners of "disclosable buildings" with water use data in a format compatible with ESPM.

The costs associated with installing a DIM, paying the fees for the appropriate inspections to local governments, and carrying out the three BMPs (program and account management, parcel water budget development, and water use data compatible with ESPM) are assumed to represent the CII direct costs incurred by the suppliers. In estimating those costs, we assumed that suppliers would have to pay for the dedicated irrigation meters (including installation) as well as pay for other additional infrastructure upgrades needed to support the meters. Our assumption is conservative because, alternatively, suppliers could decide to implement one or more of these more affordable strategies: (a) the installation of smart irrigation controllers, hardware improvements with enhanced performance and functions, pressure-regulated sprinkler spray heads, or irrigation system flow sensors for leak detection, (b) the implementation of a budget-based rate structure with allocations for outdoor landscape, and (c) remote sensing monitoring for irrigation management for soil moisture and other information (e.g., weather forecast) to inform irrigation practices.

There are approximately 11,000 CII properties in service areas of privately-owned suppliers that will meet or exceed the proposed 500,000-gallon threshold. Table 17 shows the estimated costs to privately-owned suppliers of the CII performance measures associated with the DIMs (as noted before, publicly-owned suppliers are analyzed in the Fiscal Impacts on Local Governments section). The CII DIM costs are one-time costs per supplier or per connection. We assumed that one-sixth of these costs are incurred each year between 2025 and 2030 as suppliers reach CII compliance by 2030. There are no CII DIM-related costs in 2031 or later. The largest annual cost is the installation of the dedicated irrigation meters themselves, followed by required tie-in equipment. Backflow device installation is required, as are permit and backflow inspection fees, which are paid to local governments. Across all privately-owned suppliers, the total cost of the CII DIM performance measures is approximately $14 million per year between 2025 and 2030, of which about $7.5 million per year is for DIM installation on affected properties.

Table 17: Cost of CII DIM measures incurred by privately-owned suppliers

Year	DIM Installation ($ million)	DIM Tie-ins ($ million)	Backflow Device Installation ($ million)	Backflow Inspection ($ million)	Permit Inspection ($ million)	Total ($ million)
2025	7.47	5.97	0.15	0.15	0.30	14.04
2026	7.47	5.97	0.15	0.15	0.30	14.04
2027	7.47	5.97	0.15	0.15	0.30	14.04
2028	7.47	5.97	0.15	0.15	0.30	14.04
2029	7.47	5.97	0.15	0.15	0.30	14.04
2030	7.47	5.97	0.15	0.15	0.30	14.04
2031	0	0	0	0	0	0
2032	0	0	0	0	0	0
2033	0	0	0	0	0	0
2034	0	0	0	0	0	0
2035	0	0	0	0	0	0
2036	0	0	0	0	0	0
2037	0	0	0	0	0	0
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0

Table 18 shows the estimated costs to privately-owned suppliers of the CII performance measures associated with the three BMPs. Program and account management and parcel water budget development are mostly staff costs for suppliers. Parcel water budget development costs are one-time costs per supplier or per connection; like before, we assumed that one-sixth of costs are incurred each year between 2025 and 2030 as suppliers reach CII compliance by 2030. Program and account management is assumed to be an ongoing cost per supplier or connection.

The table also shows the cost associated with privately-owned suppliers carrying out the BMP to provide owners of "disclosable buildings" with water use data in a format compatible with ENERGYSTAR portfolio manager. As explained above, we assumed that the costs associated with implementing this BMP would be akin to the energy utility costs estimated by the CEC (CEC 2020). The difference is that the costs associated with this BMP exclude the communities that already require "disclosable buildings" to report building water use, namely, San Jose, Brisbane, and Los Angeles. To estimate the costs incurred by privately-owned suppliers only, the number of privately-owned suppliers as a fraction of the total number of suppliers was applied to CEC's estimated costs. Finally, we assumed that one-fifth of the costs are incurred each year between 2026 and 2030, as suppliers reach CII compliance by 2030. (We assumed suppliers will need 2025 to identify affected CII customers).

Across all privately-owned suppliers, the total cost of the CII BMPs is approximately $190,000 in 2025 and $560,000 per year between 2026 and 2030, of which $150,000 are for the initial water budget development and $370,000 are for the ESPM-compatible water use data. After 2030, together privately-owned suppliers incur ongoing costs of $40,000 for program and account management.

Table 18: Cost of CII BMPs incurred by privately-owned suppliers

Year	Program & Account Management ($ million)	Water Budget Development ($ million)	Water Use Data ($ million)	Total ($ million)
2025	0.04	0.15	0	0.19
2026	0.04	0.15	0.37	0.56
2027	0.04	0.15	0.37	0.56
2028	0.04	0.15	0.37	0.56
2029	0.04	0.15	0.37	0.56
2030	0.04	0.15	0.37	0.56
2031	0.04	0	0	0.04
2032	0.04	0	0	0.04
2033	0.04	0	0	0.04
2034	0.04	0	0	0.04
2035	0.04	0	0	0.04
2036	0.04	0	0	0.04
2037	0.04	0	0	0.04
2038	0.04	0	0	0.04
2039	0.04	0	0	0.04
2040	0.04	0	0	0.04

Lost Revenue

Most suppliers will need to achieve a locally-determined mix of residential and CII water reductions (discussed in previous sections) to meet their water use objectives. This means that most suppliers will not be selling as much water to their customers, and therefore earning as much revenue from it, as they would in the absence of the proposed regulation.

The reduction in water delivered to household and CII customers affects these suppliers in two opposite ways. On the one hand, suppliers' total variable cost of providing water will go down. That cost saving is a direct benefit to these suppliers, and we account for it later in the Avoided Water Purchases and Production section. On the other hand, suppliers' total revenue from water sales will go down too (before accounting for any offsetting effect from potential subsequent adjustments to their rate structures). This lost revenue is a direct cost for the suppliers, and we analyze it in this section.

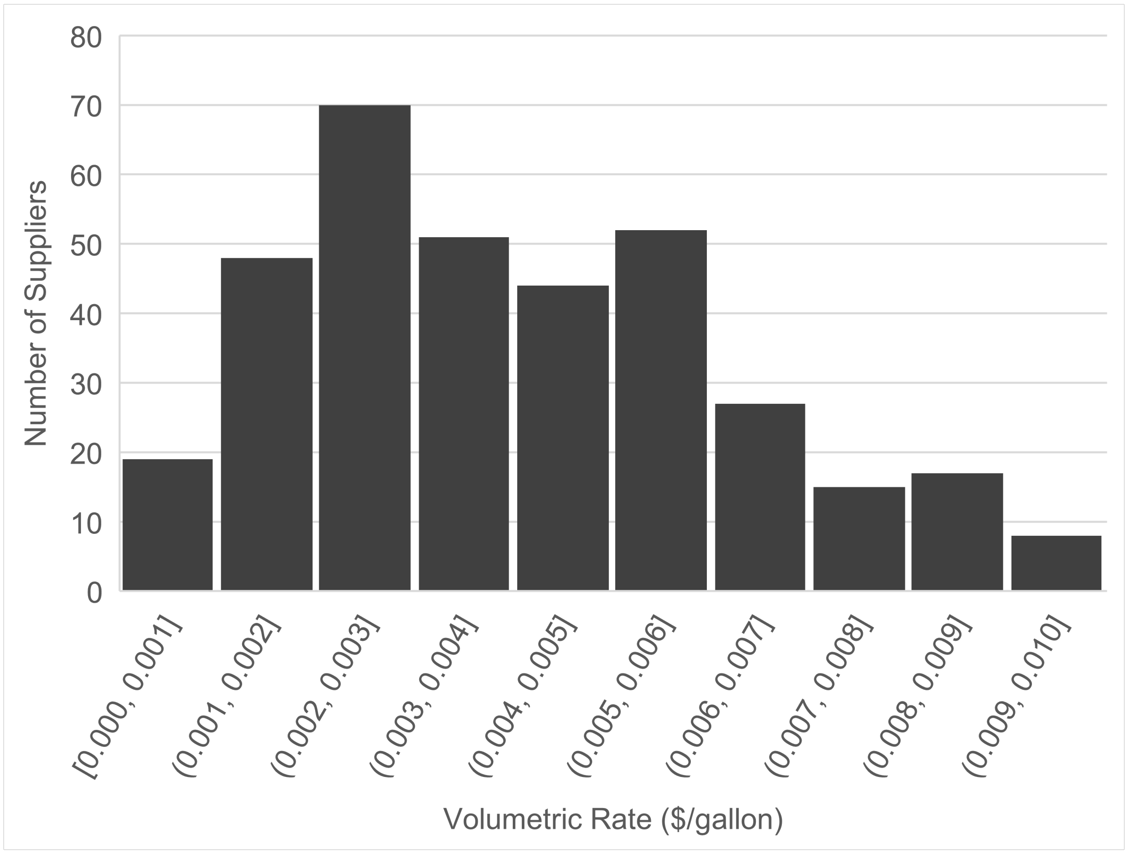
Ultimately, we expect that suppliers will fully make up for their lost revenues by adjusting their rates to end-customers over time. However, to make the lost revenue analysis in this section tractable, we keep rate structures the same in both the baseline scenario and under the proposed regulation. We discuss the potential effect of suppliers' lost revenues on higher water bills (compared to the assumed future baseline) in the Cost Pass-Through and Impacts on Water Bill section.

To calculate suppliers' lost revenues, we relied on the estimated volume of future residential water use reduction, i.e., suppliers' water savings from the residential conservation measures (we describe water savings in more detail in the Benefits of Proposed Regulation section). We also relied on data on the water rates currently charged to residential customers by suppliers. Suppliers' water rates are reported to the State Water Board periodically and have different structures and components (e.g., some suppliers charge a monthly base or fixed rate, which is independent of the volume of water used by the customer, plus a volumetric rate, which is applied to every gallon of water used by the costumer in that month; some suppliers set different volumetric rates for different water usage tiers).

To the extent possible, we relied on the volumetric rate component rather than on the fixed rate component of the rate structure, as, by definition, suppliers' revenue from the fixed rate will not be affected by water use reductions (i.e., revenue from the fixed rate is the same in the absence or presence of the proposed regulation because we assume here that suppliers make no changes to rate structures). Moreover, because only residential water rates are available, we are not able to calculate the impact on suppliers' revenue from reduced water sales to CII customers, which may pay different rates. Note, however, that much of the water savings is due to residential water efficiency measures rather than CII performance measures (as will be discussed in the Benefits of Proposed Regulation section), and therefore revenues lost on residential water sales, which can be calculated, will be significantly greater than revenues lost on CII water sales.

The median volumetric rate charged by the suppliers for which data are available is \$0.0038/gallon. The histogram below shows the distribution of volumetric rates charged by suppliers. Volumetric rates are grouped into bins along the horizontal axis. The height of each bar indicates the number of suppliers that fall into that bin. As shown in the histogram, volumetric rates can differ significantly across suppliers, from less than \$0.001/gallon to \$0.010/gallon. Our analysis accounts for that variation by relying on each of the suppliers' individual volumetric rates where available.

Figure 8: Suppliers' volumetric rates



This approach, however, has limitations. For example, volumetric rates are not always accurately reported to the State Water Board. Also, volumetric rate data in the format used here are not available for many suppliers (some do not adopt that type of rate structure, some do but do not report the value for the variable component of the rate, etc.). In such cases, we assumed the median variable rate of $0.0038/gallon. This assumption might lead to an overestimation of lost revenue of, for example, suppliers whose water reductions to meet objectives are relatively high and their actual volumetric rates are relatively low.

Lost revenue for a supplier was obtained by multiplying that supplier's water savings by the supplier's volumetric rate. The table below shows the combined lost revenues for privately-owned suppliers from 2025 to 2040. Because the volume of water savings increases over time, so does lost revenues: in 2025, privately-owned suppliers' lost revenues are estimated to be $32 million and, in 2040, approximately $80 million.

Table 19: Revenue lost by privately-owned suppliers if they do not adjust rates

Year	Lost Revenue ($ million)
2025	32.45
2026	34.67
2027	37.00
2028	39.48
2029	42.09
2030	44.86
2031	48.21
2032	51.77
2033	55.54
2034	59.54
2035	63.77
2036	66.73
2037	69.82
2038	73.05
2039	76.44
2040	79.98

Direct Cost for Typical and Small Businesses

Typical Business

To assess the direct cost impact on the typical regulated business (all regulated businesses are privately-owned suppliers), we analyzed the 67 privately-owned suppliers for which data were available. Combined, they serve approximately six million people statewide. For this analysis, a typical business is defined as a hypothetical privately-owned supplier with the average size and average attributes. The typical supplier thus defined has 22,000 service connections and serves approximately 92,000 people. The typical supplier would incur a direct cost of approximately $7.5 million in 2025. In subsequent years, the typical supplier would incur direct costs ranging between $1 million and $5 million.

Small Businesses

Suppliers are water companies (utilities) providing drinking water to the public and, pursuant to Government Code section 11342.610, are not small businesses.

Benefits of Proposed Regulation

Avoided Water Purchases and Production

One of the benefits of the proposed regulation that can be quantified is the water savings to suppliers and their customers. As a result of the proposed regulation, suppliers will spend less to acquire water, and similarly, customers will spend less on their water bills. These avoided water costs are discussed separately in this section for privately-owned suppliers and households who decide to participate in the rebate programs. The avoided water costs for publicly-owned suppliers are discussed in the Fiscal Impacts on Local Governments section.

Privately-Owned Suppliers

Suppliers will need to achieve residential and CII water reductions, in combination with use of variances and credits, where appropriate, to meet their water use objectives. The table below shows how much water privately-owned suppliers, combined, will save, as a result of their implementation of residential conservation measures and CII performance measures, beginning in 2025. These savings are calculated relative to the suppliers' water use estimates in the baseline, that is, in the absence of the proposed regulation. One of the limitations of this analysis is that it does not account for suppliers' possible use of variances and credits and, therefore, it may over-estimate water use reductions.

Most of the water savings come from the residential conservation measures. In 2025, privately-owned suppliers will save almost 33,000 acre-feet of water because of the residential measures. Water savings from the CII performance measures start in 2026 at about 3,000 acre-feet. Water savings increase gradually over time. Annually, privately-owned suppliers, combined, will save (relative to the assumed future baseline) from 37,000 acre-feet in 2026 to about 64,000 acre-feet of water in 2040. Cumulatively, privately-owned suppliers will achieve a total water reduction (relative to the assumed future baseline) of 894,000 acre-feet by the end of 2040.

Table 20: Water use reduction by privately-owned suppliers

Year	Residential (ac-ft)	CII (ac-ft)	Total (ac-ft)
2025	32,841	0	32,841
2026	34,531	3,254	37,785
2027	36,220	6,509	42,729
2028	37,910	9,763	47,673
2029	39,599	13,017	52,617
2030	41,289	16,272	57,561
2031	43,166	15,458	58,624
2032	45,042	14,685	59,727
2033	46,919	13,951	60,870
2034	48,796	13,253	62,049
2035	50,672	12,591	63,263
2036	51,398	11,961	63,359
2037	52,124	11,363	63,487
2038	52,850	10,795	63,645
2039	53,576	10,255	63,831
2040	54,302	9,742	64,044
Total	**721,236**	**172,868**	**894,105**

The residential water use efficiency measures and CII performance measures will have long-lasting effects. For example, turf replaced in 2025 will decrease water use not only in that year but also in subsequent years (compared to the assumed future baseline). Because of the long-lasting effects of the measures taken between 2025 and 2035, the year in which the residential standards are fully implemented, suppliers will continue to benefit from water savings for several years after 2035, even beyond 2040, the last year analyzed.[21]

As noted, suppliers will therefore spend less to acquire water. That is, reduced water purchases or reduced production by suppliers will result from their residential and CII measures. Suppliers' avoided costs from having to provide less water are calculated by multiplying the reduction in water delivered to customers (discussed above) and the suppliers' marginal cost of purchasing and producing water, which is a function of both the price that suppliers will pay to purchase or produce the water from 2025 to 2040 and their operational costs in that period.

To calculate a supplier's avoided water cost per acre-foot, we added the suppliers' average cost of purchasing an acre-foot of water to supplier-specific operational costs. We used the cost of purchasing water reported in annual water loss audits provided by suppliers to state agencies. Additionally, we used operational costs for distribution and treatment, such as the cost to pump, treat and deliver water to customers. These supplier-specific operational costs were obtained from the leak loss audit data. We estimated avoided water costs of approximately $1,970 per acre-foot on average in 2025, and ranging across suppliers from $1,300 per acre-foot to $3,500 per acre-foot in that year.

[21] For purposes of this analysis, however, available information supports a conclusion that neither the benefits nor the costs in any 12-month period will be greater after 2040 than in any 12 month period during the period of analysis.

To estimate the avoided water costs per acre-foot from 2025 to 2040, we assumed that (a) supplier-specific operational costs would remain constant over time in real terms, and (b) the average price that suppliers would pay for an acre-foot of water would grow over time in real terms.

California water suppliers have experienced various levels of water price growth in the past. The average nominal growth of water price from 2003 to 2015 was about 6.3 percent (Gaur and Diagne 2017), which, after adjusting for the average inflation rate in California during that same period, is equivalent to an average real growth of 4.2 percent in the price that suppliers pay for water. In this assessment, we assume that suppliers will continue to experience various levels of water price growth in the future. It is expected that water in the future will be at least as expensive as it is now, relative to the future general price level. A range of factors, such as climate change and the need for water treatment, may contribute to that trend. Accordingly, in this assessment, we assume that the average water price increases at an annual real rate of 4.2 percent in the 2025-2040 period.

Supplier-specific avoided water cost per acre-foot, together with their water use reductions, were used to calculate suppliers' avoided water costs. The table below shows the water costs avoided by privately-owned suppliers, resulting from the residential water use efficiency measures and CII performance measures. Most of the avoided water costs are associated with the residential measures. In 2025, privately-owned suppliers' avoided costs total $59 million. In the following years, avoided water costs increased gradually from $69 million in 2026 to almost $180 million in 2040.

Table 21: Water cost avoided by privately-owned suppliers

Year	Residential ($ million)	CII ($ million)	Total ($ million)
2025	58.58	0	58.58
2026	62.82	6.60	69.42
2027	67.33	13.57	80.90
2028	72.12	20.92	93.04
2029	77.21	28.70	105.90
2030	82.61	36.91	119.51
2031	88.86	36.09	124.94
2032	95.48	35.30	130.78
2033	102.50	34.54	137.04
2034	109.94	33.81	143.75
2035	117.82	33.11	150.93
2036	123.47	32.43	155.90
2037	129.41	31.78	161.19
2038	135.67	31.14	166.81
2039	142.25	30.53	172.79
2040	149.18	29.95	179.13

Residential Customers

Customers who elect to participate in the rebate programs of affected suppliers will not use as much water as they would in the absence of the proposed regulation. These water savings are a direct result of the water use efficiency measures that residential customers implement. All else being equal, water savings mean lower water bills (compared to the assumed future baseline). More specifically, water savings mean residential customers will not pay as much for their total indoor and outdoor residential water as they would in the absence of the proposed regulation (before accounting for any offsetting effect from suppliers' potential subsequent adjustments to their rate structures). Thus, the avoided water cost is a benefit for these customers.

The avoided water cost for residential customers is necessarily equal to suppliers' lost revenue, discussed in the Lost Revenue section. In fact, these are just two ways of looking at the same transaction. From the perspective of the residential customer, the customer needs less water and, therefore, purchases less water from the supplier. From the perspective of the supplier, the supplier sells less water to the customer and, therefore, earns less revenue.

As noted above, ultimately, we expect that suppliers will fully make up for the lost revenues by adjusting their rates to end-customers over time. However, in this section the analysis assumes that rate structures are the same in both the baseline scenario and under the proposed regulation. We discuss potential pass-through to residential customers through changes to rate structures in the Cost Pass-Through and Impacts on Water Bill section.

While the prior section focused on privately-owned suppliers only, this section does not make such distinction. Thus, it combines residential customers of both privately-owned and publicly-owned suppliers.

Water cost avoided by residential customers was obtained from the estimated lost revenue for privately-owned and publicly-owned suppliers, shown, respectively, in Tables 20 and 21 of this assessment. The table below shows the avoided water cost for residential customers from 2025 to 2040. Because the volume of water savings increases over time, so does water costs avoided by residential customers: customers are estimated to avoid approximately $213 million in water costs in 2025, and approximately $598 million in 2040.

Table 22: Water cost avoided by residential customers across all suppliers

Year	Water Cost Avoided by Households ($ million)
2025	213.37
2026	233.88
2027	255.73
2028	279.00
2029	303.78
2030	330.15
2031	355.71
2032	382.84
2033	411.63
2034	442.15
2035	474.51
2036	497.00
2037	520.54
2038	545.18
2039	570.97
2040	597.97

Water cost avoided by CII customers cannot be estimated with the available data, for the same reasons suppliers' lost revenue due to the CII performance measures cannot be estimated (these reasons were discussed earlier in the Lost Revenue section). Note, however, that much of the avoided water cost is due to residential water efficiency measures rather than CII performance measures.

Rebates and Other Incentives

In the Direct Costs of Proposed Regulation section, we discussed suppliers' rebates and incentives programs associated with the implementation of the residential water use efficiency measures. While rebates and incentives will be a direct cost incurred by suppliers, they will also be a benefit for residential customers who elect to participate in these programs. We assume that rebates and incentives will be disbursed to the residential customers in the same year that they implement the water use efficiency measures. The table below shows annual rebate and incentive amounts that these customers will receive in 2025-2040 from the affected suppliers. Because most of the efficiency measures are implemented in the first years of the proposed regulation, a greater portion of the rebates and incentives are paid to residential customers then. In 2025 alone, affected suppliers will pay almost $3.3 billion in rebates and other incentives to residential customers who elect to participate in their programs.

Table 23: Rebates and incentives to residential customers across all suppliers

Year	Rebates and Incentives to Households ($ million)
2025	3,297.22
2026	204.29
2027	229.12
2028	233.67
2029	243.66
2030	249.68
2031	181.46
2032	191.98
2033	194.52
2034	194.86
2035	169.23
2036	42.38
2037	42.35
2038	42.35
2039	42.04
2040	38.11

Avoided Stormwater Measures

The benefits to suppliers from the CII performance measures also include avoided stormwater-related expenses. Heavily irrigated commercial properties cause stormwater quantity and quality issues and require investments in stormwater infrastructure. Suppliers spend less on corrective measures when runoff is reduced. Based on existing literature, we used the estimated cost of stormwater-related corrective measures of approximately $20 per acre-foot (CalWEP/CaDC 2021). As with the avoided water purchases and production, stormwater-related avoided costs are a function of the water use reduction discussed previously. As shown in the table below, privately-owned suppliers’ annual stormwater benefits increase from null in year 2025 to approximately $210,000 in 2040.

Table 24: Stormwater-related costs avoided by privately-owned suppliers

Year	Stormwater Avoided Cost ($ million)
2025	0
2026	0.07
2027	0.14
2028	0.21
2029	0.28
2030	0.35
2031	0.33
2032	0.31
2033	0.30
2034	0.28
2035	0.27
2036	0.26
2037	0.24
2038	0.23
2039	0.22
2040	0.21

Energy Savings

Upgrading to more efficient fixtures and appliances leads to both water savings and energy savings. For example, ENERGYSTAR certified clothes washers use about 30 percent less water and 20 percent less energy compared to regular clothes washers (ENERGYSTAR). Energy savings that result from the proposed regulation were calculated based on the estimated water savings resulting from the replacement of inefficient clothes washers with more efficient ones (water savings were estimated with the least-cost model, discussed in previous sections). Clothes washers use heated water and heating that water requires energy. Thus, because more efficient washers use less water than inefficient ones, less water needs to be heated, and less energy is used.

We estimate that replacing inefficient clothes washers with more efficient clothes washers across suppliers' service areas will result in approximately $32 million in energy savings in 2025 and increased energy cost savings thereafter, reaching almost $54 million in 2040. The table below shows the annual energy cost savings for suppliers' residential customers of both privately-owned suppliers and publicly-owned suppliers, during the period analyzed.

Table 25: Energy cost savings for residential customers across all suppliers

Year	Energy Cost Savings ($ million)
2025	32.23
2026	33.79
2027	35.53
2028	37.69
2029	40.03
2030	42.15
2031	44.74
2032	46.51
2033	48.65
2034	50.46
2035	51.88
2036	52.23
2037	52.64
2038	52.97
2039	53.43
2040	53.84

Our estimated energy cost savings for residential customers were based on energy savings calculations performed by the Pacific Institute and energy price forecasts obtained from the U.S. Energy Information Administration. The Pacific Institute has calculated that the average energy intensity for residential indoor water use is approximate 6,800 kWh/acre-foot for electric water heaters and 67 MMBtu/acre-foot for natural gas water heaters. Consistent with the literature, we assumed that the average fuel share of residential water heaters is approximately 33 percent electric and 67 percent natural gas (Szinai et al., 2021). The energy intensities and average fuel share percentages were used to calculate the breakdown of kWh and MMBtu energy fuel savings that would result from upgrading clothes washers. Next, energy fuel savings were multiplied by energy prices to estimate energy cost savings. Annual energy price forecasts for natural gas and electricity for the 2025-2040 period were obtained from the U.S. Energy Information Administration (U.S. EIA 2022). Price forecasts during that period average at $12.45/Mcf for natural gas and $0.139/kWh for electricity in the residential sector. The price forecasts that we rely on are for the entire U.S. However, historically energy prices in California have been higher than national, and it is possible that the State's commitment to climate policies may drive them even higher. In this sense, our analysis may be underestimating energy cost savings.

Additional Benefits Not Quantified

The proposed regulation is expected to yield benefits that are not possible to quantify given the existing data. Compliance with the proposed regulation likely will:

1. **Reduce the overall pressure on the limited water resources that many sectors in California compete for and reduce the need to cut water use—in any sector—when**

there is a drought. Water is scarce in California[22] and so reduction in use of water by urban retail water suppliers increases the supply of water available for drinking and sanitation, industrial use, cultural and recreational uses, ecosystem management, agriculture, and power generation. The future expected effective market costs of water used in this analysis captures some of these values but not all of them. The expected effective market cost of water used in this analysis also reflects a "typical" year. In a dry year, when emergency actions to manage water are needed, for example, this analysis underestimates the public and private value of the water this regulation conserves. If, for example, a drought year would lead DWR to reduce State Water Project allocations (a water supply for many users in Central and Southern California), this regulation could allow DWR to manage water with a smaller reduction. Given estimates of the annual economic costs to California of drought and of water scarcity, these benefits, which are not included in the analysis here, could have an aggregate value of billions of dollars over the period of analysis. The aggregate value of these benefits depends on the future supply of and demand for water, the severity and frequency of drought, where water conserved can be used, water management decisions, and other factors. Note that this regulation will likely not eliminate the need for emergency water conservation policies.

2. **Free up suppliers' water for their future use.** Some suppliers have water saved for the future, in underground water banks or surface water storage, that they did not sell due to water use efficiency and conservation efforts.[23] This regulation will save additional water, some of which suppliers will be able to bank for use when alternative water supplies are scarcer or more costly. This is a valuable benefit.
3. **Improve water quality, improve soils, and sequester more carbon.** Reductions in over-irrigation send less pesticides, nutrients, bacteria, and metals into water bodies. Shifts to California-friendly landscapes with more deeply rooted shrubs and trees and mulch reduce run-off and can improve soils and sequester more carbon.
4. **Improve safety.** Reductions in over-irrigation reduce mosquito breeding pools and slip hazards.
5. **Reduce some landscape maintenance costs.** Shifts away from groundcovers that can require regular care and fertilizer application can reduce costs with landscape maintenance.

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[22] For example, it was estimated "urban water scarcity in California in 2020 would cost end users an estimated average of $1.6 billion per year, given current operations, allocations, and infrastructure." (Jenkins et al. 2003).

[23] For example, "Through its groundwater banking agreements, [the Metropolitan Water District (Metropolitan)] stores water with partner agencies along the State Water Project and the Colorado River Aqueduct. They either put the water into their groundwater basins using spreading grounds or exchange it for water that they would have pumped out of the ground for use. In dry years, when Metropolitan's imported supplies are limited, these partners either pump up some of the stored water for Metropolitan's use or provide their other supplies in exchange." (Metropolitan 2023). See also Central Arizona Project (2020).

6. **Reduce state costs of disposing of organic materials that should not go to landfills by increasing demand for mulch**. Shifts to California-friendly landscapes will increase the demand for mulch may and thus facilitate overall compliance with SB 1383.
7. **Protect biodiversity and support ecosystem.** Shifts to California-friendly landscapes may increase the extent of plants that provide food and shelter to important species.

Fiscal Impacts on Local Governments

Suppliers Operated by Local Governments

Most suppliers are operated by local governments, usually a city, county, or district, and these suppliers serve almost 81 percent of the total population in the state. Like privately-owned suppliers, some publicly-owned suppliers will likely incur costs to meet their water use objectives. Like privately-owned suppliers, publicly-owned suppliers on the one hand will spend less to acquire water and less on stormwater-related corrective measures, but on the other hand, will potentially lose revenue due to the water use reductions. The methodology and underlying assumptions for the calculation of those costs and benefits are the same as for privately-owned suppliers, described in prior sections. In present discounted value terms, publicly-owned suppliers would incur aggregate costs of approximately $8.45 billion and accrue benefits of approximately $9.09 billion from 2025 to 2040. The next tables break these estimates down.

Direct Costs of Proposed Regulation for Publicly-Owned Suppliers

Suppliers, including those operated by local governments, will devote staff resources toward creating and implementing efficiency and conservation programs. We assumed water use efficiency program costs are one-time costs for an administrator to learn the new regulation and create a cost-minimizing plan to meet the requirements. There are also ongoing administrative costs of compliance reporting. The table below shows the general program cost and annual reporting costs across publicly-owned suppliers. The total general program cost and reporting costs across all publicly-owned suppliers are approximately $11 million in 2025 and $1.7 million per year thereafter.

Table 26: Cost of water efficiency program creation and required reporting for publicly-owned suppliers

Year	Program Creation ($ million)	Reporting ($ million)	Total ($ million)
2025	9.04	1.74	10.78
2026	0	1.74	1.74
2027	0	1.74	1.74
2028	0	1.74	1.74
2029	0	1.74	1.74
2030	0	1.74	1.74
2031	0	1.74	1.74
2032	0	1.74	1.74
2033	0	1.74	1.74
2034	0	1.74	1.74
2035	0	1.74	1.74
2036	0	1.74	1.74
2037	0	1.74	1.74
2038	0	1.74	1.74
2039	0	1.74	1.74
2040	0	1.74	1.74

Of all public-owned suppliers analyzed, 198 are assumed to achieve water reductions through residential water use efficiency measures. Table 27 below shows the estimated direct costs that publicly-owned suppliers will incur in the years 2025 through 2040 with the programs for the residential indoor and outdoor use standards, namely, rebate and incentive programs for toilet replacement, clothes washer replacement, and turf conversion, plus a leak alert program. The estimated direct costs are shown for the four types of water use efficiency measures and were obtained directly from the least-cost analysis. The direct cost incurred by publicly-owned suppliers with the residential rebate and incentives programs is approximately $2.9 billion in 2025, and ranges between $25 million and $220 million per year in the following years. Direct costs will be incurred mainly in the first years of the proposed regulation as this is when much of the water use efficiency measures are expected to be implemented. Costs with rebate programs for turf conversion are the most significant, totaling $2.2 billion in 2025, and ranging between $23 million and $213 million per year in the following years.

Table 27: Cost of residential efficiency measures incurred by publicly-owned suppliers

Year	High-Efficiency Toilet ($ million)	High-Efficiency Washer ($ million)	Leak Detection ($ million)	Turf Conversion ($ million)	Total ($ million)
2025	383.50	246.23	0.45	2,216.30	2,846.47
2026	15.24	17.23	0.16	142.20	174.83
2027	8.49	10.96	0.05	180.09	199.59
2028	2.63	14.02	0.04	187.45	204.14
2029	1.34	9.73	0.05	203.11	214.23
2030	2.16	4.81	0.16	213.31	220.44
2031	3.44	12.46	0.16	134.55	150.61
2032	3.13	9.50	0.05	145.36	158.04
2033	4.82	6.57	0.05	149.15	160.59
2034	6.18	4.74	0.12	149.73	160.77
2035	4.64	2.65	2.20	130.39	139.88
2036	0.84	0.75	0.02	27.44	29.05
2037	0.84	0.75	0.02	27.42	29.03
2038	0.84	0.75	0.02	27.42	29.02
2039	0.84	0.75	0.04	27.10	28.73
2040	0.84	0.75	0.27	23.84	25.69

As discussed in previous sections, the costs associated with installing a CII DIM, paying the fees for the appropriate inspections, and carrying out the three CII BMPs (program and account management, parcel water budget development, and ESPM-compatible water use data) are assumed to represent the CII direct costs incurred by the suppliers. Almost 61,000 CII properties in service areas of publicly-owned suppliers will meet or exceed the 500,000-gallon threshold.

Table 28 shows the estimated costs to publicly-owned suppliers of the CII performance measures associated with the dedicated irrigation meters. The largest annual cost is the installation of the DIMs themselves, followed by required tie-in equipment. Backflow device installation is required, as are permit and backflow inspection fees, which are paid to local governments. Across all publicly-owned suppliers, the total cost of the CII DIM performance measures is approximately $76 million per year between 2025 and 2030, of which almost $41 million per year are for DIM installation on affected properties.

Table 28: Cost of CII DIM measures incurred by publicly-owned suppliers

Year	DIM Installation ($ million)	DIM Tie-ins ($ million)	Backflow Device Installation ($ million)	Backflow Inspection ($ million)	Permit Inspection ($ million)	Total ($ million)
2025	40.57	32.46	0.81	0.81	1.62	76.28
2026	40.57	32.46	0.81	0.81	1.62	76.28
2027	40.57	32.46	0.81	0.81	1.62	76.28
2028	40.57	32.46	0.81	0.81	1.62	76.28
2029	40.57	32.46	0.81	0.81	1.62	76.28
2030	40.57	32.46	0.81	0.81	1.62	76.28
2031	0	0	0	0	0	0
2032	0	0	0	0	0	0
2033	0	0	0	0	0	0
2034	0	0	0	0	0	0
2035	0	0	0	0	0	0
2036	0	0	0	0	0	0
2037	0	0	0	0	0	0
2038	0	0	0	0	0	0
2039	0	0	0	0	0	0
2040	0	0	0	0	0	0

Table 29 shows the estimated costs to publicly-owned suppliers of the CII performance measures associated with the three BMPs. Program and account management and parcel water budget development costs are mostly staffing costs for suppliers. The costs for ESPM-compatible water use data is the cost associated with publicly-owned suppliers carrying out the BMP to provide the owners of “disclosable buildings” with water use data in a format compatible with ENERGYSTAR portfolio manager (as described above, the assumed costs are based on CEC (2020) cost estimates). Across all publicly-owned suppliers, the total cost of the CII BMPs is approximately $960,000 in 2025 and $2.3 million per year between 2026 and 2030, of which $810,000 are for the initial water budget development and $1.4 million are for the ESPM-compatible water use data. After 2030, together publicly-owned suppliers incur ongoing costs of $150,000 for program and account management.

Table 29: Cost of CII BMPs incurred by publicly-owned suppliers

Year	Program & Account Management ($ million)	Water Budget Development ($ million)	Water Use Data ($ million)	Total ($ million)
2025	0.15	0.81	0	0.96
2026	0.15	0.81	1.37	2.33
2027	0.15	0.81	1.37	2.33
2028	0.15	0.81	1.37	2.33
2029	0.15	0.81	1.37	2.33
2030	0.15	0.81	1.37	2.33
2031	0.15	0	0	0.15
2032	0.15	0	0	0.15
2033	0.15	0	0	0.15
2034	0.15	0	0	0.15
2035	0.15	0	0	0.15
2036	0.15	0	0	0.15
2037	0.15	0	0	0.15
2038	0.15	0	0	0.15
2039	0.15	0	0	0.15
2040	0.15	0	0	0.15

As discussed above, suppliers will not be selling as much water to their customers as they would in the absence of the proposed regulation. Revenues lost are another type of direct cost. The table below shows the combined lost revenues for publicly-owned suppliers from 2025 to 2040. Because the volume of water savings increases over time, so does lost revenues: public-owned suppliers' lost revenues are estimated to be $181 million in 2025, and approximately $518 million in 2040.

Table 30: Revenue lost by publicly-owned suppliers if they do not adjust rates

Year	Lost Revenue ($ million)
2025	180.92
2026	199.21
2027	218.72
2028	239.52
2029	261.69
2030	285.29
2031	307.50
2032	331.07
2033	356.09
2034	382.61
2035	410.74
2036	430.27
2037	450.72
2038	472.12
2039	494.53
2040	517.99

Benefits of Proposed Regulation for Publicly-Owned Suppliers

The table below shows how much water publicly-owned suppliers, combined, will save as a result of the implementation of residential water use efficiency measures and CII performance measures, beginning in 2025. Most of the water savings come from the residential customers. In 2025, suppliers will save 205,000 acre-feet of water because of the residential measures. Water savings from the CII performance measures start in 2026 at about 18,000 acre-feet. Water savings increase gradually over time. Annually, publicly-owned suppliers, combined, will save (relative to the assumed future baseline) from about 235,000 acre-feet in 2026 to about 375,000 acre-feet of water in 2040. Cumulatively, publicly-owned suppliers will achieve a total water use reduction (relative to the assumed future baseline) of 5.4 million acre-feet by the end of 2040.

Table 31: Water use reduction by publicly-owned suppliers

Year	Residential (ac-ft)	CII (ac-ft)	Total (ac-ft)
2025	205,280	0	205,280
2026	217,442	17,993	235,435
2027	229,603	35,986	265,589
2028	241,765	53,979	295,744
2029	253,926	71,972	325,898
2030	266,088	89,965	356,053
2031	275,484	85,467	360,951
2032	284,881	81,193	366,074
2033	294,278	77,134	371,411
2034	303,674	73,277	376,951
2035	313,071	69,613	382,684
2036	314,731	66,133	380,864
2037	316,392	62,826	379,218
2038	318,052	59,685	377,737
2039	319,713	56,700	376,413
2040	321,373	53,865	375,238
Total	**4,475,751**	**955,788**	**5,431,539**

Supplier-specific avoided water cost per acre-foot together with their water use reductions were used to calculate suppliers' avoided water costs. The table below shows the water costs avoided by publicly-owned suppliers, resulting from the residential water use efficiency measures and CII performance measures. Most of the avoided water costs are associated with the residential measures. In 2025, publicly-owned suppliers' avoided costs totaled $367 million. In the following years, their avoided water costs increased gradually from $436 million in 2027 to over $1 billion in 2040.

Table 32: Water cost avoided by publicly-owned suppliers

Year	Residential ($ million)	CII ($ million)	Total ($ million)
2025	367.54	0	367.54
2026	399.92	36.49	436.41
2027	434.14	75.01	509.15
2028	470.29	115.69	585.98
2029	508.51	158.65	667.16
2030	548.90	204.06	752.96
2031	586.12	199.54	785.66
2032	625.39	195.18	820.58
2033	666.82	190.99	857.82
2034	710.53	186.95	897.48
2035	756.64	183.06	939.70
2036	786.18	179.31	965.49
2037	817.09	175.69	992.78
2038	849.41	172.20	1,021.61
2039	883.22	168.83	1,052.05
2040	918.58	165.57	1,084.15

The benefits to suppliers from the CII DIM standard and performance measures include not only the avoided water costs, but also the avoided costs of stormwater-related corrective measures. As shown in the table below, publicly-owned suppliers' combined annual stormwater benefits increase from none in year 2025 to approximately $1 million in 2040.

Table 33: Stormwater-related costs avoided by publicly-owned suppliers

Year	Stormwater Avoided Cost ($ million)
2025	0
2026	0.38
2027	0.77
2028	1.15
2029	1.54
2030	1.92
2031	1.83
2032	1.73
2033	1.65
2034	1.57
2035	1.49
2036	1.41
2037	1.34
2038	1.28
2039	1.21
2040	1.15

Several benefits from the proposed regulation, described in the Additional Benefits Not Quantified section, although relevant, are not possible to quantify given the existing data. Some of these benefits, like freeing up suppliers' water for their future use, could have relevant fiscal implications for suppliers operated by local governments.

Urban Forestry and Landscape Management Agencies

When compliance with an objective requires a reduction in residential water use, other government sectors may be affected. Several government sectors were noted within the legislative requirements as requiring an evaluation of environmental impacts, including local agencies that manage urban forestry resources, local agencies that manage urban parklands, and wastewater management.

For urban trees, potential variances—allowances for additional water use—associated with tree planting could influence how local governments and suppliers conduct outreach or incentivize urban forestry programs. For instance, a variance that incentivizes tree planting programs could result in more tree planting, but also higher management costs for downstream urban forestry agencies. It is not possible to make precise estimates of these impacts because of lack of data.

Municipal spending trends on urban forestry activities by cities in California were analyzed to understand potential fiscal impacts.

Potentially affected areas may develop or update urban forestry management plans to prioritize spending on new trees. Within the modeled scenario for the proposed regulation, urban forests within 149 suppliers would be at risk of reduced water availability. In such areas, likely mitigation actions would include improved public education programs for irrigation management, development of urban forestry management plans and updated tree inventories, and new investments in irrigation technologies adapted to tree watering needs.

If all suppliers serving areas where urban tree canopies could be affected by demand changes (149) pursued increased public education and planning, the resulting estimated total costs would be an average of $11.8 million per year between 2025 and 2035, which includes: $3 million per year for new public education and outreach focused on urban tree irrigation and planting, assuming an annual spending of $20,000 per supplier; $8.1 million per year to update urban tree inventories, assuming a cost of $600,000 for an inventory in one city; and $700 thousand per year to update urban forestry management plans, assuming a cost of $50,000 for an updated plan in one city. These results are summarized in the table below.

Table 34: Cost of mitigation actions incurred by urban forestry and landscape management agencies

Year	Public Education & Outreach ($ million)	Urban Tree Inventory ($ million)	Forestry Management Plan ($ million)	Total ($ million)
2025	3.0	8.1	0.7	11.8
2026	3.0	8.1	0.7	11.8
2027	3.0	8.1	0.7	11.8
2028	3.0	8.1	0.7	11.8
2029	3.0	8.1	0.7	11.8
2030	3.0	8.1	0.7	11.8
2031	3.0	8.1	0.7	11.8
2032	3.0	8.1	0.7	11.8
2033	3.0	8.1	0.7	11.8
2034	3.0	8.1	0.7	11.8
2035	3.0	8.1	0.7	11.8
2036	0	0	0	0
2037	0	0	0	0
2038	0	0	0	0
2039	0	0	0	0
2040	0	0	0	0

Suppliers and municipalities would also need new investments in irrigation systems with fixtures designed or reconfigured for trees, shrubs, and vegetation other than turf. These costs are assumed to be incorporated into activities associated with turf replacement.

For urban parklands, urban park areas would be considered Special Landscape Areas (SLA) within the 2018 conservation legislation framework, which would limit the extent of water use reductions directly attributable to the 2018 conservation legislation. In addition, while we evaluated the number of parkland areas that are within supplier boundaries, no data was available on existing irrigated landscape area in such areas or the extent to which such areas receive water from suppliers. The State Water Board conducted semi-structured interviews with a representative sample of park management agencies across the state. Interviews indicated that many may rely on local or municipal water sources that would not fall under the framework for any number of reasons. Interviews also noted how park managers must balance many factors in managing water and landscapes, including local fiscal constraints, water prices, local water use restrictions (not necessarily associated with statewide requirements), and public perception.

Local Wastewater Management Agencies

Another potential fiscal impact of the proposed regulation is on wastewater treatment facilities (WWTFs), wastewater conveyance systems, and wastewater recycling and reuse systems, collectively referred to as wastewater management agencies. These are downstream of suppliers and are run by city or county agencies or are organized as special districts. In the following sections we analyze the costs that each of the three types of wastewater management agencies likely will incur because of the proposed regulation, i.e., the fiscal impacts. In the Economy-Wide Impacts section we analyze the potential macroeconomic impact of the costs incurred by these agencies on the state economy.

Wastewater management agencies may experience increased costs, as well as potential benefits, when the influent volumes are reduced or become more concentrated. Collection systems in particular may experience the need for increased chemical use, increased pipe corrosion and rates of pipe replacement, increased labor for removing clogs and tree roots, increased flushing of lines, increased replacement or upgrades of pumps, and reduced energy costs associated with pumping wastewater. These costs are all related to operations and maintenance. In addition, lower flows could lead to accelerated infrastructure improvements that would be new capital investment requirements.

Similarly, wastewater treatment facilities may also experience increased costs for chemical use and treatment plant operations, and additional infrastructure improvements. Other costs could include more fines for not meeting discharge permit requirements, or hiring more consultants, among others. Past research identified reductions in energy use as a benefit associated with treating less wastewater (Koyasako 1980). Energy costs may either increase or decrease, depending upon the water quality operating parameters and pumping needs at the facility.

Finally, water reuse agencies may experience changes in operations, but also see less revenue from decreased sales of recycled water if influent is reduced to levels that force a decrease in reuse production.

The table below summarizes the estimated costs that the three types of wastewater management agencies will potentially incur because of the proposed regulation. Together, the three types of wastewater management agencies would incur costs of $385 million per year between 2025 and 2030, and $78 million per year afterward. Wastewater treatment facilities are the type most affected with costs at approximately $329 million per year from 2025 to 2030, followed by wastewater collection systems at $45 million per year in that period. Wastewater recycling and reuse agencies will lose approximately $11 million per year in revenues during the period analyzed. The calculations underlying these estimated costs are discussed in detail in the next sections. A detailed description of the methods used to evaluate efficiency standard's effects on local wastewater management agencies can be found in Appendix F.

Table 35: Cost of operations and maintenance, infrastructure improvement, and lost revenue for local wastewater management agencies

Year	Treatment Facilities ($ million)	Collection Systems ($ million)	Recycling & Reuse Agencies ($ million)	Total ($ million)
2025	329.0	45.0	11.3	385.3
2026	329.0	45.0	11.3	385.3
2027	329.0	45.0	11.3	385.3
2028	329.0	45.0	11.3	385.3
2029	329.0	45.0	11.3	385.3
2030	329.0	45.0	11.3	385.3
2031	62.0	5.0	11.3	78.3
2032	62.0	5.0	11.3	78.3
2033	62.0	5.0	11.3	78.3
2034	62.0	5.0	11.3	78.3
2035	62.0	5.0	11.3	78.3
2036	62.0	5.0	11.3	78.3
2037	62.0	5.0	11.3	78.3
2038	62.0	5.0	11.3	78.3
2039	62.0	5.0	11.3	78.3
2040	62.0	5.0	11.3	78.3

Wastewater Treatment Facilities

Future benefits and costs for wastewater treatment facilities will likely include additional annual expenditures for operations and maintenance, as well as new investments for capital infrastructure. Infrastructure system investments are typically amortized over a period of 20 to 30 years. Annual and total costs during the period of analysis for the SRIA are reported.

As a result of the regulation, preliminary statewide costs for operations and maintenance at wastewater treatment facilities are conservatively estimated to be $62 million per year during the period analyzed. For context, estimated annual total statewide operations and maintenance costs for wastewater treatment are $2.5 billion based on extrapolations with per capita expenditures in cities as reported through local government financial reports available from the California State Controller’s Office.

As a result of the regulation, preliminary annual capital improvement costs are conservatively estimated to be $267 million per year between 2025 and 2030. This is based on annual values of reported per capita spending that are likely annualized over a 20-year (or more) time horizon. For context, estimated annual total statewide capital costs for wastewater treatment are $4.5 billion based on extrapolations with per capita expenditures in cities as reported through local government financial reports available from the State Controller’s Office.

An analysis of the sensitivity of costs to assumptions and input parameters was performed. For wastewater treatment facilities, cost changes were examined in relation to two parameters. First, due to limited data availability at the time of submitting this SRIA, the analysis of impacts incorporated an assumption that 15 percent of water demand reductions by suppliers would come from indoor end-uses that impact wastewater generation, while the remaining 85 percent would come from outdoor sources and leak loss detection. This assumption was based on outreach with suppliers (OWP 2022). To understand a range of impacts, the economic impacts to WWTFs were also estimated using the model for an assumed percentage of savings from indoor end-uses of 5 and 25 percent. For the assumption that only 5 percent of demand reductions come from indoor end-uses (toilets, clothes washers), the statewide O&M costs would be $65 million per year for six years, while the statewide capital improvement costs would be $77 million per year in the same period. Alternatively, for the assumption that 25 percent of demand reductions come from indoor end-uses, the statewide O&M costs would be $61 million per year, while the statewide capital improvement costs would be $297 million per year.

To summarize, O&M costs change only slightly based on the assumed factors, driven by energy use changes. Capital costs change more significantly, driven by the number of facilities expected to experience a change in influent flow. Ultimately, the least-cost economic modeling reported in this SRIA showed the 15 percent assumption to be a conservative estimate (i.e., larger than the reductions from indoor end-uses for many suppliers).

Second, we assessed the influence of per capita spending assumptions on overall costs. From multiple data sources including municipal spending reports from the State Controller's Office (2018) and the State Water Board (2014-2018), annual statewide per capita spending on wastewater treatment O&M was assumed to be $68 per person. If this amount were assumed to be 10 percent less ($62/person), then O&M costs for treatment would be $49 million per year. If per capita spending were assumed to be 10 percent more ($75/person) then O&M costs for treatment would be $67 million per year. Similarly, annual statewide per capita spending on wastewater capital improvements was assumed to be $121/person based on reported data. If this amount was assumed to be 10 percent less ($108/person) then capital improvement costs for treatment would be $240 million per year, while if it were assumed to be 10 percent more ($133/person) then capital improvement costs for treatment would be $293 million per year.

Wastewater Collection Systems

Future benefits and costs for wastewater collection systems will likely include additional annual expenditures for operations and maintenance, as well as new investments for capital infrastructure upgrades. Infrastructure system investments are typically amortized over a period of 20 to 30 years. Annual and total costs during the period of analysis for the SRIA are reported.

As a result of the proposed regulation, preliminary statewide costs for operations and maintenance in wastewater collection systems are conservatively estimated to be $5 million per year during the period analyzed. This is based on modeling of chemical controls needed to manage additional odor, corrosion, and other issues. For context, total annual statewide O&M spending for collection systems was estimated to be $1.1 billion based on extrapolations with per capita expenditures in cities as reported through local government financial reports available from the State Controller's Office.

As a result of the proposed regulation, preliminary annual capital improvement cost for wastewater collection systems (i.e., pipe replacement) is conservatively estimated to be $40 million per year between 2025 and 2030. This is based on annual values of reported per capita spending that are likely annualized over a 20-year (or more) time horizon. For context, total annual statewide capital spending for collection systems was reported to be $1.7 billion based on extrapolations with per capita expenditures in cities as reported through local government financial reports available from the State Controller's Office.

Wastewater Recycling and Reuse Agencies

Some wastewater treatment facilities in California treat wastewater to high levels of quality for reuse in irrigation, groundwater recharge, industrial purposes, and other needs. Wastewater treatment facilities with reuse were included as part of the set of potentially affected wastewater systems, and costs for upgrades are assumed to be part of the assessment of capital cost needs.

Reuse facilities may also be subject to additional capital costs for system upgrades to address changes in water quality. The lack of comprehensive information on reuse systems throughout the state inhibited a site-specific assessment of infrastructure upgrade needs to manage future water quality issues for water reuse facilities. Thus, capital investment requirements may be underestimated for wastewater treatment facilities.

For agencies that produce and provide highly-treated wastewater for reuse, lower production may reduce revenue from recycled water sales. Approximately 18 percent of potentially affected wastewater treatment facilities that produce and sell effluent for reuse in California have at least one month of the year when a significant percentage of effluent is sold (greater than 80 percent). These facilities could be most impacted by reduced production.

Under the proposed regulation, 68 percent of the reuse facilities would be affected, and influent flow would be reduced by a total of 52,500 acre-feet, relative to the baseline, through 2030. The sales price for recycled water varies by facility and level of treatment. Some established facilities historically sold recycled water for less than $1,000 per acre-foot (LACSD 2015). Recent assessments of proposed large projects with wastewater treated to levels of quality consistent with indirect potable reuse have estimated facility production costs of $1,100 to $1,600 per acre-foot (Cooley et al. 2019). Feasibility assessments for two new large, proposed water reuse projects in Southern California estimate the production cost to be $1,600 to $1,800 per acre-foot (LADWP 2019; MWD 2016).

Accordingly, if we assume that recycled water producers sell treated effluent at a price equivalent to facility production costs of $1,500/ac-ft., and that the net drop in influent flow relative to the baseline is approximately 52,500 ac-ft., then the total lost revenue for recycled water sales is estimated to be $78.8 million through 2030, or approximately $11.3 million annually between 2025 and 2030.[24] We conservatively assumed that lost revenues after 2030 is approximately that same amount of $11.3 million per year.

Local Institutional Water Users

As discussed in the Cost Pass-Through and Impacts on Water Bill section, suppliers, both privately- and publicly-owned, may choose to pass on some or all of their increased costs and benefits to their end-customers, likely in the form of higher (or lower) monthly water bills (compared to the assumed future baseline). Some of their end-customers are local governments, i.e., local institutional water users. The pass-through calculation for local institutional water users is the same as the one performed for businesses, and, therefore, relies on the same assumptions and has the same limitations as those described in that section.

To calculate suppliers' costs relevant for pass-through to local institutional water users, we relied on suppliers' direct costs and benefits estimated for CII performance measures. Given that suppliers' estimated CII benefits exceed direct costs, we find that the average water cost for an affected CII property might decrease by approximately $168 per month in the 2025-2040 period (compared to the assumed future baseline). Because the data do not distinguish commercial, industrial, and institutional water users, the estimated water cost change per CII property is an average across all three types of properties.

Cost pass-through is not the only way in which local institutional water users might be affected by the proposed regulation. Local institutional water users will not incur the cost of purchasing from their suppliers the water that they save. More specifically, local institutional water users, as well as other CII customers, will not use as much water as they would in the absence of the proposed regulation. These water savings are a direct result of the CII performance measures that CII customers, including local institutional water users, implement. All else being equal, water savings mean lower water bills (compared to the assumed future baseline). We perform this analysis for residential customers in the Avoided Water Purchases and Production section and, as explained in that section, the water costs avoided by CII customers cannot be estimated with the available data.

Local Taxes and Fees

Local Sales Tax

As discussed in previous sections, suppliers and households will spend more on residential water use efficiency programs and CII performance measures. Wastewater management agencies and urban forestry and landscape management agencies will also incur expenses because of the proposed regulation. Much of that spending includes purchases of several types of goods, including, for example, landscape material, high-efficiency toilets and washers, valves,

[24] This value does not include costs for conveying treated effluent to end-use locations.

and water leak monitoring equipment. Sales tax will generally apply to such purchases. The proposed regulation therefore is expected to have an impact on sales tax revenues.

Sales tax rates in California have three parts: the state tax rate, the local tax rate, and any district tax rate that may be in effect. The minimum sales tax in California is 7.25 percent. Local and district tax rates range from 0.10 percent to 1.00 percent and some areas may have more than one district tax in effect (CDTFA 2022a). To estimate the impact of the proposed regulation on local sales tax revenues, we obtained tax rates, effective October 1, 2022, for California cities and counties (CDTFA 2022b), and calculated the average of the incremental local tax rate, relative to the state's 7.25 percent. The average incremental local sales tax rate corresponds to 0.94 percent. We assumed this rate for years 2025 to 2040. We analyze the impact of the proposed regulation on state sales tax in the Fiscal Impacts on State Government section.

To estimate the increase in local sales tax revenues due to the proposed regulation, we applied the incremental local sales tax rate to the costs that suppliers, wastewater management agencies, and urban forestry and landscape management agencies will incur, estimated in previous sections. We adjusted these costs to the extent possible such that only the sale of goods was included, not services. Generally, services that do not result in a tangible good are exempt from sales tax in California. The table below shows the estimated aggregate increase in local sales tax revenues during the 2025-2040 period. Local sales tax revenues will be greater in the first years of the proposed regulation as this is when much of the water use efficiency measures are expected to be implemented. Aggregate local sales tax revenues are estimated to increase (compared to the assumed future baseline) by almost $21 million in 2025, and between $500,000 and $3.6 million per year in the following years.

Table 36: Impact on local sales tax revenues

Year	Local Sales Tax Revenue Increase ($ million)
2025	20.87
2026	3.38
2027	3.49
2028	3.55
2029	3.58
2030	3.59
2031	1.41
2032	1.44
2033	1.44
2034	1.43
2035	1.28
2036	0.55
2037	0.55
2038	0.55
2039	0.55
2040	0.52

Inspection and Permit Fees

As discussed in the CII Performance Measures section, as DIM, DIM tie-ins, and backflow devices are installed, suppliers will pay fees to local governments for the appropriate permits and backflow inspections. Local governments thus will experience an increase in revenues from such fees. The aggregate increase in revenue from inspection and permit fees across all local governments will amount to approximately $2.9 million per year between 2025 and 2030. This figure is obtained from Tables 20 and 21, discussed above. We conservatively assumed that the workload generated to local governments by these inspections and permitting processes would not be fully absorbed by current staff and programs. Accordingly, we estimated that additional staff would cost approximately $1.8 million per year, including overhead, between 2025 and 2030 to local governments.

Fiscal Impacts on State Government

State Water Resources Control Board

The State Water Board does not anticipate an increase in resource needs because of the proposed regulation.

State Institutional Water Users

As discussed for local institutional water users, some of the suppliers' end-customers are state institutional water users. The cost pass-through calculation for state institutional water users is the same as the one performed for local institutional water users, and, therefore, relies on the same assumptions and has the same limitations. This calculation was performed before for end-customers that are businesses or local institutional water users, and as noted then, the data do not allow us to distinguish commercial, industrial, and institutional water users.

To calculate suppliers' costs relevant for pass-through to state institutional water users, we relied on suppliers' direct costs and benefits estimated for CII performance measures. Given that suppliers' estimated CII benefits exceed direct costs, we find that the average water cost for an affected CII property might decrease by approximately $168 per month in the 2025-2040 period (compared to the assumed future baseline). Because the data do not allow us to distinguish commercial, industrial, and institutional water users, the estimated water cost change per CII property is an average across all three types of properties.

Cost pass-through is not the only way in which state institutional water users might be affected by the proposed regulation. Collectively, state institutional water users would not incur the cost of purchasing from their suppliers the water that they would save as a result of the proposed regulation. That is, state institutional water users, as well as other CII customers, will not use as much water as they would in the absence of the proposed regulation. These water savings are a direct result of the CII performance measures that CII customers, including state institutional water users, implement. All else being equal, water savings mean lower water bills (compared to the assumed future baseline). We perform this analysis for residential customers in the Avoided Water Purchases and Production section and, as explained in that section, the water costs avoided by CII customers cannot be estimated with the available data.

State Sales Tax

As discussed in the Local Sales Tax section, much of the spending by suppliers, households, wastewater management agencies, and urban forestry and landscape management agencies includes purchases of several types of goods, and sales tax will generally apply to such purchases. The proposed regulation therefore is expected to have an impact on the state's sales tax revenue.

As mentioned above, the sales tax in California is 7.25 percent. To estimate the increase in state sales tax revenue due to the proposed regulation, we applied that rate to the costs that suppliers, wastewater management agencies, and urban forestry and landscape management agencies will incur. We adjusted these costs to include only the sale of goods, not services. The table below shows the estimated increase in state sales tax revenues during the 2025-2040 period. State sales tax revenues will be greater in the first years of the proposed regulation as this is when much of the water use efficiency measures are expected to be implemented. State sales tax revenues are estimated to increase (compared to the assumed future baseline) by almost $162 million in 2025, and between $4 million and $28 million per year in the following years.

Table 37: Impact on state sales tax revenues

Year	State Sales Tax Revenue Increase ($ million)
2025	161.68
2026	26.16
2027	27.08
2028	27.47
2029	27.74
2030	27.78
2031	10.90
2032	11.19
2033	11.16
2034	11.07
2035	9.92
2036	4.24
2037	4.24
2038	4.24
2039	4.23
2040	4.06

Cost Pass-Through and Impacts on Water Bills

The proposed regulation likely will affect the water bills of those Californians served by suppliers. The impact on water bills will reflect (a) suppliers' costs and benefits, to the extent that suppliers pass them on to customers, (b) the timing in which these costs and benefits are passed on, and (c) customers' reduced water use resulting from the implementation of the residential water use efficiency measures and CII performance measures.

Generally, cost pass-through refers to the changes a business makes to the prices of its products or services as a result of a change in the costs it incurs. Cost pass-through will not always mean more expensive products or services: if a business incurs lower costs (or experiences any other benefit) and passes it on, then, all else being equal, customers will experience lower prices. The extent of cost pass-through to customers differs according to several factors, such as utility regulation policies, and specific demand and supply conditions.

For the pass-through analysis in this assessment, we assume that suppliers will fully pass on to their customers both the direct costs that suppliers incur (e.g., cost of rebate and incentives programs for the residential water use efficiency measures, lost revenues, etc.), and the benefits that suppliers accrue (e.g., avoided water purchases and production), during the entire 2025-2040 period (estimated in previous sections).

This reflects that suppliers will likely effect changes to their rate structures as a result of the proposed regulation, for example, to manage their budgets or reduce water waste. We do not make any assumptions about the specific changes that individual suppliers may choose for their rate structures. Because we do not estimate actual changes to water rates, our pass-through analysis is closer to a “partial equilibrium” approach than it is to a “full equilibrium” approach where price-elasticities of urban water demand and supply are considered.

Additionally, we do not make any assumptions about the *timing* of pass-through, as suppliers’ decision of when to pass costs and benefits on to their customers again will depend on several supplier-specific considerations that are not in the scope of this analysis. Because most of the affected suppliers will incur relatively higher direct costs in the first years of the proposed regulation and experience relatively higher benefits in later years, it is possible that many of them will increase water rates first and decrease them later (compared to the assumed future baseline). Our analysis of pass-through considers the 2025-2040 period as a whole and disregards possible variations across the years analyzed.

This analysis combines all suppliers, both privately-owned and publicly-owned, as both types are assumed to pass on the 2025-2040 costs and benefits to end-customers in their service areas. Cost pass-through assumed here will take the form of higher water bills (compared to the assumed future baseline) for customers of suppliers whose 2025-2040 direct costs outweigh direct benefits or, conversely, lower water bills (compared to the assumed future baseline) for customers of suppliers whose 2025-2040 direct benefits outweigh direct costs. We analyzed cost pass-through for individuals, low-income communities, and businesses in suppliers’ services areas. Changes to water bills can potentially have a macroeconomic impact on the state economy, and this impact is analyzed in the Economy-Wide Impacts section of this assessment.

Individuals

To analyze the effect of the proposed regulation on residential customers’ water bills, we considered (a) suppliers’ direct costs and benefits estimated for the residential water use efficiency measures, and (b) the reduced residential water use, and associated avoided water cost by households, resulting from the implementation of the residential water use efficiency measures.

Of the 38.9 million individuals projected to reside in the service areas of all suppliers in the 2025-2040 period (including of those suppliers that we estimate would meet their water use objectives even in the absence of actions suppliers might take specifically for compliance with the proposed regulation):

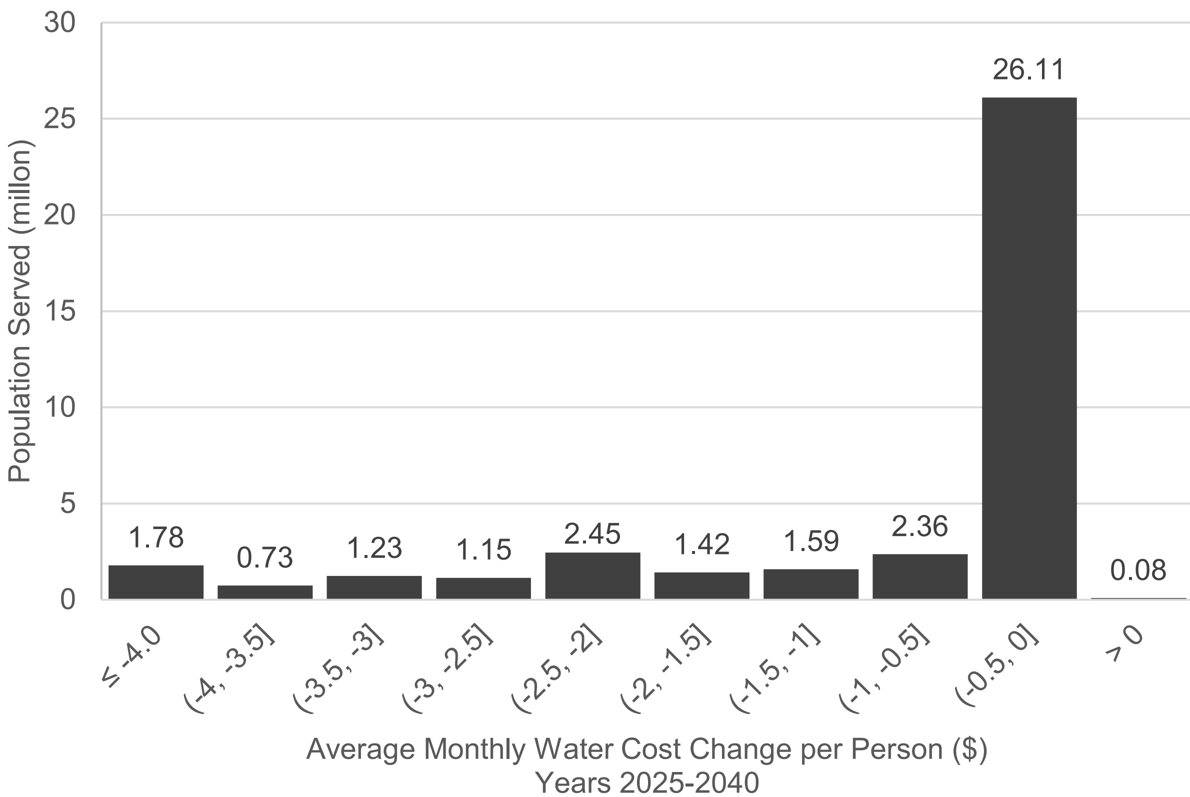
- Less than 85,000 individuals will experience higher water bills on average in 2025-2040 (compared to the assumed future baseline) because of the proposed regulation. These individuals will experience water cost increases of $0.93 per person, per month on average, relative to the assumed future baseline.

- Approximately 15.9 million individuals will experience lower water bills on average in 2025-2040 (compared to the assumed future baseline) because of the proposed regulation. These individuals will experience water cost declines of $2.07 per person, per month on average, relative to the assumed future baseline.
- The remaining 22.9 million individuals will not experience any changes in their water bills that can be attributed to the proposed regulation. These individuals are served by suppliers that will not incur any direct costs or benefits associated with the residential water use efficiency measures (because no efforts are necessary under the proposed regulation for these suppliers to meet their objectives).

To obtain the results above, we calculated, for each supplier, the average water cost change per person. This is how much the cost of water will increase or, more likely, decrease on average for an individual in each service area and in a given month in the entire 2025-2040 period, assuming that suppliers decide to pass on costs and benefits entirely. The average water cost change per person was calculated by dividing each supplier's 2025-2040 cost (after taking the benefits into account) by the population in its service area and the number of months in the 2025-2040 period (192 months). Thus, the water cost change that we calculate is an *average* across all the 192 months analyzed, and, therefore, should not be interpreted as the change that an individual customer may actually experience in their water bill in a given month.

The graph below is a visual representation of these data. Average monthly water cost changes per person (relative to the assumed future baseline) are grouped into bins along the horizontal axis. The height of each bar indicates the population served by suppliers that fall into that bin. As shown in the graph, most individuals will experience water cost *declines* of up to $4.00 per person-month on average (compared to the assumed future baseline). The majority of them (more than 26 million individuals) may experience either no changes to water costs on average or declines of up to $0.50 per person-month on average (compared to the assumed future baseline). As noted before, less than 85,000 individuals may experience increased water costs on average due to the proposed regulation.

Figure 9: Population served and average monthly water cost change (compared to the assumed future baseline) per person in 2025-2040 (disregarding possible variations across the years analyzed)



Very Low-Income and Low-Income Households

To understand the impact of the proposed regulation on the water bills of residential customers of different income levels, we had to adapt the prior analysis for households. We had to do so because the only available income data (for customers served by the suppliers) is the median household income (MHI) in their service areas. Data limitations prevented us from assessing other impacts, such as those on low-income households in areas that have high average MHI. We analyzed cost pass-through to households in the same way we did for individuals, but assumed that the average size of California households is 2.94 people (Statista 2022).

We grouped suppliers according to the MHI in their service areas. Suppliers' MHIs were compared to the California median household income (DOF 2022d) and grouped as follows:[25]

- **Very low income:** suppliers that have an MHI below 50 percent of the state MHI were identified as primarily serving very low-income households.

[25] The very low-income, low-income, and moderate-income thresholds are consistent with the income limits described in Department of Housing and Community Development (2022).

- **Low income:** suppliers that have an MHI between 50 percent and 80 percent of the state MHI were identified as primarily serving low-income households.
- **Moderate income:** suppliers that have an MHI between 80 percent and 120 percent of the state MHI were identified as primarily serving moderate-income households.
- **High income:** suppliers that have an MHI above 120 percent of the state MHI were identified as primarily serving high-income households.

As shown in the table below, in the data analyzed there are 36 "very low-income" suppliers together serving approximately 580,000 households, 154 "low-income" suppliers together serving approximately 4.4 million households, 136 "moderate-income" suppliers together serving approximately 6.5 million households, and 65 "high-income suppliers" together serving approximately 1.8 million households.[26]

The table also shows the average monthly water cost change per household for suppliers in the four income-level categories. This is how much the cost of water will increase (or decrease) on average for a household in each month in the entire 2025-2040 period (compared to the assumed future baseline), assuming that suppliers decide to pass on direct costs and direct benefits entirely. Similar to the analysis for individuals, average monthly water cost changes per household were obtained by dividing each supplier's 2025-2040 direct costs (after taking the direct benefits into account) by the number of households in its service area and the number of months in the 2025-2040 period, and then by calculating the population-weighted average across all suppliers in a given income level.

Table 38: Household average monthly water cost change (compared to the assumed future baseline) by median income level served by supplier in 2025-2040 (disregarding possible variations across the years analyzed)

Median Income Level Served by Supplier	Number of Suppliers	Number of Households	Average Household Water Cost Change
Very low	36	582,000	-$3.07 /month
Low	154	4,420,000	-$3.03 /month
Moderate	136	6,487,000	-$1.98 /month
High	65	1,745,000	-$2.87 /month

Regardless of the income level, households will on average experience lower water bills in 2025-2040 as a result of the proposed regulation (compared to the assumed future baseline). Moreover, the results in the table suggest that lower-income households would benefit slightly more from the proposed regulation than higher-income households would. More specifically, households served by very low-income suppliers and low-income suppliers might experience water cost declines of, respectively, $3.07 per month and $3.03 per month on average.

[26] Note that it is not true that all the 580,000 households served by the "very low-income" suppliers have very low incomes. Nor is it true that all the 1.8 million households served by the "high-income suppliers" have high incomes.

Households served by moderate-income suppliers and high-income suppliers might experience water cost declines of $1.98 per month and $2.87 per month on average.

These differences in average water cost changes across income levels are driven by factors that influence the least-cost calculation, such as the saturation of water-saving appliances and the amount of landscaping changes that can be done. To address potential equity impacts within their service areas, suppliers may be able to develop rate structures such that the costs and benefits of the proposed regulation will be passed on to households equitably. These potential changes to rate structures are not reflected in the averages shown in Table 38.

Businesses as End-Customers

The proposed regulation does not impose any direct costs on businesses other than suppliers. However, as with households, suppliers may choose to pass on some or all of their costs and benefits to the businesses that they serve, likely in the form of higher (or lower) monthly water bills (compared to the assumed future baseline). To calculate suppliers' pass-through to businesses, we analyzed suppliers' CII direct costs and benefits estimated in prior sections. Given that suppliers' estimated CII benefits exceed direct costs, we find that the average water cost for an affected CII property might decrease by approximately $168 per month in the 2025-2040 period (compared to the assumed future baseline).

The average monthly water cost change for a CII property was obtained by dividing the suppliers' 2025-2040 costs from CII measures (after taking the benefits into account) by the number of all affected CII properties in their service areas (approximately 72,000) and the number of months in the 2025-2040 period. However, not all affected CII properties used in this calculation are businesses – some are institutional customers. Data on businesses that are served by suppliers are very limited – the data do not distinguish commercial, industrial, and institutional water users. Thus, the average monthly water cost change per CII property is an average across all three types of properties, and it is not possible to determine whether the average monthly water cost change would be higher or lower if the average was taken across business properties only.

Economy-Wide Impacts

RIMS II Model and Assumptions

Economy-wide impacts of the proposed regulation were estimated using the regional economic model developed by the U.S. Bureau of Economic Analysis: the Regional Input-Output Modeling System (RIMS II). RIMS II is a widely accepted economic input-output model. RIMS II multipliers from the 2012 U.S. Benchmark I-O data and 2019 Regional Data for California's economy were used. More specifically, Type II RIMS II final-demand multipliers for the state of California were used to account for "direct" and "indirect," and "induced" effects.

The proposed regulation will require suppliers to meet their water use objectives, and, as discussed previously, we assumed that some of these suppliers will spend more on water use efficiency programs, including, for example, toilet and clothes washer rebate programs. Customers who elect to participate in the rebate and incentives programs will incur upfront costs associated with the implementation of the water use efficiency measures. Additionally, the proposed regulation will also increase spending by urban forestry and landscape management agencies and wastewater management agencies. We assumed that these costs represent new, additional spending or investment purchases that would impact the demand for services, equipment, and materials in "final-demand" industries.

We assign each type of spending to the most appropriate RIMS II industry code and multipliers, based on North American Industry Classification System (NAICS) descriptions (NAICS categories are more specific than RIMS II categories; RIMS II categories at a higher level of aggregation are used when needed). NAICS is the standard used by Federal statistical agencies to classify business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. We assume that all the purchases are from local (within California) manufacturers or service providers.

The table below lists the industries that would be affected by investment purchases made by suppliers, customers, as well as by urban forestry and landscape management agencies and wastewater management agencies. Each expenditure type is associated with a RIMS II industry category based on NAICS codes.

The first rows of the table refer to costs associated with achieving objectives based on residential indoor and outdoor standards. These include, for example, reporting to the State Water Board, and promoting and implementing the four types of incentive and rebate programs that involve high-efficiency toilets and clothes washers, and water use efficiency for outdoor landscapes by replacing turf with low-water and climate appropriate landscapes. Leak detection and alerts and landscape conversion involve multiple expenditure types, such as equipment and installation services. The next rows of the table refer to costs associated with complying with CII performance measures. These include, for example, dedicated irrigation meter installation, and parcel water budget development. The last rows refer to costs that urban forestry and landscape management agencies and wastewater management agencies will incur, for example, public education and outreach, urban tree inventory, and chemical use.

Table 39: Expenditure types and affected final-demand industries

Expenditure Type	Code	RIMS II Industry*
Program creation	5419A0	All other miscellaneous professional, scientific, and technical services
Reporting	5419A0	All other miscellaneous professional, scientific, and technical services
Efficiency toilets	327100	Clay product and refractory manufacturing
Efficiency washers	335220	Major household appliance manufacturing
Leak detection	33451A	Watch, clock, and other measuring and controlling device manufacturing
	334220	Broadcast and wireless communications equipment
	811200	Electronic and precision equipment repair and maintenance
	511200	Software publishers
	541511	Custom computer programming services
Turf conversion	541300	Architectural, engineering, and related services
	111400	Greenhouse, nursery, and floriculture production
	33291A	Valve and fittings other than plumbing
DIM installation	811200	Electronic and precision equipment repair and maintenance
DIM tie-ins	33451A	Watch, clock, and other measuring and controlling device manufacturing
Backflow device installation	811200	Electronic and precision equipment repair and maintenance
Permit inspection	S00A00	Other government enterprises
Backflow inspection	S00A00	Other government enterprises
Program & account management	5419A0	All other miscellaneous professional, scientific, and technical services
Water budget development	5419A0	All other miscellaneous professional, scientific, and technical services
Public education & outreach	5419A0	All other miscellaneous professional, scientific, and technical services
Urban tree inventory	111400	Greenhouse, nursery, and floriculture production
Urban forestry mgmt. plans	5419A0	All other miscellaneous professional, scientific, and technical services
New infrastructure	332996	Fabricated pipe and pipe fitting manufacturing
	33391A	Pump and pumping equipment manufacturing
Chemical use	325180	Other basic inorganic chemical manufacturing

** The Regional Input–Output Modeling System (RIMS II) is a regional economic model developed and maintained by the US Bureau of Economic Analysis (BEA).*

As discussed in previous sections, suppliers, urban forestry and landscape management agencies, and wastewater management agencies likely will cover the costs of this spending through increased fees on residential and CII water and wastewater customers. All else being equal, when customers face higher water bills, they have less to spend on other items. Thus, to take that effect into account, we further assumed that, within RIMS II, the increased water bills can be treated as a reduction in household earnings and spending (compared to the assumed future baseline).

Additionally, households who elect to participate in suppliers' rebate and incentives programs will incur the upfront costs associated with the implementation of the water use efficiency measures. While that spending will have a positive effect on the final-demand industries listed in the table above, it will also negatively affect households' budgets, even after rebates, likely in the form of decreased spending elsewhere. Like higher water bills, we assumed that, within RIMS II, household after-rebate costs associated with the implementation of the water use efficiency measures can be treated as a reduction in household earnings and spending.

Equivalently, as discussed in the Benefits of Proposed Regulation section, households who elect to participate in suppliers' rebate and incentives programs will save water (compared to the assumed future baseline) and therefore avoid the cost of water that they would have purchased otherwise. They also will save on their energy bill. We assumed that, all else being equal, these household cost savings will positively affect households' budgets, likely in the form of increased spending elsewhere. We assumed that the estimated household cost savings can be treated within RIMS II as an increase in household earnings and spending.

Total California household spending therefore is assumed to drop by an amount equal to the total costs of compliance after accounting for the rebates that households receive and household cost savings. The RIMS II multiplier for the "Households" sector, code "H00000" was used in this assessment. The assumption that household spending statewide will drop by the described amount was made to keep the modeling simple, because the data needed for a more precise analysis do not exist. Unavailable data include the sectors for which final demand for goods and services will be affected by water charges, the degree of those effects, and the degree to which affected suppliers will increase water charges faced by businesses or governments.

Assumptions embedded in this approach include that the increased water charges and spending with water use efficiency measures are equivalent to decreased earnings as defined in RIMS II (wages, salaries, and proprietors' income). Thus, the model may not fully reflect the economic behavior of those people whose earnings are not as defined in RIMS II. Assumptions also include that people outside of California will not experience higher water charges due to the proposed regulation. Below are additional considerations embedded in this approach:

- Some suppliers may not be able to pass all their increased costs on to their customers, for a variety of reasons. If this happens, our estimates overestimate the decrease in gross state product modeled as a reduction in household income.
- Suppliers' customers are businesses and government entities, not just households. Thus, impacts modeled as a reduction in household income through the H00000 multiplier is overestimated, and water cost increases for other entities are ignored. Other entities or sectors for which water costs are a major element of their production and that get water from suppliers that must comply with the regulation will be impacted (some of these businesses may be able to rely on untreated water for their needs, such as for irrigation or other non-potable needs).

- The proposed regulation will not increase costs uniformly across suppliers and customers, in which case households will be affected to varying degrees across different service areas, rather than equally across all water customers in California. Thus, aggregate, statewide impact modeled based on the H00000 multiplier will mask a distribution of impacts.
- Some suppliers could offer discounted rates to those who qualify, and funding opportunities may be available to suppliers, such as programs administered by the State Water Board that provide grants and low-interest loans, in which case the impact modeled as a reduction in household income will be overestimated.
- Some people, such as those living in apartments, will not be billed directly for their individual water use, so the impact on their budgets will be less than assumed (though all else being equal, their rents may be increased (decreased) to reflect higher (lower) water costs). Thus, all else being equal, impacts on household spending will be less than assumed here.
- Some households, businesses, and government entities have their own private wells or are not getting water from an affected supplier. Thus, the aggregate, statewide results below will mask a distribution of impacts.
- Potentially significant water conservation benefits, for example, as described in the Additional Benefits Not Quantified section, are not modeled. As noted, these substantial benefits are hard to quantify. If these were accounted for, the results likely would change substantially (because the monetary benefits would change the model output).

The RIMS II model and its application here depend on further assumptions and are subject to certain limitations:

- Potentially significant benefits to households or other water customers are not modeled. As noted, these benefits will include improved water quality, creation of healthy soils, and reduction of short-lived climate pollutants. To the extent that these benefits have a positive impact on public health, they could have been modeled as a lower demand for healthcare and related services, but as explained, these benefits are hard to quantify. If these benefits were accounted for, all the results would change (because the monetary benefits would change the model output).
- Suppliers may find more cost-effective ways to comply with the proposed regulation other than the ones described in this assessment. These other compliance activities would thus cost less than estimated here. Therefore, the costs and economic impacts in this analysis represent the upper limits of costs and economic impacts for the proposed regulation.
- RIMS II multipliers only estimate the impact from changes in final demand on one or more regional industries (in this assessment, industries that are listed in the table above).

- RIMS II results describe what the state of the economy may be like once all sectors make all assumed economic adjustments. As there is no timeline in the RIMS II model, results listed for any year should be interpreted as the outcomes in the new economic equilibrium due to the costs of the proposed regulation in that year.
- Businesses in the affected industries have no permanent supply constraints. Supply constraints will not be a problem in the long run, as markets will adjust to provide the goods and services needed for compliance.
- Businesses in the affected industries can satisfy additional demand with an increase in inputs and labor from within the State. This assumption might not be fully realistic: some portion of goods and services needed for compliance might come from out of state. However, the majority share of the changes in final demand due to the proposed regulation are for products and services that are generally provided to suppliers by California firms. Thus, to the degree this assumption is violated, the economic impacts of the proposed regulation in California are likely to be smaller in magnitude than the modeling suggests because they will impact economies inside and outside of California.
- Businesses have fixed patterns of purchases, and there will be no technological changes that shift what inputs are needed to create outputs, and the RIMS II data used, for 2019, is appropriate. These might not be fully realistic, but these are common assumptions when using models such as RIMS II. While the economy has changed since 2019, that is the most recent set of RIMS II multipliers available. Note that suppliers and providers of goods and services are likely to find more cost-effective solutions to satisfy the requirements of the proposed regulation over time. Thus, to the degree these assumptions are violated, the economic impacts of the regulation may be different from what the modeling suggests.

Gross Output, Gross State Product, and Business Impact

Economy-wide impacts estimated with RIMS II were estimated for gross output, value added, earnings, and jobs. As explained above, our modelling approach combines the effects of higher demand for the goods and services needed for compliance with the proposed regulation and the effects of higher charges for water and wastewater lowering household spending. The table below shows the macroeconomic effects obtained with the RIMS II multipliers.

Table 40: Projected impacts on California economy

Year	Gross Output ($ million)	Value Added ($ million)	Earnings ($ million)	Employment (Part- and full-time jobs)
2025	4,117.15	2,103.05	1,434.73	17,882
2026	1,142.63	586.65	323.02	5,018
2027	1,277.93	667.36	371.36	5,939
2028	1,396.97	735.99	407.35	6,686
2029	1,526.30	812.65	450.01	7,565
2030	1,656.76	890.13	492.37	8,458
2031	1,404.72	795.32	430.28	8,437
2032	1,467.74	833.12	452.72	8,878
2033	1,525.21	867.40	471.49	9,279
2034	1,583.62	902.00	489.84	9,678
2035	1,620.52	925.48	498.96	9,965
2036	1,513.06	867.48	449.41	9,405
2037	1,553.09	890.79	461.44	9,666
2038	1,595.35	915.40	474.14	9,942
2039	1,639.84	941.32	487.48	10,233
2040	1,683.06	966.64	499.94	10,519

Gross output is the value of the goods and services produced by an economy. It is principally measured using industry sales or receipts, including sales to final users and sales to other industries (intermediate inputs) during a given period. For that reason, gross output is commonly used as an aggregate measure for business impacts. The table contains the main results. In 2025 – the year with the greatest spending by suppliers and households – the estimated increase in state gross output is $4.1 billion. Increase in gross output ranges from $1.1 billion to $1.7 billion per year in the following years.

Value added, or gross state product, is a measurement of a state's output; it is the sum of value added from all industries in the state. Thus, it excludes the values of direct inputs and intermediate inputs, either domestically produced or imported. Value added is the state counterpart to the Nation's gross domestic product. As shown in the table, the state's value added is estimated to increase by $2.1 billion in 2025. Increase in value added will range from $500 million to $1 billion per year in the following years. These economy-wide impacts are negligible compared to California's economy. California's Gross State Product (GSP) in 2021 was almost $3.4 trillion (DOF 2022a). The estimated increase in value added in 2025 therefore corresponds to less than 0.07 percent of the 2021 GSP.

Earnings and Statewide Impact on Individuals

Earnings consist of wages and salaries and of proprietors' income, which is the net earnings of sole-proprietors and partnerships. Employer contributions for health insurance are also included. Table 40 shows that earnings within the state will increase by $1.4 billion in 2025. In the following years, increase in earning ranges from $300 million to $500 million per year. Again, these economy-wide impacts are negligible compared to California's economy.

California’s personal income was approximately $3.0 trillion in 2021 and is projected to increase to a little over that amount in 2025 (DOF 2022c). The estimated increase in earnings in 2025 is therefore only about 0.05 percent of the projected personal income for that year. However, as discussed in previous sections, note that households that decide to participate in the rebate programs may experience more significant changes in their monthly water bills and household budgets.

Creation or Elimination of Jobs within the State

Employment consists of full-time and part-time jobs. As shown in Table 40, the total number of jobs within the state is estimated to increase by almost 18,000 in 2025. Increase in jobs statewide will range from 5,000 to 10,000 per year in the following years.

If we consider the residential water use efficiency measures, the top industries experiencing increased employment are architectural, engineering, and related services; greenhouse, nursery, and floriculture production (including compost and mulch operations); and valve and fittings other than plumbing – mostly because of the increase in the demand for turf conversion to California-friendly landscape. This is unsurprising given the heavy reliance on residential landscaping conservation efforts in reducing water use. If we consider the CII measures, the top industries experiencing increased employment are electronic and precision equipment repair and maintenance; and watch, clock, and other measuring and controlling device manufacturing. Again, this is unsurprising given that CII measures are assumed to include installation of DIMs, backflow devices, and tie-ins in the affected CII properties. Increased wastewater treatment will affect employment in other basic inorganic chemical manufacturing and fabricated pipe and pipe fitting manufacturing.

As with the estimated impact on GSP and earnings, the overall impact of the proposed regulation on jobs is negligible compared to California’s labor force. The state’s civilian labor force consisted of almost 19 million individuals in 2021 (DOF 2022b), and is projected to increase to 19.8 million in 2025 (DOF 2022c). Thus, the estimated impact on employment in 2025 is less than 0.1 percent of the projected civilian labor force for that year.

Increase of Investment in the State

The increased production by various businesses, due to increased spending by suppliers, households, urban forestry and landscape management agencies, and local wastewater management agencies, should be met through increased production by in-state companies.

Landscape services will grow, and given that these are labor-intensive, it seems unlikely that out-of-state companies will displace local landscaping companies. Production and manufacturing in other growth industries, including greenhouse and nursery production, valve and fittings manufacturing, household laundry equipment, and plumbing fixture manufacturing, will experience growth as well, which should attract in-state producers. The growth of these firms will require investment in capital equipment and raw materials.

Additionally, as discussed above, local wastewater management agencies are expected to invest in wastewater infrastructure improvements, such as pipe replacement in wastewater collection systems, and other related infrastructure projects, amounting to approximately $1.6 billion from 2025 to 2040. These investments in wastewater-related infrastructure will in turn increase production and manufacturing in other industries including fabricated pipe and pipe fitting manufacturing, and pump and pumping equipment manufacturing, which, again, should attract in-state manufacturers. The growth of these firms will require further investment in capital equipment and raw materials.

Creation of New Businesses or Elimination of Existing Businesses

The main businesses affected by the proposed regulation are urban retail water suppliers. Because these are generally local monopolies, households and CII customers usually do not have a choice between their water service supplier and another one. Thus, the proposed regulation is not expected to cause entry of new suppliers or the exit of existing ones. Based on increased expenditures by suppliers on residential water use efficiency measures and CII measures, and also on increased expenditures by urban forestry and landscape management agencies, and wastewater management agencies, the top industries experiencing increased sales growth rates include greenhouse, nursery, and floriculture production (including compost and mulch operations); major household appliance manufacturing; valve and fittings other than plumbing; architectural, engineering, and related services; and watch, clock, and other measuring and controlling device manufacturing. Sales growth can be met by increases in the size of existing firms or the creation of new firms in these industries. For traditionally local and small scale, labor-intensive firms such as landscapers or nurseries, sales growth will probably encourage new small businesses. On the other hand, existing manufacturers of major household appliances and plumbing fixtures may expand production.

Comparative Advantages or Disadvantages for Businesses

The proposed regulation would not put in-state firms at a disadvantage. As noted, before, households and CII customers purchase water from their local water supplier, and they generally do not have a choice between their water service supplier and an out-of-state enterprise. Landscape services are labor-intensive and will likely be provided by existing California-based businesses. Products needed for residential and CII water conservation, such as laundry equipment and valve and fittings manufacturing, tend to be provided by sectors that already compete across state lines. Thus, the proposed regulation is not expected to affect the relative interstate competitiveness of California as a location for those industries.

Incentives for Innovation in Products, Materials, or Processes

We expect spending by suppliers to spur innovation in certain areas. Given the noticeable increase in spending on landscape conservation programs, we anticipate that the industry will respond by developing new technologies and products, for example, new irrigation systems and products, new California-friendly and climate-ready landscapes, improved composting and mulch operations and processes, and by improving on existing installation processes. Many households will seek new low-cost California-friendly landscape strategies, and entrepreneurs who can supply products and services accordingly will grow. Additionally, leak detection equipment and infrastructure are growing and developing, and the increased spending by suppliers will hasten those developments.

Alternatives to Proposed Regulation

Staff evaluated two alternatives to the proposed regulation, which consider different Landscape Efficiency Factors as well as the irrigation status of the landscapes (Irrigable Irrigated, Irrigable Not Irrigated) that the efficiency factor would be applied to. The alternatives also consider different thresholds above which CII landscapes would have to have a dedicated irrigation meter installed or an “in-lieu” technology implemented. These alternatives were described in detail in the Introduction.

In this section, the two alternatives and the proposed regulation were compared by calculating the cost-effectiveness for each of them. Cost-effectiveness was defined as the present discounted value of the 2025-2040 costs divided by the total estimated water use reduction in that period.[27] However, the many data limitations and assumptions underlying the quantification of water use reduction and cost impacts, discussed in previous sections, make the cost-effectiveness calculated in this assessment an incomplete metric. The results are summarized in the table below and discussed next.

[27] Note that, for clarity in the computation of the cost-effectiveness of the three scenarios, the cost amounts include costs incurred not only by privately-owned suppliers but also by publicly-owned suppliers.

Table 41: Projected impact and cost-effectiveness of proposed regulation, Alternative 1, and Alternative 2, from 2025 to 2040

Projected Impact		Alternative 1	Proposed Regulation	Alternative 2
Water savings	(ac-ft)	4,102,628	6,325,644	7,166,479
	(relative to proposed regulation)	65%	100%	113%
Benefit	($ million)	10,219	15,635	17,891
	(relative to proposed regulation)	65%	100%	114%
Cost	($ million)	9,863	13,459	14,862
	(relative to proposed regulation)	73%	100%	110%
Cost-effectiveness	($/ac-ft)	2,404	2,128	2,074
	(relative to proposed regulation)	113%	100%	98%

The main drivers of the estimated impacts of Alternatives 1 and 2 are qualitatively the same as the ones of the proposed regulation. Most of the estimated benefits for the two alternatives originate from reduced water purchases or reduced water production (compared to the assumed future baseline) by the affected suppliers. They also originate from reduced water use by, and thus lower water bills for, the residential customers (compared to the assumed future baseline). Most of the estimated costs for the two alternatives originate from the implementation of residential water use efficiency measures and revenues that would be lost by suppliers (and, to a lesser extent, wastewater management agencies) (compared to the assumed future baseline). Like the proposed regulation, and assuming a discount rate of 3 percent, the quantified benefits of Alternatives 1 and 2 are estimated to exceed the respective quantified costs.

Alternative 1, which is less stringent than the proposed regulation, would save approximately 4.1 million acre-feet of water in the entire 2025-2040 period, about 65 percent of the water saved under the proposed regulation. Benefits during that period are estimated to outweigh costs, with present discounted values of $10.2 billion and $9.9 billion, respectively. The estimated cost-effectiveness of Alternative 1 is approximately $2,404/ac-ft.

Alternative 2, which is more stringent than the proposed regulation, would save approximately 7.1 million acre-feet of water in the entire 2025-2040 period, about 113 percent of the water saved under the proposed regulation. Benefits during that period also are estimated to outweigh costs, with present discounted values of $17.9 billion and $14.9 billion, respectively. The estimated cost-effectiveness of Alternative 2 is approximately $2,074/ac-ft.

A comparison of the estimated cost-effectiveness of the two alternatives and proposed regulation ranks Alternative 2 as the most cost-effective in the 2025-2040 period, and Alternative 1 as the least cost-effective. Alternative 2 is slightly more cost-effective than the proposed regulation (2.5 percent more cost-effective), but significantly more expensive in absolute terms (10.5 percent more expensive), and therefore was not chosen over the proposed regulation.

The cost-effectiveness metric, as defined in this assessment, factors in not only the estimated costs for suppliers—the only party on which the proposed regulation imposes obligations—

but also the estimated costs for parties assumed here to be indirectly affected, like residential customers and wastewater management agencies. In this sense, the cost-effectiveness metric does not pertain to any specific party; rather, it pertains to the regulation being proposed (and the two alternatives considered) and it allows for the comparison across regulatory scenarios, as shown in Table 41. Therefore, the cost-effectiveness estimates shown in the table are not directly comparable to other metrics, such as the average cost that a supplier typically incurs for each acre-foot of water delivered in its service area.

Economy-wide impacts for each of the alternatives were also estimated, and, like the economy-wide impacts for the proposed regulation, are negligible compared to California's economy.

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Appendices

Appendix A. Analysis of Data on Urban Water Supplier Conservation Programs

This analysis seeks to identify and characterize conservation rebate programs implemented by suppliers, using conservation information provided in Electronic Annual Reports to the State Water Resources Control Board.

A.1. Data

Urban water suppliers' (suppliers) conservation program information was derived from electronic annual Reports (eARs) submitted to the State Water Board for 2020 and 2021. eARs are mandatory annual surveys of public water systems to collect critical water system information.

eARs contain a range of information. Conservation program information was acquired from Section 17 of the eAR on Water Conservation and Drought Preparedness, using 2020 and 2021 data. Section 17 asks suppliers to provide information on conservation activities in their service areas by either submitting a direct link to a webpage that summarizes these activities or by sending an email that detailed conservation activities to the State Water Board.

The eAR dataset included information on whether the supplier provided rebates for residential, CII, and/or Landscape Irrigation measures, as well as details on the specific fixtures and devices covered under these rebate programs. The dataset included the following parameters pertaining to conservation rebate programs:

- Does the supplier provide rebates on residential plumbing, fixtures, and devices?
- If provided, which residential plumbing, fixtures, and devices are included in the rebate program?
- Does the supplier provide rebates on CII plumbing, fixtures, and devices?

- If provided, which CII plumbing, fixtures, and devices are included in the rebate program?
- Does the supplier provide rebates on landscape irrigation plumbing, fixtures, and devices?
- If provided, which landscape irrigation plumbing, fixtures, and devices are included in the rebate program?

A.2. Methodology

Conservation rebate information collected from suppliers using eARs is qualitative data that requires interpretation and coding using qualitative content analysis, a research method that uses systematic classification and identification of patterns to allow for the interpretation of subjective text data scientifically.

Inductive content analysis was used to categorize text-based conservation rebate information into common groups to allow for the comparison of fixtures and devices rebated under different supplier conservation programs. Inductive content analysis codes text data using categories derived directly and inductively from the raw text data. This confers the advantage of categorizing text data using direct information gained from the eAR survey dataset without imposing preconceived theoretical perspectives. The inductive content analysis consisted of the following three steps (Table A.1):

- Step 1: suppliers were filtered for systems implementing conservation rebate programs for residential, CII, and landscape irrigation.
- Step 2: Conservation rebate information for systems identified in Step 1 were read repeatedly to gain a sense of whole and recurring highlighting phrases that appear to capture the theme of the research question and the objective of the analysis: What water conservation, plumbing, fixtures, devices, and measures are included under suppliers' conservation programs?
- Step 3: Highlighted phrases expressing similar concepts were grouped into mutually exclusive categories. If necessary, categories established were revisited, subsumed, and/or formulated into new categories.

Table A. 1: The three steps of text analysis using Inductive Content Analysis, and examples

Conservation Rebates Offered? (Step 1)	Highlighting Whole and Recurring Phrases (Step 2)	Grouping into Categories (Step 3)
Yes	High-Efficiency Toilet	PHET Toilet
	High Efficiency Toilet (HET)	
	HE Toilet	
	ULF Toilet	
	PHET Toilet	
	Toilet	
	Toilet Fixture	
	High Performance Low Flush Toilet	
	High Efficiently Toilet Rebate Program	
	HE Clothes Washer	HE Clothes Washer
	Clothes Washers	
	MF Clothes Washers	
	HE Washers	
No		Not Applicable

HE = High Efficiency, PHET = Premium High Efficiency Toilet, MF= Multi Family, ULF = Ultra Low Flush

After analyzing and converting conservation rebate information into standardized categories, descriptive statistical analyses were conducted to determine the following:

- Percent of suppliers that provide rebates under their conservation programs to water-saving plumbing, fixtures, devices, and measures for residential, CII, and landscape irrigation
- A breakdown, in percent terms, of the categories of water-saving measures rebated under conservation programs for residential, CII, and landscape irrigation
- A breakdown, in percent terms, of the category combinations of water-saving measures rebated under conservation programs for residential, CII, and landscape irrigation

A.3. Results

Tables A.2 through A.4 present results from the analysis of efficiency programs as reported by suppliers.

Table A. 2: Statistics on conservation program characteristics adopted by suppliers

	Number			Percent of total		
Does the PWS:	**Yes**	**No**	**Unknown**	**Yes**	**No**	**Unknown**
Have an Outreach Program	262	55	0	82.6%	17.4%	0.0%
Have Monthly Water Budgets	15	192	110	4.7%	60.6%	34.7%
Offer Residential Water Use Surveys	130	154	33	41.0%	48.6%	10.4%
Offer CII Water Use Surveys	92	171	54	29.0%	53.9%	17.0%
Provide Rebates on Residential Plumbing Fixtures and Devices	210	71	36	66.2%	22.4%	11.4%
Provide Rebates for Landscape Irrigation Efficiency	213	57	46	67.2%	18.0%	14.5%
Provide Rebates for Turf Replacement	164	119	34	51.7%	37.5%	10.7%
Provide Rebates on CII Plumbing Fixtures and Devices	178	86	53	56.2%	27.1%	16.7%
Provide Water Loss Reduction Systems (Leak Detection Program)	67	163	87	21.1%	51.4%	27.4%
Provide Other Programs	61	107	149	19.2%	33.8%	47.0%
Includes Financial Costs/Breakdown	7	162	148	2.2%	51.1%	46.7%

Table A. 3: Percent of suppliers implementing rebated residential plumbing measures, devices, and fixtures

Category	Number of suppliers	Percent of total (total = 211)
Indoor Fixtures and Appliances		
Premium High Efficiency Toilets	192	91.00%
High Efficiency Clothes Washer	184	87.20%
Showerheads	18	8.53%
Faucet Aerators	11	5.21%
Hot water Recirculation System/Components	11	5.21%
Ultra-Low and Zero Water Urinals	8	3.79%
High Efficiency Dishwater	9	4.27%
Shower timers	2	0.95%
Meters and Valves		
Pressure Regulator/ Pressure Reducing Valve	6	2.84%
Flow Control Valves	1	0.47%
Flowmeter	1	0.47%
Submeter	1	0.47%
Greywater Systems (Laundry to Landscape)		
Greywater Laundry to Landscape	4	1.90%
Landscape Measures		
Lawn/Plant/Turf Replacement/Conversion	150	71.09%

Table A. 4: Percent of combinations of rebated residential measures, devices, and fixtures implemented by suppliers

Residential Fixture Combinations	Number of suppliers	Percent of total (Total = 211)
Premium High Efficiency Toilet, High Efficiency Cloth Washer, Turf Replacement	121	57.3%
Premium High Efficiency Toilet, High Efficiency Cloth Washer	51	24.2%
Premium High Efficiency Toilet, Turf Replacement	12	5.7%
High Efficiency Cloth Washer, Turf Replacement	9	4.3%
Turf Replacement	8	3.8%
Premium High Efficiency Toilet	7	3.3%
High Efficiency Cloth Washer	3	1.4%

Appendix B. Estimating Baseline and Regulatory Scenarios

To estimate current and future baseline conditions and the required water use reductions needed under the proposed regulation and alternatives, we adopted a hybrid approach using information gained from end-use-modeling and seasonal adjusted monthly measures using eAR data, as well as water use efficiency data gathered through an extensive outreach effort. The process of implementing the end-use modeling approach includes collecting spatial data and building characteristics, estimating fixture efficiency and consumption, calibrating end-use modeling results, forecasting demands using stock modeling, and comparing projected water use with estimated objectives.

B.1. Identifying Potentially Affected Suppliers

DWR collects data for approximately 472 suppliers every five years through Urban Water Management Plans. DWR uses this data to identify qualifying suppliers. For instance, as part of developing existing water use standards through SBx7 7, DWR evaluated total per capita targets for 445 suppliers. Each supplier is assigned a unique identifier, the “DWR ID” within reporting. Data is collected, standardized, maintained, and published every five years.

The State Water Board tracks data for water supply agencies using Public Water System Identification Numbers (PWS IDs). PWS IDs are standard throughout federal and state reporting and each public water system across the U.S. has a unique PWS ID. Population, water production, and many other data fields for public water systems are collected through the annual electronic Annual Report and the Monthly Water Conservation Reporting datasets.

DWR IDs and PWS IDs do not align in all cases. For suppliers with one contiguous service territory, PWS IDs can be directly matched with DWR IDs. For suppliers with multiple territories, however, DWR uses one ID to refer to the entire area, while the State Water Board tracks data by individual service territories that are each assigned a unique PWS ID. Some of these smaller territories would qualify as suppliers through state definitions of serving more than 3,000 connections or providing more than 3,000 acre-feet of water annually to retail customers.

Throughout the analysis for economic and environmental effects, both IDs were maintained. We created the best available list that linked DWR IDs and PWS IDs. Most of the calculations that compared forecasted demand with objectives were easiest to complete using DWR IDs based on linking available data. After linking necessary and available data to evaluate objective parameters, historic demand, and forecasted demand, future compliance trends could be assessed for 391 suppliers.

B.2. Collecting Spatial Data for Land Use and Building Characteristics

The end-use modeling approach considered spatial data at multiple scales. First, at the most detailed scale, land use and building characteristics were derived from a commercial dataset of land use and tax assessor information, which was provided by the State Water Board for use in this project. The dataset integrates county tax assessor records with additional real estate databases to create a comprehensive dataset, though still one with important limitations. Second, parcels were aggregated to supplier agency service territories. For each agency, the number of parcels and associated characteristics across land use types were calculated, based on a cleaned dataset of parcel information that accounted for assessor data inconsistencies as best as possible. Finally, suppliers were aggregated to the ten standardized hydrologic regions across the state. Table B.1 lists the attributes associated with the statewide standardized assessor data used in the analysis.

Table B. 1: Parcel and building attributes included in the database of parcels

Attribute	
Derived from assessor data	**Derived from building footprint data and GIS analysis**
Census Block Group (CENSUS_BLOCK_GROUP)	Parcel Area (Parcels_LA.SHAPE_Area)
Parcel APN Number (PARCELAPN)	Building Footprint Area (Buildings.SHAPE_Area)
Avg assessed value of land (VAL_ASSD_LAND)	Parcel ID (Parcel_GIS_ID)
Avg value of improvements (VAL_ASSD_IMPRV)	Building ID (Building_GIS_ID)
Avg total assessed value (VAL_ASSD)	
Number of Stories (STORIES_NUMBER)	
Land use code \ (USE_CODE_STD_LPS)	
Lot Size Area (LOT_SIZE_AREA)	
Lot Size Unit (LOT_SIZE_AREA_UNIT)	
Building Square-Feet (BLDG_SQFT)	
Year built (YR_BLT)	
Effective Year Built (YR_BUILT_EFFECT)	
Number of rooms (TOTAL_ROOMS)	
Number of bedrooms (BEDROOMS)	
Total Number of Baths (Sum of TOTAL_BATHS)	
Number of pools (POOL_INDICATOR)	
Last Date of Sale (LAST_SALE_DATE_TRANSFER)	
Recording Date of the Last Sale (DATE_FILING)	

Using county-level assessor data for urban resource analysis purposes involves uncertainty. Many types of errors exist. First, properties that do not have a local tax liability are less likely to have updated data. These include parks, schools, universities, and other publicly held land. Property characteristics are more accurate for residential and commercial properties that must be assessed for value on a regular basis. Second, particular classes of properties, especially multifamily properties, can be mislabeled, with overlapping parcels. Third, properties can have mislabeled data for addresses or other characteristics. Finally, aggregated spatial layers that assemble sub-parcels can help match assessor data to the spatial scale of utility billing records or other characteristics (Porse et al. 2016; Reyna and Chester 2015). Even after significant cleaning of the dataset, some level of uncertainty in building stock and land use characteristics was expected.

Aggregated assessor data was used to create a list of parcels in each supplier agency's service territory in support of keeping track of the stock of buildings over time. Building footprint data was added to the attributes to develop a calculation of pervious land area that did not include the building footprints associated with a parcel.

B.3. Estimating Fixture Efficiency and Water Consumption

After integrating spatial data and quantifying the types and ages of buildings in a supplier, assumptions of fixture efficiency could be applied to the summary building statistics. As part of implementing an industry-best-practice approach for urban water demand modeling, we examined existing literature to evaluate water use by indoor and outdoor fixtures over time. These included clothes washers, dishwashers, faucets, showerheads, irrigation sprinklers, and others. This built on decades of work from industry and researchers, who have accrued and published comprehensive and formatted datasets. Such sources include the Alliance for Water Efficiency, the Water Research Foundation, the Pacific Institute, the California Energy Commission, and industry consultants through many studies (AWE 2020a; DeOreo et al. 2011, 2016; DeOreo and Mayer 2012; Gleick et al., 2003; Mayer et al., 1999, 2015).

Eq. B.1: The volume of water consumption per day for a given end-use (V_{T_e}) is equal to the number of uses per day in the building for the fixture (n_e) times the volume of water consumed per use (V_{u_e})

$$V_{T_e} = n_e \cdot V_{u_e}$$

The number of uses for a fixture (n_e) is based on considering existing literature, sociodemographic data from the U.S. Census, such as average number of persons per household within a block group, and results from the study of indoor water use in support of the rulemaking standard, which became available in 2021.

To estimate fixture efficiency, a dynamic approach that considered change over time was required. As buildings are bought, sold, and renovated over time, the efficiency of indoor and outdoor fixtures changes. It is impossible to know exactly what fixtures exist in a given household or building, but knowing land use and real estate characteristics can help with making assumptions about fixture efficiency. Water use efficiency of fixtures in a building can be assumed by estimating their likely time of installation or replacement, based on knowing the stated consumption per use by such fixtures that were standardly available on the California market, as shown in Table B.2 for indoor fixtures. The table was assembled after integrating multiple sources of information and iteration. A study supported by the Water Research Foundation included a survey of federal and state changes in water use efficiency requirements of fixtures over time (Diringer et al. 2018).

Compiling available resources on changes in fixture efficiency helps inform a table of important time periods. For each of these periods, the number of buildings either constructed, sold, or renovated during that time lends to assuming the associated efficiency of fixtures. Through a highly detailed end-use modeling approach, the model calculations keep track of estimated changes in fixture efficiency over time in a given building for all buildings in a supplier agency's service territory.

The time periods in Table B.2 denote the different vintages. Table B.2 illustrate assumptions of fixture efficiency used in the end-use modeling. The assumptions may evolve based on results from ongoing indoor water use evaluations or calibration procedures by the university team and State Water Board staff.

Table B. 2: Fixture and appliance gallons per capita per day (GPCD) by vintage in 2030 based on US federal and California policies and initial baseline projections

Water Use (GPCD)	Toilet	Clothes Washer	Shower	Bathroom / Kitchen Faucet	Leak	Other	Bath	Dishwasher	Total
Pre-1950	35	16.8	25.1	33.3	7.9	2.5	1.5	1.4	123.5
1950-1977	25	16.8	25.1	33.3	7.9	2.5	1.5	1.4	113.5
1978-1993	17.5	15.3	9.9	17.5	7.9	2.5	1.5	1.2	73.3
1994-2006	8	11.2	9	14.7	7.9	2.5	1.5	0.9	55.6
2007-2009	7.8	9.5	8.5	14.2	7.9	2.5	1.5	0.8	52.7
2010	7.7	9.4	8.4	14	7.9	2.5	1.5	0.6	52
2011-2013	7.5	8.4	8.1	13.5	7.9	2.5	1.4	0.5	49.8
2014	6.4	8.2	7.2	11	4.3	2.5	1.5	0.4	41.5
2015	6.4	6.4	7.2	11	4.3	2.5	1.5	0.4	39.7
2016-2017	6.4	6.3	7.2	10	4.3	2.5	1.5	0.4	38.5
2018-2021	6.4	5.7	6.5	10	1.6	2.5	1.5	0.4	34.5

B.4. Indoor and Outdoor Water Use Efficiency Improvements from Utility Rebate Programs

Data was collected from suppliers and regional agencies throughout California on past water use efficiency rebate and incentive programs. Data was primarily available for Southern California and the San Francisco Bay Area. In both locations, suppliers can participate in regional water use efficiency programs administered by regional agencies and may enhance regional program offerings with local funding.

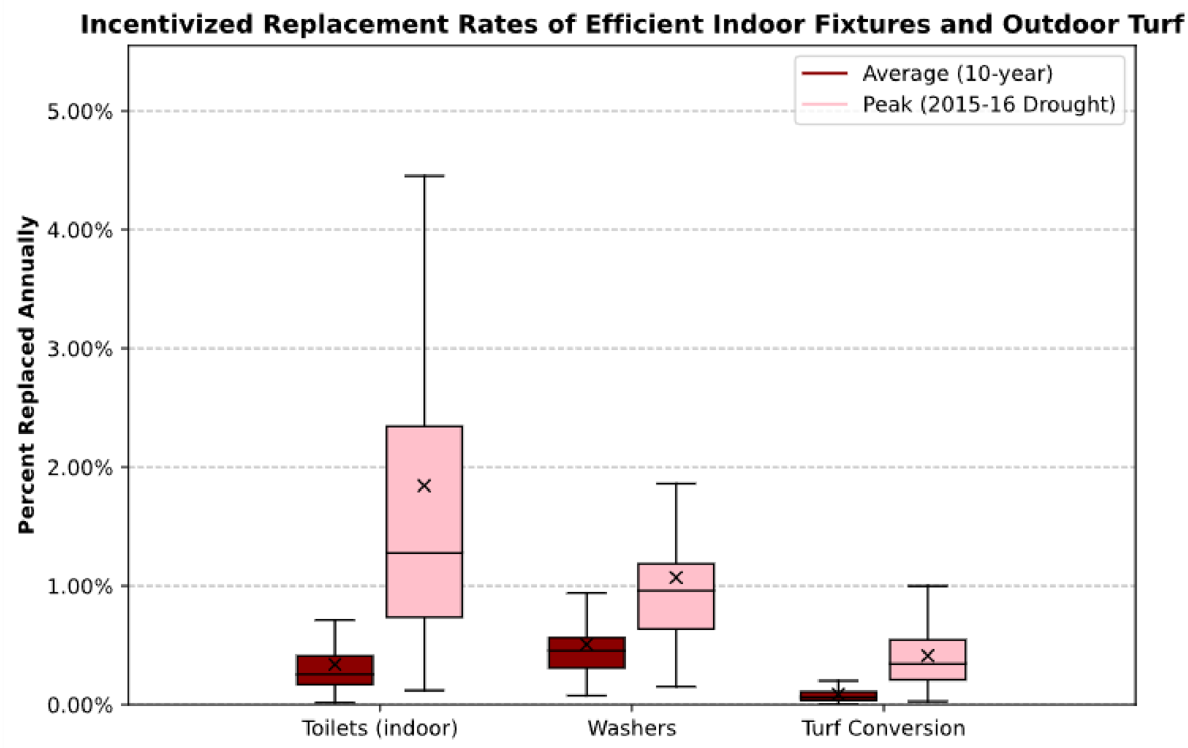
Program data was available starting as early as 2011, depending upon the program and rebate. Data was variably available at either the supplier or regional level. For each geographic area, the total number of properties was estimated by attributing parcels within the supplier boundaries and summing the number of properties by land use type, which allowed for calculating the number of bathroom and kitchens based on the property data.

The annual rate of replacement from rebates were calculated for three rebates of interest: toilets, clothes washers, and turf replacement. For toilets and clothes washers, the number of rebates was divided by the number of bathrooms or houses, with the simplifying assumption that each household had one clothes washing machine. For turf replacement, the replacement rate was calculated as percent area replaced based on dividing the total area of projects in a year by the irrigated area.

Replacement rates were calculated for two values: the average annual rate across a decade and a peak annual rate. The peak rates usually corresponded with drought (2014–2016), when agencies boosted local or regional water use efficiency programs. For toilets, the average annual rate of replacement in a supplier for areas with available data was 0.3 percent (range = 0.0 percent–2.9 percent), while the average annual peak replacement rate was nearly 2 percent (range = 0.1 percent–18.8 percent). For clothes washers, the average annual rate of replacement was 0.5 percent (range = 0.1 percent–3.8 percent), while the annual peak replacement rate was 1.1 percent (range = 0.2 percent–7.9 percent). For turf replacement, the average annual rate of replacement was 0.1 percent (range = 0.0 percent–0.3 percent), while the annual peak replacement rate was 0.4 percent (range = 0.0 percent–1.3 percent).

These average annual rates of replacement corresponding with rebate programs ("incentivized") for toilets, washers, and turf conversion were assumed to occur in all years through the forecast scenario result in a 3 percent decline in water use over a 10-year period, averaging 0.3 percent per year (Figure B.1). The peak replacement values were assumed to correspond to drought responses, which are captured through the Net Adaptation Effect, described in a later section.

Figure B. 1: Annual replacement rates of toilets, clothes washers, and turf associated with agency-funded rebates for water use efficiency actions, based on data from 2010–2020 across suppliers in California



Notes: Based on data compiled from multiple agencies across the state spanning approximately 100 suppliers. Rebate data provided by or extracted from public reports by agencies in Southern California, the San Francisco Bay Area, and the Sacramento metropolitan area. Fixture replacement rates were estimated as annual number replaced with incentives divided by the number of existing fixtures based on statewide parcel data. Annual turf conversion rates were estimated as the annual area replaced with incentives divided to total irrigable area based on estimates in a supplier from DWR.

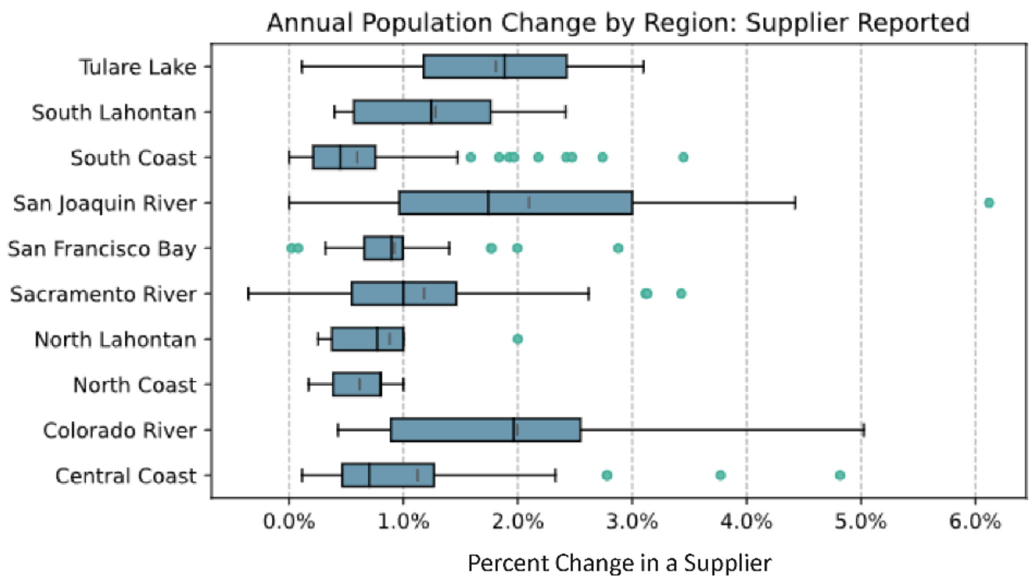
The assumptions for ongoing water use efficiency investments through rebates drew on existing literature and reported data (Figure B.1). In semi-structured interviews, suppliers were asked about existing water conservation programs and how such offerings aligned with what may be needed for future demand reductions. Of those that responded, suppliers had ongoing water conservation programs and most agencies provided more than one type of rebate. High-efficiency toilets, turf removal, and education were the most common.

B.5. Population Changes

Population projections were obtained from three sources: state-level estimates through 2060 and county-level estimates through 2030, both from the Department of Finance (DOF 2022e), and supplier-level estimates through 2045 from DWR’s Urban Water Management Plans. Population projections for the supplier service areas were adjusted such that, when aggregated at the county and state levels, they would align with DOF’s population projections.

UWMP population estimates first were compared with DOF projections. The average annual rate of county-level growth from DOF data was 0.5 percent, while the average annual rate of supplier-level growth from UWMP data was 1.05 percent. County-level DOF annual average growth rates do not exceed 1.2 percent for any county, while approximately one-third of suppliers (158) had average annual growth rates that significantly exceeded DOF's annual average growth rates.

Figure B.2: Unadjusted average annual percent change in population for a supplier (2020–2030)



Note: Based on data from DWR Urban Water Management Plans (2015–2020).

Similarly, comparing the 2030 projected populations, statewide population based on supplier-level estimates from UWMP data were approximately 4.5 percent larger than statewide estimates from DOF data. Statewide population based on supplier-level projections was calculated assuming that the urban population served by suppliers will remain constant at 95 percent. In order to have supplier-level projections aligned with DOF's 2030 population projections, population projections for each supplier in 2030 were adjusted by 3 percent (decrease), which was equally applied to all suppliers. Similar comparison and adjustments were made to the 2035 and 2040 population projections, using DOF's state-level population estimates.

The assumed adjustments have a few limitations. For example, county-level DOF data covers the entire state while supplier-specific UWMP data that covers areas with approximately 95 percent of the population. The adjustment factors applied to all suppliers did not consider supplier-specific population projections and did not evaluate local conditions such as new development or population migration, which could explain if a supplier's reported UWMP population projections differed significantly from local county values.

Finally, population projections that were missing for certain suppliers were imputed by assuming the median population growth rate across all suppliers for which projections were available.

B.6. End-Use Modeling of Fixture Efficiency: Implementation

Boosting the prevalence of efficient indoor and outdoor devices has been a key tool used by regulatory and water management agencies to promote water use efficiency and conservation. Replacing indoor and outdoor devices that use water typically results in new devices that use less water per unit of application as a result of technological innovations and changes in standards and building codes. Water agencies develop many types of programs that provide incentives and rebates to customers who undertake water-saving actions, such as replacing older water-consuming appliances and fixtures or removing turf. This analysis considered increased efficiency of devices based on the following:

1. **Code-based (“natural”) replacement rate**, which is the rate at which devices are replaced after failure or end of life.
2. **Enhanced replacement rate**, which is the rate at which devices are replaced based on incentives or preferences to update a device before its end of life.

Code-based replacement, also termed natural replacement, is driven by the lifetime of devices, the frequency of use that can limit or extend the typical device lifetime, and land use factors such as the rate of home construction or remodeling. Code-based replacement can be modeled by understanding how the number of devices (toilets, clothes washers, faucets, and others) changes over time based on typical device lifetimes, as well as the changes in water consumption per use for fixtures sold in the marketplace.

Enhanced replacement occurs when residents or businesses choose to replace devices before their end of life. This may result from personal preferences to reduce consumption or water agency incentives that motivate a personal choice for voluntary replacements or upgrades. Enhanced replacement from water agency incentives and rebates can be estimated by collecting data on past rebate programs.

The annual decline in indoor per capita use was evaluated using an end-use model developed as part of this project and populated by data from industry sources, as well as outreach with suppliers in California. Appendix D provides further details on the implementation of the end-use modeling for baseline demand to estimate net costs and benefits.

The end-use model evaluates per capita use over time for the period spanning from 2020 to 2040 considering baseline and enhanced rates of fixture replacement. Data for the efficiency of fixtures associated with ages of households and standard accepted lifetimes of fixtures and appliances was accumulated and standardized from literature. The end-use model incorporated efficiency improvements for toilets, kitchen and bath faucet fixtures, showerheads, clothes washers, and dishwashers. The end-use model integrated land use and building ages by analyzing a commercial statewide dataset with real estate tax assessor and parcel information for all properties in the State of California (Digital Map Products 2021). The State Water Board provided the parcel data as an ESRI file geodatabase. For each supplier with GIS boundaries, a .csv file was created with a list of properties in the service territory and attributes associated with each. The .csv files served as an input for modeling fixture efficiency over time by assuming an exponential decay function for replacement rates.

The end-use modeling for each supplier estimated several parameters. First, the modeling estimated the change in gallon per capita per day (gpcd) use from indoor fixture efficiency improvements from 2020 to 2040, calculated as the percent change from model per capita values across the 20-year time frame. Second, the modeling estimated the saturation rate of the most efficient fixtures for each year from 2020 to 2040. Third, the analysis estimated number of these fixtures in each supplier's territory using the parcel information and assumptions of household fixture prevalence.

The end-use modeling considered two scenarios: efficiency improvements with natural replacement rates driven by fixture lifetimes, and efficiency improvements with enhanced replacement rates driven by both fixture lifetimes and additional adoption of efficient fixtures in the household through incentivized replacement from rebate programs offered by suppliers. The end-use modeling simulated a "stock" model capable of evaluating the available fixtures still available for replacement given natural or enhanced rates of replacement. For the first scenario of natural replacement rates, standard appliance lifetimes were used to estimate the average efficiency of a fixture in a household of a given age considering replacement over time. For the second scenario of enhanced replacement rates, incentive-based replacement that occurs before the end of the appliance lifetime was incorporated for clothes washers and toilets by reducing the lifetime of each by an assumed percentage. Data for water use efficiency rebate programs was collected from suppliers in Southern California, the San Francisco Bay Area, and a few other supplier territories in the state dating back to as early as 2011 for purposes of evaluating average annual replacement rates across retailers in several major urban areas. The collected data included rebates for approximately 100 suppliers in urban areas across the state. The average rate of replacement during non-drought years was used as part of the end-use modeling to capture the extent of on-going fixture efficiency improvements not related to injections of funding that have occurred in many regions during periods of significant drought and water scarcity. Such declines were accounted for through another procedure.

The average annual change in per capita efficiency in an agency was used to model declines in residential indoor per capita use from 2020 through 2040 related to technological improvements. An exponential decay function was used to model replacement rates based on an estimated lifetime. Enhanced replacement rate was used for toilets and clothes washers in the residential sector. To evaluate the functional parameters for modeling, values from literature were used. Toilets have an estimated lifetime of 25 years (lambda = 0.4), while clothes washers have an estimated lifetime of 14 years (lambda = 0.71). The lambda values for the modeling with exponential decay functions can be interpreted as an annual rate of replacement.

Enhanced rates of replacement for toilets and clothes washers based on accumulated rebate data was 22 years (lambda = 0.45) for toilets and 13 years (lambda = 0.76) for clothes washers, which are equivalent to 0.5 percent annual replacement rates from incentives. This did not include drought-based incentives, which are considered through the Net Adaptation Effect, described below. These values are underestimates for some suppliers that have invested in incentives and overestimates for others that have not. Rebate data indicated negligible incentives for other fixtures.

Through 2030, statewide indoor water use based on the natural replacement rate was estimated to decline in a supplier of 0.6 GPCD (range = 0.3–0.7 GPCD) from indoor fixture efficiency, which is equivalent to 1.1 percent. This aligns with existing modeling at the county level, which is included as a Technical Appendix to the 2021 IRWUS (Mitchell 2016). Enhanced rates of replacement due to incentivized rebates from suppliers yield an average annual decline in a supplier of 0.6 GPCD (range = 0.3–0.7 GPCD). Over the entire period from 2020–2030, the estimated average value of indoor fixture efficiency improvements in a supplier (unweighted) is 5.8 GPCD and 5.8 GPCD for the natural and enhanced rates of replacement. While these are unweighted average values across suppliers, for the demand forecast, the sum of these values specific to a supplier was included as the change in residential indoor demand, which resulted in an average decline of 8 percent (unweighted) in a supplier.

B.7. Adaptation Effects and Water Demand

While weather can influence water demand and irrigation needs, prolonged periods of reduced precipitation, a major component of drought, have yielded temporary and permanent reductions in water demand. During drought periods, a significant reduction in water demand can occur. This can be followed by a period of rebound. The persistent effect of a drought year, net of rebound, is the expected net adaptation effect. In developing the baseline scenario for this analysis, we assumed this net adaptation effect will be a 0.5 percent decline in water use per year. This reflects an assumption that 30 percent of years may be drought years and an assumption that the net adaptation effect of a drought year will be comparable to the net adaptation effect estimated from the 2014-2016 drought period and the 2016-2018 rebound period.

B.8. Outdoor Residential Water Use Efficiency from Turf Replacement

Replacing water-using indoor and outdoor devices typically results in new devices that use less water per unit of application because of technological innovations and changes in standards and building codes over time. Additionally, removing turf lawns and replacing yards with low-water use and climate-appropriate vegetation including bushes, shrubs, and trees can reduce outdoor water demand.

Water agencies develop many types of programs that provide incentives and rebates to customers that undertake water-saving actions such as replacing older water-consuming appliances and fixtures or removing turf. These actions boost ongoing indoor and outdoor water use efficiency. Some evidence indicates that a household that replaces a turf lawn with a water-efficiency landscape through a rebate program may generate additional converted yards that did not participate in the program, with a resulting “neighborhood effect” acting as a water savings multiplier for water agencies rebate investments (Pincetl et al. 2019). In the absence of data from more regions, however, a neighborhood effect was not included in this analysis.

To identify a value of assumed future outdoor water demand as part of the forecast, the analysis considered historical trends in estimated outdoor water use and turf replacement programs. For outdoor water use, annual changes in residential outdoor demand were evaluated using monthly water conservation data. Outdoor demand varies significantly over the course of the year, with most demand occurring in summer and early fall. From 2014–2020, the maximal value of outdoor per capita demand within the year was estimated for each supplier based on the difference between the minimum and maximum month values of per capita demand (2-month averages). Many suppliers had large values of annual change in a given year due to data gaps and inconsistencies. The distribution of median annual rates of change in suppliers was -5 percent. This value was used as a benchmark, but did not incorporate potential effects that drought can have to permanently reduce demand.

For rebate programs, the rate of turf replacement associated with rebates was evaluated for each supplier as the total land area converted in a year through a rebate divided the sum by the total irrigable irrigated land area for each year with data. The average annual replacement rate and the peak annual replacement rate were calculated for years since 2011. The replacement rate of other outdoor fixtures such as irrigation controllers and rotating nozzles was not estimated.

The average annual replacement rate of turf in a supplier, based on areas with supplier-specific data, was 0.2 percent (0.0 percent–0.3 percent) of irrigated area replaced annually. The peak average annual replacement rate of turf in a supplier was 0.4 percent (0.0 percent–1.3 percent). This average annual value of assumed change in landscapes results in an annual equivalent reduction in water demand. This assumed change was based on the simplified outdoor standard framework and assumed no change in the supplier-wide value of the Evapotranspiration Factor (LEF) applied to the reference evapotranspiration.

Over fifteen years, this average annual rate of replacement was assumed to yield a 4 percent decline in outdoor water demand. This was based on analysis using two methods. The first method reduced landscape area by the 0.2 percent of turf replaced annually in the Model Water Landscape Ordinance equation. The change in total water demand over a 15-year period yielded a 3 percent decline. The second method calculated change in total water demand by applying an assumed rate of water savings from replacing turf (gallons per capita per day, per square-foot) drawn from literature to the annual area replaced. These results yielded a percent decline that ranged from 4.2 percent to 5.9 percent. The percent change varied with values of the LEF, which is equivalent to the outdoor standard and considers efficiency of vegetation and irrigation equipment. A value of 0.7 corresponds with a 4.2 percent decline in demand over a 15-year period, while a value of 0.5 corresponds with a 5.9 percent decline in water demand.

The effects of higher rates of turf replacement associated with the 2014–2016 drought period were assumed to result in the “net adaptation effect” explained in the previous section.

Based on the modeled estimates using assumed savings, outdoor residential water use was assumed to decline by 4.5 percent in a supplier through 2035 due to incentive-based turf replacement occurring in the absence of drought. Notably, the aggregate change is sensitive to the assumed evapotranspiration adjustment factor and could be influenced by more prevalent high-efficiency sprinkler heads and control nozzles.

B.9. Commercial, Industrial, and Institutional Water Use

CII indoor demand and CII outdoor demand on properties without dedicated irrigation meters is not included in the water use objective. For CII properties with dedicated irrigation meters, water use is assessed based on reported values for water deliveries in the “landscape irrigation” category, e.g. parks, medians, playing fields, etc. At the moment, key data is missing to evaluate how the CII DIM standard will affect the objective. Reported values for CII DIM water use were therefore used to assess both demand and the objective. Increase in CII DIM water use increases both the reported demand and the objective, so the net effect is zero. However, current and future CII demand must still be estimated as part of the forecast to compare total urban demand in a supplier with its existing water use target from SBx7 7. Assumed future CII indoor and outdoor demand (not associated with dedicated irrigation meters) was calculated by applying annual rates of change to baseline CII water demand derived from eAR data. The rate of change in this excluded CII demand is assumed to be 0.5 percent per year when accounting for increased efficiency due to CII performance standards. However, the baseline change (i.e. change over time in the absence of the CII performance standards) from 2020 to 2035 is negligible for excluded CII. Therefore, future changes to the excluded CII values are mainly associated with CII performance standards. It is assumed that CII demand would decrease by a total of 7.5 percent from 2020–2035 as a result of suppliers implementing the Performance Measures required by the proposed regulation.

B.10. Water Loss

Water loss may occur within suppliers’ systems or on private properties (residential and commercial) served by suppliers. Both types are relevant as part of AB 1668 and SB 606 but are considered in different ways.

For water loss in suppliers’ systems, state agencies collect information on water loss reporting from suppliers and use it to enact regulatory requirements for water loss reductions as part of SB 555. Suppliers will receive a volumetric water loss target that is included in the water use objective, which must be met starting January 2028, with data submitted from 2025 through 2027.

During interviews, respondents were asked if they would use activities undertaken as part of SB 555 compliance to address potential demand reductions associated with AB 1668 and SB 606. If so, these would need to be considered as marginal impacts from AB 1668 and SB 606 over and above the SB 555 requirements. Among respondents, there was near consensus that water leak reductions beyond the requirements of SB 555 are not a viable or cost-effective option to reduce overall water use. Given reported non-revenue water losses ranging between 3 percent and 6 percent, most agencies stated that any further reductions in water loss run into the law of diminishing returns and are not financially cost-effective. This is particularly the case with water agencies in Northern California where the price of water per acre-foot is 50 percent to 75 percent lower than in Southern California. For example, one agency in Northern California reported that it was more cost-effective to pay for annual non-revenue water loss at an average cost of $150,000 than to replace drinking water pipelines at $1 million per mile. One supplier noted that it was considering reducing water loss by 1 percent to 2 percent through pressure management, valve leak detection, fire hydrant leak detection, and better data analytics as an alternative to replacing pipelines.

For water loss on residential and commercial properties served by suppliers, customer-level leak detection programs were considered as a potential water use reduction tool available for suppliers.

B.11. Net Baseline Water Demand Forecast through 2035

Through the forecasting approach with assumptions, the future volumetric and percent change (average annual and 10-year total) in per capita and total demand in 2035 was estimated (Table B.4).

Each of the components of total water demand (X_{all}) was estimated through 2035 to yield a total and per capita volume for each supplier (Equation B.2). These included residential indoor ($X_{r,indoor}$) and residential outdoor ($X_{r,outdoor}$) use, as well as water loss (L) and excluded demands (E) that were assumed to be static[28].

$$X_{all} = X_{r,indoor} + X_{r,outdoor} + L + E$$

Eq. B. 1: The total water demand (X_{all}) is expressed as the sum of residential indoor ($X_{r,indoor}$) use, residential outdoor ($X_{r,outdoor}$) use, water loss (L), and excluded demands (E)

Through 2035, both total and per capita statewide demand, calculated as the sum of all water demand in urban areas divided by the sum of the total urban population, are forecasted to decrease (Table B.4). Total per capita demand (summing both the regulated and excluded components) is forecasted to decrease by 14 percent from 136 GPCD in 2020 to 117 GPCD in 2035 absent the regulation, while residential per capita demand (indoor and outdoor) is forecasted to decrease by 12 percent from 83 GPCD in 2020 to 73 GPCD in 2035. Total urban

[28] Section B.10 notes that changes in the excluded CII components, while accounted for in the model, are minimal in the absence of performance standards.

water demand is forecasted to decrease by 7 percent from 5.57 in 2020 to 5.16 million acre-feet (MAF) in 2035. This translates to a baseline reduction of approximately 410,000 acre-feet, or approximately 7 percent of total current statewide urban demand in suppliers.

Table B. 3: Total and per capita trends in water demand, based on analysis of multiple data sources and modeled demand

Parameter	Indoor Residential	Outdoor Residential	Total Residential	Total Urban
Per Capita, 2019/2020 (GPCD)	47	36	83	136
Per Capita 2035 (GPCD)	40	33	73	117
Per Capita Change (%) 2020-2035	-15%	-8%	-12%	-14%
Volume, 2019/2020 (MAF)	1.95	1.52	3.47	5.57
Volume, 2035 (MAF)	1.79	1.47	3.26	5.16
Volumetric Change (%), 2020-2035	-8%	-3%	-6%	-7%
Volumetric Change, 2020-2035 (AF)	-160,000	-50,000	-210,000	-410,000

Notes: based on data from multiple sources available at the time of analysis, including the State Water Board's Monthly Conservation Reporting data (2014–2020), the electronic Annual Reports (2013–2019), and modeled data. Forecasted trends incorporate changes in population. Indoor demand forecast includes fixture efficiency improvements from natural fixture replacement and enhanced fixture efficiency improvements from incentive programs outside of drought. Outdoor demand forecast includes increased efficiency from turf replacement based on observed rates of replacement (by area) and a net drought effect.

For supplier-specific values, the annual average decrease (unweighted for population) in indoor per capita water use is expected to be 0.88 percent (+/- 0.11 percent) in a supplier, while outdoor demand based on the standardized assumption across agencies is forecasted to decrease on average by 0.78 percent (Table B.4). Combining changes in per demand and population yields an annual 0.37 percent (+/- 1.07 percent) decrease in indoor volume and an annual 0.26 percent (+/- 0.99 percent) decrease in outdoor volume on average, per supplier. The difference in the per capita and total values is explained through population growth and variable rates of conservation. The sum of these, plus other components mentioned in Equation B.2, yielded an average annual per capita decrease in total demand in retailers of 0.74 percent (+/- 0.61 percent) in a supplier, while total demand decreased on average by 0.27 percent (+/- 0.83 percent).

Table B. 4: Results for annual per capita and total percent changes in urban water demand in a supplier through 2035. The table reports the average and median values of supplier-specific annual percent change, not weighted for population, over the 15-year period of 2020 to 2035

Parameter	Per Capita Demand 2020-2035 Annual % Change in a Supplier: Average	Per Capita Demand 2020-2035 Annual % Change in a Supplier: Median	Total Demand 2020-2035 Annual % Change in a Supplier: Average	Total Demand 2020-2035 Annual % Change in a supplier: Median
Indoor Residential ($X_{r, indoor, theoretical}$)	-0.88%	-0.91%	-0.37%	-0.70%
Outdoor Residential ($X_{r, outdoor}$)	-0.78%	-0.78%	-0.26%	-0.62%
Total Residential ($X_{r, total}$)	-0.84%	-0.85%	-0.33%	-0.64%
Total (X_{total})	-0.74%	-0.76%	-0.27%	-0.53%

For per capita demand, 95 percent of suppliers would experience annual per capita demand reductions. For total demand, however, only 76 percent of those suppliers would see annual reductions in total volume due to population growth outpacing conservation gains in some service areas.

Appendix C. Framework for Calculating Water Use Objectives

Suppliers, not individuals or households, would be subject to the proposed regulation. s must comply with the urban water use objective, not the individual standard-based budgets. A supplier's urban water use objective is an estimate of aggregate efficient water use for the previous year based on adopted water use efficiency standards and local service area characteristics for that year. A supplier's water use objective equals the sum of standard-based budgets for:

- Residential indoor use
- Residential outdoor use
- CII landscapes with dedicated irrigation meters (DIMs)
- Real water losses

When applicable, the urban water use objectives will also include:

- Variances (for example, for water use associated with livestock)
- A bonus incentive for potable recycled water

Residential Indoor Use Standard

The 2018 conservation legislation set the standard for efficient residential indoor use. In 2022, SB 1157 lowered the standard, based on joint recommendations from DWR and the State Water Board. The residential standard is 55 gallons per capita per day (GPCD) until 2025; from 2025 to 2035, it is 47 GPCD; and, 2030 onwards, it is 42 GPCD. In evaluating how the objectives might impact suppliers, three scenarios were analyzed by State Water Board staff. Each scenario assumed the residential indoor standards specified in statute.

The formula for calculating the efficiency budget for residential indoor use is:

$$\mathrm{R}_{indoor} = S_{indoor} \cdot P \cdot \text{days in the year}$$

Eq C.1: Residential indoor water use budget, in gallons (R_{indoor}) is equal to the residential indoor standard, in gallons per person per day (S_{indoor}) multiplied by the supplier's service area population (*P*) multiplied by the days in the year.

Residential Outdoor Use Standard and the Standard for CII Landscapes with DIMs

In evaluating how the urban water use objective component of the regulation might impact suppliers, three scenarios were analyzed by State Water Board staff. Table C1 compares the standards used and the irrigated status of the landscapes the standards would be applied to for the proposed regulation and the two alternatives.

Table C1: Comparing the proposed regulation with Alternative 1 (A1) and Alternative 2 (A2)

	Proposed Regulation LEF (%)	Proposed Regulation INI Buffer	A1 LEF (%)	A1 INI Buffer	A2 LEF (%)	A2 INI Buffer
Now through 2024						
Residential Outdoor	80	No	80	Yes	80	No
CII landscapes with DIMs	80	N/A	80	N/A	80	N/A
2025 through 2034						
Residential Outdoor	63	No	63	Yes	55	No
CII landscapes with DIMs	63	N/A	63	N/A	45	N/A
2035 onwards						
Residential Outdoor	55	No	63	Yes	55	No
CII landscapes with DIM	45	N/A	63	N/A	45	N/A

CII = Commercial Industrial Institutional, DIM = Dedicated irrigation meter, INI = Irrigable non irrigated, LEF= Landscape efficiency factor

The formula for calculating the efficiency budget for residential outdoor use is:

$$R_{outdoor} = S_{outdoor} \cdot RLA \cdot ET_{o,Net} \cdot 0.62$$

Eq. C.2: The budget for outdoor irrigation of residential landscape areas, in gallons ($R_{outdoor}$), is equal to the standard for residential outdoor water user, expressed as a landscape efficiency factor ($S_{outdoor}$) times the Residential Landscape Areas (RLA) in square feet, times the net evapotranspiration ($ET_{o,Net}$) in inches per year, times the 0.62 unit conversion factor (gallons per square feet times inches)

The formula for calculating the efficiency budget for CII landscapes is:

$$I_{DIM} = S_{DIM} \cdot A_{I,DIM} \cdot ET_{o,net} \cdot 0.62$$

Eq. C.3: The budget for outdoor irrigation of landscape areas with dedicated irrigation meters in connection with CII potable water, in gallons (I_{DIM}), is equal to the standard for outdoor irrigation of landscape areas with dedicated irrigation meters in connection with CII potable water, expressed as a landscape efficiency factor (S_{DIM}) times the irrigated area of CII landscapes with Dedicated Irrigation Meters, in square feet ($A_{I, DIM}$) times net evapotranspiration ($ET_{o,Net}$), in inches per year, times 0.62 unit conversion factor, in gallons per square feet times inches

Real Water Losses

A separate State Water Board regulation established unique supplier-specific standards for real water losses. The State Water Board previously reported on the estimated economic and fiscal impacts of that regulation. Because the costs associated with the water loss regulation have already been accounted for through a separate regulatory process, staff did not account for them here. For context, we've included information about how the water loss budgets will be calculated.

Some suppliers own and operate single systems; others own and operate multiple systems. Some of these systems have unique water loss standards based on their number of service connections; for others, the unique standards are based on the length of their distribution systems. Because of this variability, there are multiple formulae that could be used to calculate water loss budgets.

For suppliers that own and operate a single system and have a standard based on the number of service connections, the formula for calculating the efficiency budget for real water losses is:

$$B_{water\ loss} = S_{water\ loss} \cdot C \cdot \text{days in year}$$

Eq. C.4: $B_{water\ loss}$ equals $S_{water\ loss}$ times C times days in year

Where:

- $B_{water\ loss}$ is the system-specific water loss budget, in gallons per year.
- $S_{water\ loss}$ is the system-specific water loss standard, in gallons per connection per day.
- C is the number of service connections.

For suppliers that own and operate a single system and have a standard based on the length of their distribution system, the formula for calculating the efficiency budget for real water losses is:

$$B_{water\ loss} = S_{water\ loss} \cdot M \cdot \text{days in year}$$

Eq. C.5: $B_{water\ loss}$ is equal to $S_{water\ loss}$ times M times days in year.

Where:

- $B_{water\ loss}$ is the system-specific water loss budget, in gallons per year.
- $S_{water\ loss}$ is the system-specific water loss standard, in gallons per mile per day.
- M is the length of distribution system, in miles.

For suppliers that own and operate multiple systems, the formula is the sum of system-specific water loss budgets.

Variances

Variances are for unique uses of water that could have a material effect on an urban retail water supplier's urban water use objective. For a supplier to request and receive a variance, the associated use must exceed a threshold of significance, which, for most of the variances, must be at least 5 percent of the sum of the residential indoor, residential outdoor, CII landscapes with DIMs, and water loss efficiency budgets. There is specific formula that will be used to calculate the efficient water use allowable under each variance. Provided they represent a unique and significant use of water, the proposed regulation includes variances for the following:

- Evaporative coolers
- Fluctuations in seasonal populations
- The planting of new, climate-appropriate trees
- Horses and other livestock.
- Pools, spas, and other water features
- Areas irrigated with recycled water having high levels of total dissolved solids.
- Soil compaction and dust control.
- Ponds and lakes to sustain wildlife.
- Emergency response
- Commercial or noncommercial agricultural use.

Bonus Incentive

Urban retail water suppliers that deliver water from a groundwater basin, reservoir, or other source that is augmented by potable reuse water will be eligible for a bonus incentive. With the bonus incentive, eligible suppliers will be able to adjust their urban water use objective based on the volume of potable reuse water delivered to residential customers and landscape areas with dedicated irrigation meters (DIM) in connection with Commercial, Industrial, and Institutional (CII) water use.

The bonus incentive is not to exceed 15 percent of the urban water supplier's water use objective for any potable reuse water produced at an existing facility. An existing facility is defined as one with a completed environmental review on or before January 1, 2019, that becomes operational on or before January 1, 2022, and that uses microfiltration and reverse osmosis technologies to produce the potable reuse water.

The bonus incentive is not to exceed 10 percent of the urban water supplier's water use objective for any potable reuse water produced at any facility that is not an existing facility.

The formula for calculating the bonus incentive is as follows:

$$Bonus\ Incentive\ =V_{PR}\ \cdot\ \frac{D_{RDIM}}{T_{PW}}$$

Eq. C.7: Bonus incentive is equal to V_{PR} times the quotient of D_{RDIM} and T_{PW}

Where:

- V_{PR} is the volume of potable reuse water from groundwater (V_{PRG}) or surface water (V_{PRS}) or the sum of both.
- D_{RDIM} is the volume of potable reuse deliveries associated with residential and CII landscapes with DIMs.

- T_{PW} is the volume of potable water production.

For suppliers that obtain potable reuse water from a groundwater source, the formula for calculating the volume of potable reuse water is as follows:

$$V_{PRG} = V_G \left(\frac{LF \cdot R}{V_{BP}}\right)$$

Eq. C.8: V_{PRG} is equal to the V_G times the product of *LF* and *R* divided by V_{BP}
Where:

- V_{PRG} is the volume of potable reuse water from groundwater.
- V_G is the volume of the water extracted from the groundwater basin.
- *R* is the recharge volume.
- *LF* is the loss factor.
- V_{BP} is the volume of the total basin extractions.

For suppliers that obtain potable reuse water from a surface water source, the formula for calculating the volume of potable reuse water is as follows:

$$V_{PRS} = V_{SW} \left(\frac{LF \cdot A}{V_{SWP}}\right)$$

Eq. C.9: V_{PRS} is equal to the V_{SW} times the product of *LF* and *A* divided by V_{SWP}
Where:

- V_{PRS} is the volume of potable reuse water from surface water.
- *A* is the volume of augmented potable reuse surface water.
- *LF* is the loss factor.
- V_{SWP} is the volume of total augment potable reuse.
- V_{SW} is the volume of total potable reuse from surface water.

Appendix D. Residential Indoor and Outdoor Water Use and Savings Calculations

D.1. Methods for Calculating Baseline Urban Per Capita Water Use

Methods of determining residential outdoor use are varied and often depend on estimates of residential indoor use because indoor and outdoor residential use are rarely metered separately. Some of the attempts to quantify residential outdoor use are detailed by the Pacific Institute (2013) and summarized below.

Hydrologic Region Method (eq. D.1)

$$\text{Outdoor Water Use is equal to Population, multiplied by Urban Water Use, multiplied by Percentage of Urban that is Residential, multiplied by Percentage of Use that is Outdoor}$$

Summer–Winter Method (eq. D.2)

$$\text{Outdoor Water Use is equal to Average Urban Water Use in Winter (October through March) minus Average Urban Water Use in Summer (April through September)}$$

Minimum Month Method

This method assumes that throughout the year, indoor water use remains relative constant (Mayer et al. 1999). In this approach, the minimum residential water use month, typically in the winter months, for a given area is assumed to represent only indoor water use. The difference between this month and the water use for the rest of the year is taken to represent the residential outdoor water use. For more semi-arid regions of California with households that maintain water-intensive outdoor landscaping during winter months, this method may not be an appropriate representation of the outdoor water demand and has the potential to underestimate outdoor water use.

Average Month Method

The average month method uses the average of the lowest water use months (December to February) to gauge outdoor water use. Similar to the minimum month method, the average month method has a similar indoor water use overestimation because of semi-arid water intensive landscapes even during winter months.

Representative City Method (eq. D.3)

Water use for a region, in GPCD, is equal to the sum of each representative city's population divided by the sum of all representative cities multiplied by the hydrologic region population multiplied by the water use of the representative city multiplied by percent of outdoor water use multiplied by percent of urban water use:

$$\text{Water use for region} = \Sigma\ [(\text{city population}/\text{sum of populations}) * \text{hydrologic region population} * \text{water use by city} * \text{percent outdoor} * \text{percent urban}]$$

Discussion of these methods ultimately led to the Seasonal Adjustment Method (SAM), which is used for the estimation of indoor residential water use. The SAM uses billing data from dedicated irrigation meters to infer residential winter irrigation water use. Outdoor residential water use is then calculated as total residential water use minus the SAM-estimated indoor residential water use. The SAM in conjunction with eAR water use data established a baseline for residential indoor water use and residential outdoor water use.

D.2. Estimating Residential Indoor Water Use with Fixture and Appliance Lifetimes

To estimate the impact that the residential indoor water use standard has on residential indoor water use for a supplier, we estimated the difference in baseline use and what use would be if suppliers adhered to the budgets established by the efficiency standards. This appendix provides several measures that may be part of a supplier's Water Use Efficiency (WUE) program. We obtained values for water use by appliance and fixture from a variety of sources including residential end use studies and flow tracing analyses (see, for example, Mayer et al. 1999; DeOreo et al. 2011; DeOreo et al. 2016; Mayer et al. 2015). Additionally, studies using Flow Trace Analysis, have allowed indoor residential water use literature to parse out individual appliance uses (DeOreo et al. 1996), further enabling demand-side management programs to verify applicable water savings.

The residential indoor use estimates rely on two main components: determining the indoor use values and estimating the type of or stock of appliances and fixtures within homes. The former relies on previous use literature studies, and the latter incorporates legislative timelines, turnover, and available saturation data. To develop a method of calculating residential indoor water use savings for different efficiency measures, a series of several steps was required:

1. Determine appliance and fixture water use using techniques commonly found in other residential indoor water use estimations. These fixture values are found in literature (DeOreo et al. 2011, DeOreo et al. 2016; Mayer et al. 1999).
2. Establish several housing vintage bins based on federal and California water efficient standards while incorporating saturation data resulting from such sources as WaterSense and Energy Star.
3. Incorporate fixture and appliance turnover, including the impacts of Water Efficient Plumbing Fixtures Requirements (SB 407).
4. Create a vintage portfolio for each supplier by incorporating service parcel data and grouping parcels together into vintages.
5. Calculate a weighted-water savings value for each measure for each suppliers using the characteristic and parcel makeup of each area.

Step 1: Determine water using fixtures and related GPCD formulations.

To estimate the GPCD for each vintage and appliance or fixture, a typical use value per person per household was taken from water demand literature and applied to the estimated vintage gallons per use. The vintage usage values incorporated saturation data from WaterSense and Energy Star. The equation to calculate GPCD for an appliance or fixture in a vintage is shown below:

$$GPCD_{Vintage\ i} = \frac{\#Uses}{Person \cdot Day} \cdot \left[\frac{Gallons}{Use}\right]_i$$

Where $\left[\frac{Gallons}{Use}\right]_i = Gallons\ per\ use\ within\ each\ vintage$

Eq. D.4: GPCD for each appliance or fixture, except showerheads and faucets, within a vintage is equal to the number of uses per person per day for the appliance or fixture multiplied by the gallons per use for the appliance or fixture within a vintage.

The equation to calculate GPCD for showerheads and faucets is modified to include average minutes of use and throttling assumptions. The equation is shown below:

$$GPCD_{Vintage\ i} = (Avereage\ minutes\ of\ use) \cdot \frac{\#\ Uses}{Person \times Day} \cdot \left[\frac{Gallons}{Minute}\right]_i \cdot (Throttling\ Assumption)$$

Where, $\left[\frac{Gallons}{Minute}\right]_i = Gallons\ per\ minute\ within\ each\ vintage, i$

Eq. D.5: GPCD for showerheads or faucets within a vintage is equal to the average minutes of use multiplied by the number of uses per person per day multiplied by gallons per minute for the fixture within a vintage multiplied by the throttling assumption.

To calculate the GPCD values for all water uses, not including leaks, the “other” category, or bathtubs, use values and behaviors were taken from DeOreo et al. (2016). A summary of the GPCD for each indoor appliance and fixture and the assumptions used is shown in Table D.1. This analysis also assumes that each household has at least one of the fixtures or appliances in the home with a “presence” value equal to 1.

The GPCD for leaks was taken from literature values and was assumed to be greater for older housing vintages and smaller for new vintages. Values for leak GPCD came from DeOreo et al. (2016) where the average reported value of 7.9 GPCD was assumed for all vintages prior to 2014. A value of 4.3 GPCD was assumed for the vintages of 2014 to 2017 because it is the median value reported in DeOreo et al. (2016) and matches the general leak assumption that younger houses will have a lower number of leaks. For the most recent vintage, a leak volume of 1.6 GPCD was assumed, which is the result of dividing the median leak value (4.3) by the average number of household residents reported (2.65).

The GPCD for Other is assumed to be 2.5 GPCD for all vintages and includes evaporative cooling, humidification, water softening, and other uncategorized indoor uses. It is taken from DeOreo et al. (2016).

The GPCD for baths is assumed to be 1.5 GPCD for all vintages and is taken from DeOreo et al. (2016).

Ultimately, GPCD was calculated for each fixture or appliance within each vintage and is shown in Table D.2 below. The highlighted vintage periods indicate that there was a reduction in the GPCD for the appliance or fixture with yet-to-be-discussed incorporation of replacement and saturation data. The progressively lower GPCD has been the result of more efficient water use measures.

Table D. 1: Calculations for indoor water use

Water Use	Use Assumptions	Vintage Period Pre-1950	1950-1977	1978-1993	1994-2006	2007-2009	2010	2011-2013	2014	2015	2016-2017	2018-Present
Toilet	Flushes per person per day	5	5	5	5	5	5	5	5	5	5	5
	Gallons per Flush	7.0	5.0	3.5	1.6	1.56	1.54	1.50	1.28	1.28	1.28	1.28
	GPCD	35	25	17.5	8	7.8	7.7	7.5	6.4	6.4	6.4	6.4
Showerhead	Average Minutes of Use	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Uses per Person per Day	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
	Fixture Gallons per Minute	7	7	2.75	2.5	2.4	2.4	2.3	2	2	2	1.8
	Use Throttling Assumption	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
	GPCD	25.1	25.1	9.9	9.0	8.6	8.6	8.3	7.2	7.2	7.2	6.5
Bathroom Faucet	Average Minutes of Use	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Uses per Person per Day	20	20	20	20	20	20	20	20	20	20	20
	Gallons per minute	5	5	2.63	2.2	2.1	2.1	2	1.7	1.7	1.5	1.5
	Use Throttling Assumption	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
	GPCD	33.3	33.3	17.5	14.7	14.0	14.0	13.3	11.3	11.3	10.0	10.0
Kitchen Faucet	Average Minutes of Use	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Uses per Person per Day	20	20	20	20	20	20	20	20	20	20	20
	Gallons per Minute	5	5	2.63	2.2	2.1	2.1	2	1.7	1.7	1.5	1.5
	Use Throttling Assumption	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%	67%
	GPCD	33.3	33.3	17.5	14.7	14.0	14.0	13.3	11.3	11.3	10.0	10.0

Water Use	Use Assumptions	Vintage Period Pre-1950	1950-1977	1978-1993	1994-2006	2007-2009	2010	2011-2013	2014	2015	2016-2017	2018-Present
Clothes Washer	Gallons per Load	56.0	56.0	51.0	37.3	31.8	31.3	28.1	27.3	21.5	20.9	18.8
	Use per Person per Day	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	GPCD	16.8	16.8	15.3	11.2	9.5	9.4	8.4	8.2	6.5	6.3	5.6
Dishwasher	Gallons per Load	14	14	14	9	7.7	5.8	4.9	4.3	4.4	3.7	3.6
	Use per Person per Day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	GPCD	1.4	1.4	1.4	0.9	0.8	0.6	0.5	0.4	0.4	0.4	0.4
Bath	GPCD	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Leaks	GPCD	7.9	7.9	7.9	7.9	7.9	7.9	7.9	4.3	4.3	4.3	1.6
Other*	GPCD	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

**Other includes: evaporative cooling, humidification, water softening, and other uncategorized indoor uses. Green shaded cells indicate GPCD totals*

Table D. 2: Visualization of changes in water use for specific appliance or fixtures

Water Use (GPCD)	Vintage Period Pre-1950	1950-1977	1978-1993	1994-2006	2007-2009	2010	2011-2013	2014	2015	2016-2017	2018-Present
Toilet	35.0	25.0	17.5	8.0	7.8	7.7	7.5	6.4	6.4	6.4	6.4
Clothes Washer	16.8	16.8	15.3	11.2	9.5	9.4	8.4	8.2	6.4	6.3	5.7
Shower	25.1	25.1	9.9	9.0	8.5	8.4	8.1	7.2	7.2	7.2	6.5
Faucet	33.3	33.3	17.5	14.7	14.2	14.0	13.5	11.0	11.0	10.0	10.0
Leak	7.9	7.9	7.9	7.9	7.9	7.9	7.9	4.3	4.3	4.3	1.6
Other	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Bath	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Dishwasher	1.4	1.4	1.4	0.9	0.8	0.6	0.5	0.4	0.4	0.4	0.4
Total	**123.5**	**113.5**	**73.3**	**55.6**	**52.7**	**52.0**	**49.8**	**41.5**	**39.7**	**38.5**	**34.5**

Green shaded cells indicate a decrease in value from previous time period

Step 2: Establish vintages based on legislation and incorporate available market data.

To establish vintages that better represent the likely differences of water fixtures between older housing stock and newer housing stock, categories were created to reflect legislative changes affecting these fixtures and appliances. These are meant to mark intervals of significant changes at both the federal and California state level. Table D.3 presents a summary of the legislative findings and how they relate to the vintage periods. For each vintage, the GPCD of each fixture or appliance was calculated at the time of the housing construction and does not yet incorporate the effects of turnover. See Table D.1 for a summary of vintage specific values for GPCD and assumed use metrics like gallons per flush, load, or minute. Vintages after 1994 incorporate market saturation data of WaterSense and ENERGY STAR labeled fixtures and appliances.

In 1996, the U.S. EPA and the U.S. Department of Energy announced their ENERGY STAR partnership, establishing voluntary performance standards for many appliances. In 2006, the EPA WaterSense program was launched. WaterSense is both a label for water-efficient products and a voluntary partnership program that promotes water efficiency. WaterSense specifications are not standards, and ENERGY STAR specifications were not adopted by the Department of Energy until 2011.

Table D. 3: Legislation and programs timeline for determining vintages

Vintage Period	Legislation and Programs in Effect	Toilet	Clothes Washer	Showerhead	Bathroom / Kitchen Faucet	Dishwasher
Pre-1950	No Legislation – Baseline Vintage, Vickers (2001)					
1950–1977	No Legislation – Vickers (2001)	X				
1978–1993	CEC 1978	X	X	X	X	
1994–2006	EPA 1992, 63 FR 13308 (1998), ENERGY STAR (1996, 2004), WaterSense (2006)	X	X	X	X	X
2007–2009	WaterSense (2006), EISA (2007), ENERGY STAR (2008)	X	X	X	X	X
2010	AB 715**, EISA (2007), ENERGY STAR (2008)	X	X	X	X	X
2011–2013	AB715**, 77 FR 31918 (2013), EISA (2007), ENERGY STAR (2009, 2011, 2012)	X	X	X	X	X
2014	AB715**, CALGreen2013	X	X	X	X	X
2015	77 FR 32307, ENERGY STAR (2015)		X			
2016–2017	CEC Title 20 (2016), ENERGY STAR (2016)		X		X	
2018–Present	77 FR 32307, CEC - Title 20 (2016)		X	X		

*** As stated in California Assembly Bill 715, sales for high-efficiency toilet models should have reached 67 percent by January 1, 2011, 75 percent by January 1, 2012, and 85 percent by January 1, 2013.*

Step 3: Incorporate fixture and appliance turnover, including SB 407 impacts. Apply to vintage efficiency rates.

Vintage efficiency rates determined for the fixtures and appliance in the previous section were adjusted to incorporate turnover rates. As appliances and fixtures get older, they will fail and need to be replaced at some point, *t* years. An appliance or fixture that failed outside of a vintage period—i.e., a toilet failing 20 years in an unrenovated house built 1985—would have its 3.5 GPF water use replaced with the 2005 water use toilet of 1.6 GPF.

Koeller (2017) uses a 25-year lifetime for toilets and assumes a natural replacement rate of four percent annually of the remaining installed stock each year of non-efficient fixtures. The California Urban Water Agencies Phase 1 Water Savings Study[29] documents a device lifetime of 8–14 years for clothes washers, conservatively we used the upper end for clothes washer lifetime. For faucets, showerheads, and dishwashers, average device lifetimes and standard deviations were calculated from the range of lifetimes in the Water Research Foundation's *Integrating Water Efficiency into Long-Term Demand Forecasting's Appendix E*, shown in Table D.4 (Cooley et al. 2018). Alternative lifetime estimates were also found in several company websites (i.e., OnTime Service[30]).

Table D. 4: Fixture and appliance average lifetime and standard deviation

Fixture/Appliance	Average Lifetime (years)	Standard Deviation
Faucets	17.50	2.5
Showerhead	8.50	3.0
Dishwasher	11.50	2.1

Vintage efficiency rates from Step 1 were adjusted to account for fixture and appliance turnover rates over time using an exponential decay function:

$$N(t) = N_0 e^{-\lambda t}$$

Eq. D.6: The number of devices of a given efficiency at year t is calculated as the number of devices at year 0 multiplied by e to the product of negative lambda and year t. N(t) is the number of devices of a given efficiency at year t, N_0 is the number of devices at year 0, and λ is the percent of device failing each year. The turnover rate, λ, is calculated as the inverse of the device lifetime.

[29] *CUWA Phase 1 Water Saving Study* by California Urban Water Agencies, April 13th 2015
[30] https://ontime59.com/faucet-lifespan-repair-or-replace/

$$\lambda = \frac{1}{Device\ Lifetime}$$

Eq: D.7: The percent of devices failing each year, λ, is equal to one divided by the device lifetime.

The exponential decay function assumes a constant percentage, λ, of remaining stock is replaced each year. Because of this, the greatest replacement occurs in year one, when the remaining stock is the largest.

In addition, the analysis takes into consideration impacts of Senate Bill (SB) 407, passed by the legislature in 2009. Among other requirements, SB 407 required single-family homes sold after 2017 to be retrofitted with more efficient plumbing fittings and fixtures. While SB 407 also established efficiency requirements for remodeled single-family homes, multifamily residences, and commercial buildings, this analysis did not attempt to quantify those prospective impacts.

To analyze the prospective impact of SB 407 on single-family homes sold or transferred after 2017, parcel data for California was acquired from LandVision, a map-based real estate application with a nationwide parcel database that ties parcel boundaries to several property and tax attributes, such as the most recent sale date. For single-family homes, SB 407 identified specific efficiency factors for toilets, showerheads, and faucets in single-family houses at the time of sale and requires upgrading them if they do not meet those efficiency factors for that sale. In estimating its impact, it is assumed SB 407 only resulted in upgrades for houses sold in 2017 or thereafter. By 2017 and 2018, the 2009 factors became irrelevant, as Californians could no longer purchase products reflecting the older standards. This analysis incorporates contemporary standards. Table D.5 below summarizes the differences.

Table D. 5: Comparing the 2009 SB 407 efficiency requirements with contemporary efficiency standards

Fixture	SB 407 requirements	2017 CA requirements	2018 CA requirements
Toilets	1.6 GPF	1.28 GPF	1.28 GPF
Showerheads	2.5 GPM	2 GPM	1.8 GPM
Kitchen faucets	n/a	1.8 GPM	1.8 GPM
Bathroom faucets	2.2 GPM	1.2 GPM	1.2 GPM

If a single-family home were sold or transferred after 2017, we considered the impacts of SB 407 on pre-2016 vintages by adjusting the efficiency values of toilets, showerheads, and faucets from their baseline to their contemporary flow rate. For example, if a 1940s home were sold in 2018, we assumed that home’s toilet would now use 1.28 GPF rather than 7 GPF. For the appliances unaffected by the SB 407 directive (i.e., clothes washers and dishwashers), we assumed natural turnover rates as described above.

For each vintage, Figure D.1 shows how turnover (assuming an exponential decay function) and the impacts of SB 407 affect total and fixture specific GPCD rates as well as fixtures efficiencies.

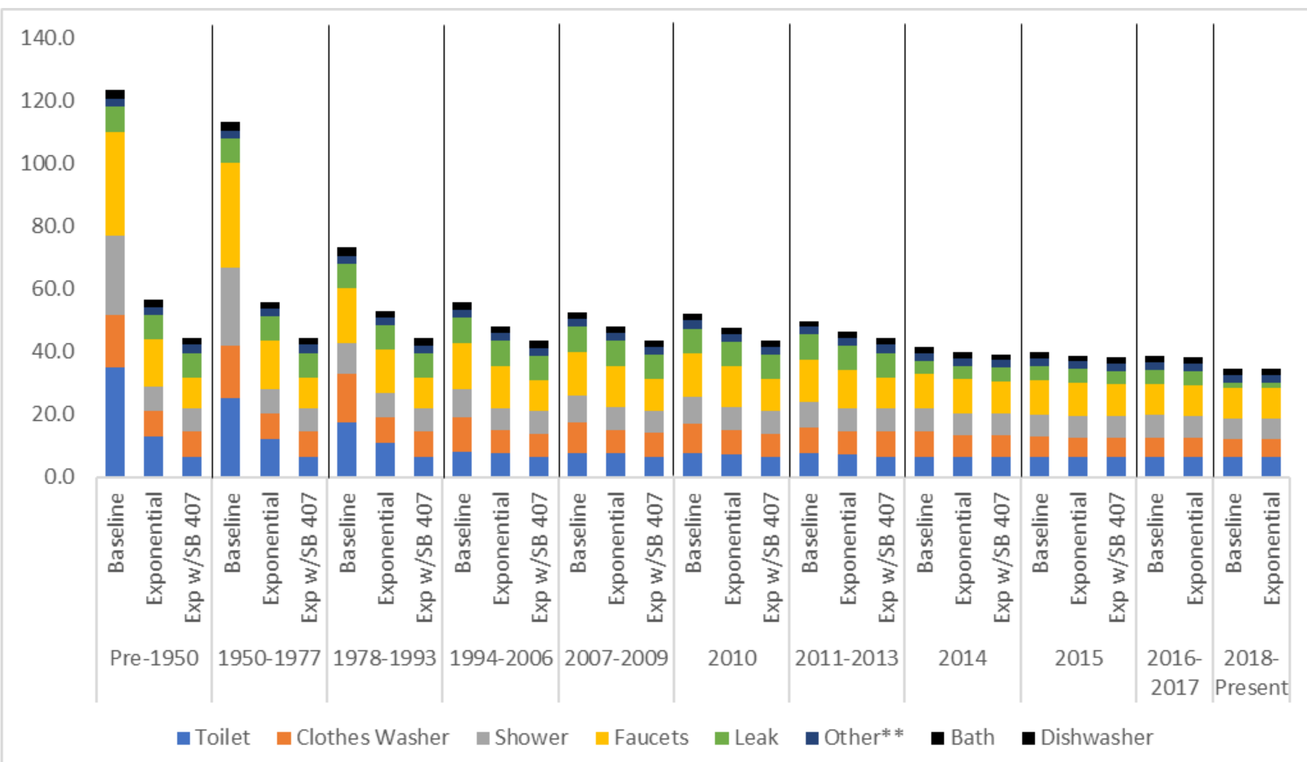
For each vintage, a weighted average for each appliance or fixture efficiency was created, as is common in stock modeling. Each fixture or appliance's water use for a certain vintage is calculated as follows.

$$Weighted\ Water\ Use\ within\ a\ Vintage = \sum_{i=1}^{n} c_i X_i$$

Eq. D.8: The weighted water use for each appliance or fixture within a vintage is calculated as the sum of each fixture or appliance's weight corresponding to a certain water use efficiency multiplied by that fixture or appliance's water use.

Where *n* is the number of different water use efficiencies within each vintage for a fixture or appliance, X_i is the water use for each appliance or fixture, and c_i is the determined weight for each appliance or fixture water use efficiency within each vintage after incorporating turnover.

Figure D. 1 Cumulative fixture and appliance efficiency (gallons per capita per day) without replacement (Baseline), replacement based on exponential decay (Exponential) without and with the impact of SB 407 (Exp w/SB 407)



An important caveat is that this analysis only takes into consideration natural or passive, not incentivized, turnover rates. For many suppliers in California, long-term investments in conservation programming have resulted in substantially higher turnover rates than those we modeled to estimate current statewide IR-GPCD. For example, for the City of Santa Cruz, this model predicts IR-GPCD to be no lower than 52 GPCD. The City itself calculates their current IR-GPCD to be 34 GPCD (City of Santa Cruz 2017). To predict an IR-GPCD value of 34 for Santa Cruz, the turnover rates for fixtures and appliances would have to be multiplied by 8, and leaks across all housing vintages would have to be set at 1.6 GPCD to come close at 35.2 IR-GPCD. This highlights how conservation programs impact residential adoption of water efficient appliances. Table D.6 details the City of Santa Cruz example.

Table D. 6: City of Santa Cruz example

Water Use	Assumed turnover rates in model	Turnover rates to optimize efficiency
Toilet	4%	32%
Clothes Washer	11.1%	89%
Shower	11.8%	94%
Bathroom/ Kitchen Faucet	5.7%	46%
Dishwasher	8.7%	70%
Leaks	7.9 – 1.6 GPCD	1.6 GPCD
Modeled RI-GPCD for the City of Santa Cruz	52	35.2

According to the City of Santa Cruz's Water Conservation Master Plan's 2011 Baseline Survey results, 90 percent of toilets in Single Family homes were 1.6 gallons per flush (GPF) or less. The City models that 1.28 GPF toilets have a 100 percent replacement fixture market share beginning in 2015 and a 100 percent new fixture market share beginning in 2012. In contrast, the exponential decay function with a natural turnover rate of 4 percent predicts approximately 60 percent of toilets were 1.6 GPF or less in 2011. The model for this analysis uses a 100 percent replacement and new fixture market share for 1.28 GPF toilets beginning in 2014.

D.3. Understanding Residential Outdoor Water Use with the Model Water Efficient Landscape Ordinance

In California, about half of all residential water use is used for landscape irrigation (Colby et al. 2006; Evans and Sadler 2008; Gleick et al, 2003; Hilaire et al. 2008; Sabo et al. 2010). Some of the greatest water conservation potential lies in outdoor water use. As climate change presents the hazard of longer-term drought periods, outdoor water use conservation can enable suppliers to embrace resilient strategies. Accurately projecting demand and determining water savings from water efficiency measures are key parts of this process.

The passage of AB 325 in 1990 created the Water Conservation in Landscaping Act that required DWR to establish a Model Water Efficient Landscape Ordinance (MWELO). MWELO went into effect January 1, 1993, requiring all agencies, except in demonstrable unnecessary situations, to adopt a water efficient landscape ordinance by 1993[31].

MWELO has made strides in savings through the adoption, implementation, and enforcement of efficiency measures. Landscape design, installation, and maintenance of water efficient landscapes can yield substantial residential outdoor water savings and can be the most cost-effective conservation measures to implement. For example, LADWP has identified that water savings from landscape irrigation will have the maximum cost-effective potential by the year 2035 (LADWP 2020).

MWELO sets a landscape's Maximum Applied Water Allowance (MAWA) based on:

- A reference evapotranspiration (ET_o) so that regional climate variances could be considered.
- An Evapotranspiration Adjustment Factor (*ETAF*) meant to adjust for plant factors and irrigation efficiency.
- A landscaped area (*LA*) that included "the entire parcel less the building footprint, driveways, non-irrigated portions of parking lots, landscapes such as decks and patio, and other non-porous areas. Water features are included in the calculation of the landscaped area."
- A conversion factor from inches/year to gallons/sq ft/year (0.62)

The latest MWELO update (2015) sets the ETAF for residential landscapes at 0.55 and 0.45 for nonresidential landscapes. Special Landscape Areas can have an ETAF as high as 1.0. Special Landscape Areas (SLAs) are areas of the landscape dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water and recreational areas. The equation to calculate the MAWA for a landscape is:

$$\mathrm{MAWA} = (\mathrm{ET_o})\ (0.62)\ [(\mathrm{ETAF} \cdot\ \mathrm{LA}) + (1\text{-}\ ETAF \cdot SLA)]$$

Eq. D.9: MAWA is calculated as reference evapotranspiration multiplied by 0.62 multiplied by the sum of the evapotranspiration adjustment factor multiplied by landscape area and 1 minus the evapotranspiration factor multiplied by special landscape area.
Where:

- *LA* is estimated irrigable landscape area,
- ET_o is the reference evapotranspiration value,
- E_f is an evapotranspiration adjustment factor associated with plant water needs and irrigation efficiency,
- 0.62 is a unit conversion factor to convert to gallons.

The evapotranspiration adjustment factor from equation D.10 (E_f) captures both the water needs of plants (*PF*) and the efficiency of installed irrigation equipment (*IE*):

31 https://www.latc.ca.gov/general_information/mwelo/

$$E_f = \frac{PF}{IE}$$

Eq. D.10: The evapotranspiration adjustment factor is equal to plant factor divided by the efficiency of the installed irrigation equipment.

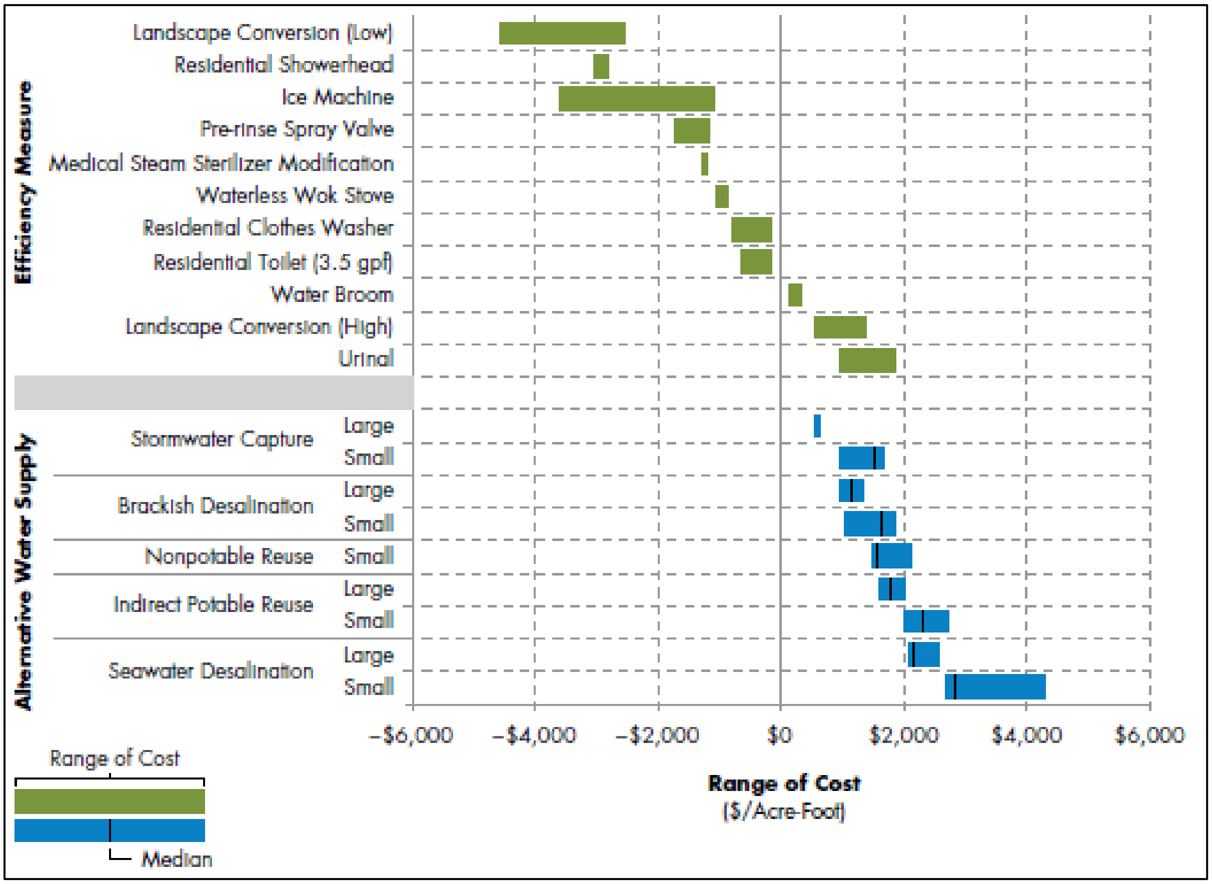
The evapotranspiration adjustment factor, when multiplied by ET_o, estimates the amount of water needed to maintain plants and vegetation. Plant water needs rely on the statewide WUCOLS framework and follow general ranges of 0 to 0.3 for low water use plants, 0.4 to 0.6 for plants with moderate water needs, and 0.7 to 1.0 for plants with high water needs. The irrigation efficiency factor characterizes the amount of water used to irrigate intended plants as a fraction of the total amount of water applied to the landscape. The ET adjustment factor, then, accounts for both of these influences on the amount of water that needs to be applied to the landscape to maintain selected plants. A lower ET adjustment factor can be met by either selecting plants with lower water needs or installing more efficient irrigation devices.

D.4. Outdoor Water Savings Measures

As utilities strive and continue to make developments in water efficiency, many implement strategies to reduce residential outdoor water use. These measures revolve around improving irrigation efficiency and reducing residential outdoor demand via landscape transformations. CalWEP, AWE, and other organizations outline Best Management Practices regarding standard implementation for outdoor demand reduction measures. Common tools used in the analysis of water use analysis and measure unit costs of water are the decision support system models from Maddaus Water Management (MWM) and AWE's Conservation Tracking Tool. Both have been used to estimate long range demand projections. Demand projections work to establish baseline use that incorporates natural fixture and appliance replacement and plumbing codes, as well as measure potential water savings. For this analysis, outdoor measures employed by water agencies are incorporated in a similar manner as the models used in estimating water savings and ultimately their unit measure costs.

Many agencies develop different programs to aid in conservation with variability in rollout, effectiveness, and participation. The following discussion characterizes commonly quantifiable savings and capture to a reasonable degree the types of outdoor measures implemented by suppliers and their agencies to conserve water. In other words, costs per measure and measure water savings are captured via a review of available water savings literature and documents. Past literature indicates that different measures have various cost effectiveness. For example, Cooley and Phurisamban (2016) presents a levelized costs of water conservation and efficiency measures and alternative water supplies that is shown in Figure D.2. It lists different measures for water efficiency and accounts for the "full capital and operating costs of a project or measure over its useful life" in a cost-benefit approach. Data for Cooley and Phurisamban (2016) was based on industry estimates, operational experience, and expert advice. On top of water use forecasts, Heberger et al. (2016) suggests that forecast should consider the effect of the Model Water Efficient Landscape Ordinance, which this analysis does.

Figure D. 2: Levelized Cost of Alternative Water Supplies and Water Conservation and Efficiency Measures, in 2015 dollars per acre-foot



Notes: All values are rounded to two significant figures. Costs for water supplies are based on full-system cost, which includes the cost to integrate the supply into a water distribution system. Ranges for water supplies are based on 25th and 75th percentile of project costs, except for large storm water projects, which include the full cost range of the two projects. Conservation and efficiency measures shown in this figure represent only a subset of the measures examined in this study due to space limitations. Cost ranges for water conservation and efficiency measures are based on varying assumptions about the incremental cost and/or water savings associated with a measure.
Source: Cooley and Phurisamban (2016)

Hanak et al. (2006) develops a framework for analyzing conservation measures for California lawns. Increases in outdoor efficiency are often the first line of attack for water utilities for implementing water use reductions. Water savings from measures aimed at decreasing outdoor water use are estimated as irrigation efficiency increase, a decrease in the plant ET, or both. Water savings in the Hanak et al. (2006) analysis are based on first determining theoretical water needs of residential lots and then comparing with actual water needs of residential lots. That said, outdoor water savings through utility-run programs often leverage landscape transformation programs that focus on irrigation efficiency, plant ET requirements, and smart controllers. Various lawn interventions exist and can go by the names of “cash for grass,” xeriscape, turf conversion, and water-wise landscaping, while other outdoor interventions include free mulch and education outreach (Gregg et al. 2007; Mitchell et al. 2017).

To forecast water savings due to conservation measures, regional demographics, market penetration, unit water savings, and other measures, specific factors are considered. As with indoor water use, rate of replacement is considered. Measure life, the length of time that measures are effective in their water savings, are assumed to be permanent for most measures. For example, residences replacing turfgrass with water efficient landscapes are not reinstalling turfgrass again, and on the other side, savings due to surveys have a measure life of around five years.

Outdoor water conservation measures can vary from program to program but, as previously mentioned, they typically either improve irrigation efficiency, decrease water demanded from plants, or both. In addition to implementing outdoor water-saving technologies and landscapes, cities have made educational efforts to stretch water supplies, decrease overwatering, and eliminate water waste. The City of Sacramento Department of Utilities[32], like many other municipalities, has released “Water Wise” water scheduling and how-to-water guides as a way of ensuring water conservation practices via ordinances, education, and outreach. These types of savings are more difficult to quantify given the variations in human behavior and their interaction with new technologies, but media coverage and outreach can influence changes in water use behavior and should be part of water managers toolkit (Quesnel and Ajami 2017).

There is no accepted baseline standard in how outdoor water savings are measured; however, a review of literature conducted by Mayer et al. (2015) lists a summary of water savings by measure (Table D.7). Depending on the circumstances (i.e., the climate, the customer, program implementation, etc.), water savings can be quite variable.

Table D. 7: Ranges of savings by measure

Measure	Lower Bound	Upper Bound
Water budget-based rates	10%	20%
Mandatory drought irrigation restrictions	18%	56%
Voluntary drought irrigation restrictions	4%	12%
Customized mailed home water use reports		5%
Conservation education programs	2%	12%
Florida-Friendly Landscaping	50%	76%
Xeriscape rebates (New Mexico)		33%
Xeriscape conversion (Nevada)	34	60+ gallons per square foot
Urban densification (MA)		5%
Natural and manufactured shade (Israel)		50%
Soil moisture sensor-based control (FL)	24%	92%
Residential weather-based control (CA)	6%	14.9%

32 https://www.cityofsacramento.org/Utilities/Water/Conservation/Water-Wise-Tools.

Measure	Lower Bound	Upper Bound
Commercial weather-based control (CA)	8%	27.5%
ET signal-based control (FL)	23%	34%
Rain switch and pause (FL)	25%	41%
Weather-based control (NM)	34%	54%
Weather-based control (NV)	4.6%	68%
Rotating sprinkler heads	≤ 0	31%

**Some savings estimates did not differentiate between indoor and outdoor reductions, but in all cases the primary focus was on outdoor. Source: Mayer et al. (2015)*

In this analysis, the overall water savings for each of the residential outdoor measures are explained below along with general program descriptions and cost information. These methods were decided upon from a survey of common water savings measures implemented by California's largest wholesale water supplier, Metropolitan Water District of Southern California.

Outdoor water savings measures:

- Residential Rotating Nozzle
- Drip Irrigation
- Turf Removal
- Smart Timers
- Soil Moisture Sensor Systems
- Rain Shut-off Devices (Weather Based Irrigation Controllers (WBIC))
- California Sprinkler Adjustment Notification System
- Rainwater Capture
- Home Water Reports/Survey

Residential Rotating Nozzle

Description:
High efficiency rotating nozzles are designed to replace stationary or fixed spray irrigation nozzles that traditionally overwater by applying water at a rate faster than soil infiltration rates, leading to runoff, or overdesign due to poor uniformity rates. Installation of multi-trajectory and multi-stream (rotating) nozzles with low-precipitation rates had 45 percent increases in distribution uniformity (MWDOC 2019). Due to the measures reduction in precipitation rates of the sprinklers, longer run times may be needed to meet a landscape's water demand, 1.7 to 2.3 times as long (Solomon et al. 2007).

Water Savings:
Water use for the high efficiency rotating nozzles can have precipitation rates range from 0.4 to 0.6 in/hr. For this analysis, we will assume the average of the two values 0.5 in/hr (MWDOC 2019). Use of rotating nozzles resulted in only 11 percent site reduction and a unit water

savings of 1.55 gallons per day per nozzle or 56 gallons per day per site (MWDOC 2019). Mayer et al. (2017) refers to average low quarter distribution uniformity improvement of 0.26 from 0.44 to 0.70 and a hypothetical single point water savings estimation of 31 percent (Solomon et al. 2007).

Drip Irrigation

Description:
Drip irrigation is designed to replace traditional systems by increasing water use efficiency through targeting of the plant root zone. Efficiencies of drip systems result in dry weather runoff elimination and a lower irrigation of the area. Drip irrigation can be modified to meet plant needs throughout the seasons.

Cost:
MWDOC has a $0.20 per square foot rebate for spray to drip area conversion but the USBR Final Project Report on MWDOC's *Spray-to-Drip Conversion Pilot Project* "Residential applicants could receive a base rebate of up to $0.50 per square foot of conversion area (up to $0.30 from Reclamation and a match of $0.20 from MWDOC)" which, using an average of 350 square feet converted per kit, resulted in an incentive of up to $175 per "kit" (350 x .50). Commercial applicants could receive a base rebate of up to $0.20 per square foot of conversion area, with $0.20 fully funded by MWDOC as a match (MWDOC 2019).

Water Savings:
Water use for drip irrigation systems is in the range of 0.3 to 2 gallons per hour and normally uses less than 1 gallon per hour, cutting outdoor irrigation in half and eliminating water wasted in runoff. Sites studied in the Spray-to-Drip Conversion Pilot Project (MWDOC/USBR 2018) report had average residential water savings of 0.121 gpd/Sq. Ft. and 84 gpd per project site (24 percent reduction) while commercial water savings were 0.066 gpd/Sq. Ft. and 473 gpd per meter (19 percent reduction) as shown in Table D.8. Efficiency estimations listed below in Table D.9 come from the Vis et al. (2007) and MWDOC (2019) and include drip/micro irrigation as the most efficient irrigation system type.

Table D. 8: MWDOC "Spray-to-Drip" evaluation results

Sector	gpd / square feet	gpd / site	% Reduction
Residential Drip Conversion	0.121	84	24%
Commercial Drip Conversion	0.095	473	19%

Source: CLWUE Program Water Savings

Table D. 9: Irrigation efficiency percentages

Irrigation System Type	Efficiency
Drip/Micro-Irrigation	80 to 95
Landscape Spray Systems	40 to 65
Landscape Rotor Systems	50 to 75
Brass Rotor Systems	60 to 85

Sources: Haley et al. (2007); MWDOC (2019), and Vis et al. (2007).

Turf Removal

Description:
The removal of turf grass is one of the measures with the most effective water savings for homeowners. The SoCal Water$mart program requires that projects for turf removal include:

- 3 plants per 100 square feet of transformed area
- A stormwater retention feature
- No hardscape installed in the transformed area. Permeable hardscape permitted
- Replacement or modification of overhead spray sprinklers

Cost:
As of 2021, Metropolitan Water District (MWD) is offering a rebate of $2.00 per square foot up to 5,000 square feet of converted yard per year. Statewide costs can range from $0.50/sf to $3.75/sf (MWD 2015). For example, the utility unit cost per rebate for lawn replacement for the City of Fresno is $0.50 per square foot for single family homes while the single-family, multifamily, and commercial “Cash for Grass” utility unit cost per rebate is $3.50 per square foot up to $6,000[33].

Some of the benefits of instituting a landscape transformation program can include reducing peak demand, reduce design requirement placed on water infrastructure, and avoidance of other costs that decrease customer bills (Chestnutt et al. 2019). With that said, literature estimates of costs on both the utility and customer side are not well documented, and there are few studies that incorporate time, maintenance costs, and the impact associated with efficiency programs (Mayer et al. 2015). These programs can be costly, complicated, and labor-intensive (Chestnutt et al. 2019).

Water Savings:
Water savings from turf removal are determined by estimated total irrigable area of turf to be replaced and its necessary water needs prior to turf replacement. Then an estimation of total water needs after turf replacement has occurred and post-turf replacement water needs have stabilized is needed. These savings are dependent on other factors that include plant factors and regional differences for evapotranspiration, temperature, and precipitation (Litvak et al.

[33] City of Fresno, 2022. *Lawn to Garden Rebate.* Department of Public Utilities Water Conservation.

2014; Litvak et al. 2017; Pekelney and Chestnutt 1997). Because the program of turf replacement incorporates irrigation efficiency increases, water savings from the turf replacement program not only includes savings due to a change in plant factors but also increases in irrigation efficiency that result from smart meters, efficient drip systems, or other outdoor technologies. Knock-on water savings may also be present due to neighborhood adoption effects of nearby neighbors spurred on to implement turf replacement (Pincetl et al. 2017).

Chesnutt et al. (2019) found decreasing water savings per square foot of turf conversion. In their study, they reject the null hypothesis that WS/SF were exactly proportional to the number of SF of turf replaced. Analysis in this study is detailed enough to suggest that departures from the normal temperature in spring have the largest percentage effect. Furthermore, they present weak evidence for the lower initial water savings as plants become established when turf conversion first takes place, but there are still very significant and long-lasting water savings after 10 or more years. Bijoor (2018) echoes this assessment by showing that water savings continues into year 5 of the study. Water savings in the Chesnutt (2020) study ranged from 11 to 76 gallons per year. As would logically be expected, larger pre-intervention mean water use is correlated with larger mean participant water savings (AWE 2019). One of the major confounding issues with landscape transformation studies are the challenges in methodological design. These include programmatic differences, weather variation, and customer heterogeneity (Chesnutt 2020). For example, Baker (2021) relies on the differences-in-differences design for the study of the Las Vegas Valley Water District “Cash-for-Grass” rebate program, meaning that paralleled average water use among non-participants and participants is a major assumption. Bijoor (2018) makes use of this assumption as well. As noted above, these programs are effective and result in significant water savings (Alliance for Water Efficiency 2018).

With many of these difficulties noted, the Task 6 process still needed to settle on a value or process for estimating the water savings of landscape transformation or turf removal. As such, the estimates for water savings could be based on AWE (2018), where average participant water savings widely varied. The 95 percent confidence interval reported for the City of Austin was between 23.7 GPD and 71.7 GPD with a mean net water savings of 47.8 GPD. Results for other cities studied are shown in Table D.11.

Table D. 10: Average participation effect from estimated water use models of single-family customers

Utility	Average Participant Savings, β_{LT} (gpd/meter)	lower bound (gpd/m)	upper bound (gpd/m)	Participant pre-intervention use (gpd/meter)	Average Participant Savings (%)	Lower Bound (%)	Upper Bound (%)	Mean Turf Sq. Ft. replaced	Mean Savings per Sq. Ft per year (gl/yr)	Type of Program
Austin	47.7	23.7	71.7	252.4	18.9%	9.4%	28.4%	1549.3	11.2	Cash for Grass
Guelph	10.3	5.7	14.8	149.1	6.9%	3.8%	9.9%	N/A	N/A	Outreach and Support
North Marin	100.0	83.1	117.0	400.6	25.0%	20.7%	29.2%	599.9	60.9	Cash for Grass
Petaluma	27.6	9.5	45.7	207.0	13.3%	4.6%	22.1%	N/A	N/A	Mulch Madness
Sacramento	111.7	61.0	162.4	377.0	29.6%	16.2%	43.1%	919.3	44.3	Cash for Grass
San Diego, City	109.8	95.6	124.1	330.4	33.2%	26.7%	37.6%	959.2	41.8	Cash for Grass
SNWA	280.6	277.3	284.0	724.2	38.8%	38.3%	39.2%	1348.0	76.0	Cash for Grass
Santa Rosa	54.9	50.4	59.4	240.4	22.8%	21.0%	24.7%	852.1	23.5	Cash for Grass
San Diego CWA	114.8	98.5	131.2	329.6	34.8%	29.9%	39.8%	1046.0	40.1	Incentives and Classes

Source: AWE (2018).

Other options for estimating the water savings due to turf replacement include taking a mean value of agency literature compiled estimates, explained below, or even establishing a ratio of water savings (gal/ft^2/yr) to reference ET_o (in/yr) and multiplying by an area's ET_o to account for regional differences. This last suggestion does not fully incorporate Chesnutt (2020) recommendation against using a single variable to explain the effect weather has on residential water consumption. Literature values for turf replacement water savings were given in volume per square foot.

Table D. 11: Water savings and reference ET_o from literature review

Turf Replacement	Water Savings (Gal / square feet / yr)	Ref ET_o (inches / yr)	Description
Moulton Niguel	24.6	44.7	Referenced in Bijoor (2018) - California Data Collaborative
Santa Clara Valley WD	48	49	Bijoor (2018) SCVWD. Year 5.
Santa Clara Valley WD	31	49	Bijoor (2018) SCVWD. Year 2-5.
Santa Cruz	19	36	City of Santa Cruz Water Conservation Master Plan (2017)
AWE Tracking Tool	36		AWE Tracking Tool. For Reference.
LADWP	29.6	50.1	LADWP WCPS M1 to M3 efficiency level improvement. Table G-1e. Ref ET_o from 2015 MWELO for LA
MWDOC	44.5	47	MWDOC's CLWUE Report (2018)
Average	33.2		-

Due to the measure's evapotranspiration adjustment factor dependency on both plant factor and irrigation efficiency, LADWP's Residential Landscape Irrigation efficiency level increase will be used. This results in an (E_f) change from 1.83 that includes an overwater factor of 1.5 to an E_f of 0.65, resulting in a change in E_f of 1.18. This overwater factor is a common assumption (see Maddaus decision support system model for the City of Santa Cruz) and leaves room for certainty improvements. ET_o will vary by supplier region but turf replacement water savings will pair area replaced in each boundary along with the ET_o for that boundary and incorporate the measure savings assumption in the E_f.

Residential Smart Timers and Rain Shut-off Devices (WBIC)

Description:
Efficient residential irrigation systems can integrate automated reporting of weather conditions to reduce the amount of watering in cooler weather to prevent over-irrigation and apply water only when needed. These devices work by using local evapotranspiration data to make determinations of a systems watering schedule and irrigation requirements. The USBR in partnership with MWDOC evaluated the impacts of smart timers in their reports, *OC Smart Irrigation Timer Rebate Program – Program Evaluation*[34] and *Evaluation of Municipal Water District of Orange County's Comprehensive Landscape Water Use Efficiency Program.*[35]

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[34] *OC Smart Irrigation Timer Rebate Program Evaluation*, Municipal Water District of Orange County, 2015.
[35] *Evaluation of Municipal Water District of Orange County's Comprehensive Landscape Water Use Efficiency Program (CLWUE).* Municipal Water District of Orange County, US Bureau of Reclamation.

Table D. 12: Prices and service costs for select weather-based irrigation technology

	Suggested Retail Price			
Company	**Low**	**High**	**Average**	**Annual Service Cost**
Accurate WeatherSet	$ 222.00	$ 1,440.00	$ 831.00	-
Alex-Tronix	$ 150.00	$ 2,695.00	$ 1,422.50	-
Aqua Conserve	$ 264.00	$ 6,193.00	$ 3,228.50	-
Calsense	$ 1,050.00	$ 3,925.00	$ 2,487.50	-
Cyber-Rain	$ 399.00	NA	$ 399.00	-
ECO Research	$ 198.00	NA	$ 198.00	-
ET Water Systems	$ 831.00	$ 2,985.00	$ 1,908.00	$ 75–199
Hunter (ET System)	$ 450.00	NA	$ 450.00	-
Hunter (Solar Sync)	$ 129.00	NA	$ 129.00	-
HydroPoint WeatherTRAK	$ 340.00	NA	$ 340.00	$48 and up
HydroSaver7	$ 1,800.00	$ 2,800.00	$ 2,300.00	-
Irrisoft Weather Reach	$ 695.00	$ 785.00	$ 740.00	$ 0–350
Irritrol	$ 325.00	$ 909.00	$ 617.00	$ 48–84
Rain Bird (ETMi & ETC)	$ 650.00	$ 775.00	$ 712.50	$ 0–350
Rain Bird (ESP-SMT)	$ 325.00	$ 450.00	$ 387.50	-
Rain Master	$ 674.00	$ 4,039.00	$ 2,356.50	$ 120–180
The Toro Company	$ 325.00	$ 3,050.00	$ 1,687.50	$ 48–120
Tucor	$ 1,290.00	$ 1,980.00	$ 1,635.00	$ 72–360
Weathermatic	$ 350.00	$ 950.00	$ 650.00	-
Weathermiser	$ 130.00	$1,295.00	$ 712.50	-
Average	$ 529.85	$ 529.85	$ 2,284.73	$ 1,159.60
Standard Deviation	$ 433.65	$ 433.65	$ 1,601.50	$ 902.78

Source: USBR (2015)

Water Savings:
The average water savings percentage reduction is used from their survey of suppliers. For a site-specific evaluation of water savings due to WBIC, MWDOC (2018) estimates that WBIC reduced water consumption by 50 gallons per day (11 percent site reduction) and 50 gallons per clock. Interestingly, when the WBIC measure was combined with participating in the study's turf replacement program, statistically significant increases in water savings were realized compared with the WBIC treatment only (87 gallons per day (27 percent reduction overall) and 0.125 gallons per day per square foot per timer. Table 12 of the MWDOC CLWUE program evaluation is listed below in Table D.14.

Table D. 13: Smart timer efficiency research

Study Title	Author	Sector	GPD Savings	% of Total Water Use	% of Outdoor Water Use
Residential Runoff Reduction Study, 2004	A&N Technical Services, T. Chesnutt	Res.	41	10%	-
		Comm.	545	-	21%
Commercial ET-Based Irrigation Controller Water Savings Study, 2006	A&N Technical Services, T. Chesnutt	Comm.	601	-	22%
MWDOC SmarTimer Rebate Program Evaluation, 2011	A&N Technical Services, T. Chesnutt	Res.	49	9%	-
		Comm.	727		28%
OC Smart Irrigation Timer Rebate Program, 2014	M. Baum-Haley	Res.	59	11%	18%
		Comm.	320	-	10%
Evaluation of MWDOC's CLWUE Program, 2018	R. Waite	Res.	50	11%	-

Source: MWDOC Smart Timer Evaluation (2014)

An alternative approach to estimating water savings is to average USBR compiled data for manufacturer-reported water savings percentages seen in Table D.15. In order to estimate water savings due to this measure, an average of water savings percentages from the United States Bureau of Reclamation (USBR) for both ET Controller and Moisture Sensor Systems is needed. The manufacturer-reported percentage of water savings does not necessarily match the technical studies range of 9 percent to 11 percent.

Table D. 14: Manufacturer-reported water savings (percent)

	Company	Manufacturer-Reported Water Savings (Percent) Low	High	Average
Weather Based Irrigation Technology	Accurate WeatherSet	25	NA	25
	Alex-Tronix	10	30	20
	Aqua Conserve	21	28	24.5
	Calsense	20	40	30
	Cyber-Rain	38	38	38
	ECO Research	20	40	30
	ET Water Systems	20	50	35
	Hunter (ET System)	30	NA	30
	Hunter (Solar Sync)	30	NA	30
	HydroPoint WeatherTRAK	16	58	37
	HydroSaver7	NA	NA	NA
	Irrisoft Weather Reach	20	50	35
	Irritrol	16	58	37
	Rain Bird (ETMi & ETC)	30	80	55
	Rain Bird (ESP-SMT)	20	50	35
	Rain Master	25	40	32.5
	The Toro Company	16	58	37
	Tucor	25	50	37.5
	Weathermatic	20	50	35
	Weathermiser	34	52	43
Average		23	48	34
Standard Deviation		6.99	12.58	7.51

Source: USBR (2015)

<u>Soil Moisture Sensor Systems</u>

Description:
According to SoCal Water$mart, a soil moisture sensor system (SMSS) detects the soil moisture content in the active plant root zone where it is installed. When connected to an irrigation controller, it is capable of bypassing a scheduled irrigation event if soil moisture exceeds a user-defined threshold. Smart controllers are a relatively low-cost technology capable of improving lawn irrigation efficiency, reducing total applied water, and limiting pesticide and nutrient runoff (Brezonik and Stadelmann 2002; McCready and Dukes 2011).

Cost:

Table D. 15: Smart meter costs

	Company	Suggested Retail Price Low	High	Average
Soil Moisture Based	Acclima	$ 147.00	$ 2,997.00	$ 1,572.00
	Aquaqspy (formerly Agrilink)	$ 329.00	$ 329.00	$ 329.00
	Baseline	$ 149.00	$ 4,295.00	$ 2,222.00
	Calsense	$ 1,260.00	$ 5,135.00	$ 3,197.50
	Dynamax	$ 470.00	$ 570.00	$ 520.00
	Irrometer	$ 100.00	$ 3,146.00	$ 1,623.00
	LawnLogic	$ 250.00	$ 2,149.00	$ 1,199.50
	MorpH2O	$ 250.00	NA	$ 250.00
	Tucor	$ 1,470.00	$ 2,160.00	$ 1,815.00
Average		$ 491.67	$ 2,660.14	$ 1,575.90
Standard Deviation		$ 510.00	$ 1666.06	$ 964.40

Source: USBR (2015)

On the socalwatersmart.com website, rebates reportedly start at $80 or $35 per Irrigation Controller Station. Eligible SMSS can have a maximum of 11 inactive stations per controller.

Water Savings:
In areas with frequent rainfall, soil moisture sensor systems can save considerable amounts of water when compared to those without soil moisture sensor systems, reducing residential irrigation between ranges of 42 percent to 72 percent on average (Cárdenas-Lailhacar and Dukes 2012). Because California is drought-prone, soil moisture sensor systems could be less effective at water efficiency, so irrigation run times, frequency, and threshold setting should be carefully considered. Savings during dry periods decreased to -1 percent to 64 percent with turf occasionally dipping below acceptable quality (Cárdenas-Lailhacar and Dukes 2012).

In order to estimate water savings due to this measure, an average of water savings percentages from the United States Bureau of Reclamation (USBR) for both ET Controller and Moisture Sensor Systems as shown in Table D.17. The average water savings percentage reduction is used from their survey of suppliers.

Table D. 16: Average water savings percentages from the United States Bureau of Reclamation (USBR) for both ET controller and moisture sensor systems

		Manufacturer Reported Water Savings (Percent)		
	Company	**Low**	**High**	**Average**
Soil Moisture Based	Acclima	30	40	35
	Aquaqspy (formerly Agrilink)	20	50	35
	Baseline	30	50	40
	Calsense	20	40	30
	Dynamax	NA	NA	NA
	Irrometer	24	60	42
	LawnLogic	44	44	44
	MorpH2O	NA	NA	NA
	Tucor	NA	NA	NA
Average		28	47	38
Standard Deviation		9.03	7.66	5.24

Source: USBR (2015)

<u>Rainwater Capture (Rain Barrel)</u>

Description:
Rainwater capture is intended to capture non-potable rainwater to be used in various activities, including watering lawns and plants, as well as washing tools, cars, and pets. How much water is available for capture is dependent on the amount and timing of rain, the area of the roof, and the size of the catchment. Rain barrels are low-cost systems that aid in reducing urban water demand with the added benefit of detaining rainfall and protecting local water sheds. The City of Santa Cruz Master Conservation Plan (2017) assumes four effective fills per year for a lifetime of 20 years. The City of Santa Cruz offers rain barrels for purchase at a discount and assumes a 50 percent subsidy. This program is modeled off of the Honolulu Board of Water Supply rain barrel catchment program, which offers rebates for 55-gallon rain barrel purchases.

Cost:
City of Santa Cruz estimates 25 percent administration markup percentage and a fixture cost of $30 to the utility and $50 to the customer (City of Santa Cruz 2017). Rebates offered through SoCal Water$mart and through the City of Santa Monica are shown in Tables D.19 and D.20. Bay Area Water Supply and Conservation Agency (BAWSCA) and participating member agencies are offering rebates of up to $200 dollars (BAWSCA 2023).

Table D. 17: Rebate offers through SoCal Water$mart

Product	Rebate Amount
Rain Barrel (50-199 gallons) (max. quantity: 2)	$35.00
Cistern (200-500 gallons) (max. quantity: 1)	$250.00
Cistern (501-999 gallons) (max. quantity: 1)	$300.00
Cistern (1000+ gallons) (max. quantity: 1)	$350.00

Table D. 18: Rebates offers through City of Santa Monica

Product	Rebate Amount
Rain Barrel (0–199 gallon)	$200.00
Small Cistern (200–499 gallons)	$500.00
Large Cistern (500+ gallon)	$2,000.00

Water Savings calculated by the following formula (**eq. D.11**):

$$55 \text{ gallon barrel} \times 4 \text{ barrel fills per year} = 220 \text{ gallons per year}$$

Or to incorporate local rainfall into calculation, gallons saved per year are equal to the roof footprint area, in sq. ft., multiplied by rainfall in inches per year, multiplied by 1 foot per 12 inches, multiplied by 7.48 gallons per cubic foot (**eq. D.12**):

$$\text{Gallons per year} = \text{Roof Footprint Area } (sq\ ft) \cdot \text{Rainfall } (inches/year) \cdot (1\ ft/12\ inches) \cdot 7.48\ (gal)/(1\ cubic\ ft)$$

<u>Home Water Reports</u>

Description:
Behavior is a large factor as property owners routinely overwater (Endter-Wada et al. 2008) regardless of landscape type. Correcting overwatering through education can successfully lead to significant water savings. This type of measure is based off of marketing and social norms in the field of social psychology and can be referred to as a “social-norm-based” efficiency program (Mitchell and Chesnutt 2013). Home water reports are not restricted to a residential indoor or outdoor category and reflect overall home water use.

Cost:
Cost varied based on how a report was delivered, with paper reports being more expensive per household. Estimated per household annual cost for paper was $6.40 to $6.60 and estimated per household annual cost for electronic was $4.50 to $5.00, so the economic advantage of one report over another is an issue of the avoided cost of water saved. By considering fixed and variable costs, Mitchell and Chesnutt (2013) assumed paper reports were $4.00 to $6.00 per household and electronic were $5.50 to $7.50 per household.

Water Savings:
Mitchell and Chesnutt (2013) found an estimated 5 percent mean effect estimated using the differences-in-differences method for their pilot study for East Bay Municipal Utility District (EBMUD). They reported that water savings in groups receiving paper reports versus emailed reports was on the range of 4.5 to 6.5 percent and 3.5 to 5.5 percent, respectively. This would result in annual water savings on the range of 4,287 and 6,192 gallons for households receiving paper reports and 3,334 and 5,240 gallons for households receiving electronic reports.

Appendix E. Cost Minimization Framework

In this appendix, we present the mathematical representation of the cost minimization framework for determining individual supplier's optimal mix of water use efficiency measures. First, we identify suppliers needing to reduce water use using the results from water demand modeling projections, discussed in previous appendices, as well as the proposed residential indoor and outdoor standards for each supplier. Second, for each supplier, the optimization framework finds the combination of residential indoor and outdoor water use efficiency (WUE) measures that minimize the cost of reducing water use to meet the proposed residential standards, subject to supplier-specific constraints.

Let C_t be the cost of compliance with the residential indoor and outdoor standards for a supplier in year *t*, let $c_{i,t}$ be the unit cost of WUE measure *i,* and let $X_{i,t}$ be the quantity of that measure chosen by the supplier for that year. The cost minimization problem for the supplier can be expressed as:

$$min \sum_{t=2025}^{2040} C_t = \sum_{t=2025}^{2040} \sum_{i=1}^{I} c_{i,t} \cdot X_{i,t}$$

Eq. E.1: Minimize the cost of compliance C_t from year 2025 to year 2040, which, for a given year, is equal to the sum of the cost of individual WUE measures, where the cost of a measure in a given year is equal to the unit cost of that measure $c_{i,t}$ times its quantity $X_{i,t}$.

subject to

$$R_t \geq \max\{\,0\,, (B_t - W_t) - (B_{t-1} - W_{t-1})\,\}$$

Eq E.2: Reduction R_t in the supplier's residential indoor and outdoor water use achieved in year *t* must be greater than or equal to the maximum between zero and the difference between the estimated residential water use in the baseline in year *t*, B_t, minus the estimated residential water use under the proposed regulation in that year, W_t, and the estimated residential water use in the baseline in year *t-1*, B_{t-1}, minus the estimated residential water use under the proposed regulation in that year, W_{t-1}.

Where R_t is the reduction in the supplier's residential indoor and outdoor water use achieved in year *t*, when the supplier decides to implement the set of WUE measures in quantities $\{X_{i,t}\}$ for *i* = 1 to *I*. Thus, R_t is a function of $X_{i,t}$ and measure-specific water savings parameters. B_t is the estimated baseline residential water use for this supplier in year *t* (i.e., absent the proposed regulation), and W_t is its estimated residential water use under the proposed regulation. W_t is obtained from the application of residential indoor and outdoor standards as discussed in previous appendices (and accounts for the bonus incentive for potable recycled water use, but not variances).

In addition, there are limits on how many devices can be updated in any given year and over the years considered in the analysis. The number of existing devices of older vintages that can be replaced with new devices that meet current water use efficiency standards decreases over time in each vintage bin, as devices get updated by individuals on their own over time. With the knowledge that any new homes will be efficient given current standards and regulations, we can use the current vintage of devices as well as current and projected saturation rates (based on natural and enhanced replacement rates as defined in Appendix B) to approximate the maximum number of measures that are possible in any given period. Thus, the cost minimization framework accounts for the limit on the number of older vintage devices or irrigated land area that can be updated with more efficient devices or replaced with lower water demand landscapes, after accounting for any natural or enhanced replacement included in the baseline calculations. Leak detection and alerts would similarly be limited by the number of existing connections at the time of the last standard requirement (2019). As WUE measures are adopted in each year, whether in the baseline or in response to the regulation, the total amount of remaining devices or land area that can be made more efficient declines every year through 2040.

Unit cost and water savings parameters were derived from an extensive review of the literature (see Appendix D for this review). These cost and savings functions provide the nonlinearity that comes with decreasing returns to WUE efforts through increasing costs or decreasing water savings as more WUE measures are adopted by suppliers.

Appendix F. Methods to Evaluate Affected Wastewater Management Agencies

This appendix provides more information about the wastewater analysis, including 1) a description of the ways in which wastewater treatment plants and collection systems might be affected by and respond to lower and/or concentrated flows; 2) the methods used; and 3) a statewide summary of the number of systems that may be at risk under all three different scenarios.

F.1. Possible effects and response to lower and more concentrated flows

Wastewater treatment facilities and collections systems face multiple challenges resulting from the combined effects of an aging infrastructure, changing influent characteristics, topography, and climate change. Changes in influent flow and higher concentrations from water use efficiency and conservation exacerbate operational challenges.

Wastewater managers and system designers pursue numerous mitigation and adaptation actions in response to seasonal and long-term changes in flow. Such actions are necessary, as many collection and treatment systems are designed, built, and funded over decades. During this time, significant changes in water use habits, climate and drought, and consumer products occur that require proactive managerial actions to maintain system operations. Short-term actions focus on mitigating undesired effects and are necessary to respond to fast changes that maintain flow and effluent water quality. Long-term actions focus on adapting systems to meet future conditions, including changes in flow and more stringent water quality requirements. Predicting future conditions is a recognizable challenge. Systems designed in recent decades may have often used assumptions of indoor urban water consumption that are higher than recently observed values. Thus, wastewater collection, treatment, and reuse systems will continue to face the need for mitigation and adaptation actions to respond to changing conditions.

F.2. Wastewater Collection Systems

Collection system managers have various responses they can undertake to deal with undesired effects of lower influent flows. For instance, managerial and operational responses to control odors may include:

- Odor control facilities: In large facilities such as pump stations, odor control equipment can be installed. Odor scrubber technologies include activated carbon adsorbers, biofilters, and chemical scrubbers (Tchobanoglous et al. 2003). In gas phase, odorous compounds are dissolved into solutions containing chemicals such as sodium hypochlorite, potassium permanganate, and hydrogen peroxide. Technology-intensive facilities such as these are not appropriate for small sources such as individual manholes. Manhole covers fitted with canisters filled with activated carbon or compost-like biological media are available commercially.

- Chemical feeds to wastewater: Various chemicals are used to suppress the production of odors in wastewater. These include sodium and magnesium hydroxide ($NaOH$ and $Mg(OH)_2$), calcium nitrate ($Ca(NO_3)_2$),and iron salts (Abdikheibari et al. 2016; Park et al. 2014). Chemical feed facilities may be distributed at various locations throughout the conveyance network.

Similarly, managerial and operational responses to control corrosion in wastewater may include:

- Chemical feeds to wastewater: Suppressing H_2S production by chemical means also addresses the associated corrosion problem.
- Coating pipes and appurtenances (manholes): For existing infrastructure, corrosion-resistant epoxy and other erosion-resistant coatings are available (Water Research Foundation 2017). These are especially useful in manholes and pump stations. Coating the interior of pipes is not generally practical.
- Pipe replacement and slip-lining: Replacing pipes is one of the most expensive management responses. Pipes that remain intact, however, can be slip-lined with plastic materials that shield corrosion-prone pipe material and establish a smooth interior. Slip-lining pipes is an established technology, but because of costs, it is mainly used to prolong the life of older pipes that are subject to corrosive conditions. It is not widely used as a preventive measure on young pipe.

Table F.1 summarizes how lower and/or more concentrated flows might impact collection systems, and what mitigation actions operators may take.

Table F. 1: Summary of effects of lower flows on collection systems and mitigation responses

Effects	Mitigation Actions
Deposition of solids in wastewater collection system	Increased labor to flush solids, equipment purchases
Increased sulfide generation causing corrosion of pipes	Replace or upgrade collection pipes
Increased sulfide generation causing odor complaints	Increased chemical usage, equipment needs
Root intrusion and blockages in small diameter laterals	Increased labor and chemical usage, equipment purchases
Generation of methane gas	No response
Increased cycling of lift station pumps, reduced pumping efficiency	Lift station upgrades to address reduced pipe life
Blockages of lift station pumps	Increased labor
Lift station corrosion from increasing sulfide causing	Lift station upgrades to address reduced lifespan of equipment

F.3. Wastewater Treatment Systems

Facilities that process and manage wastewater are constructed using relatively mature technologies available at the time when the facility is being designed. The systems are designed, constructed, operated, and financed over decades. Recent decades have seen significant changes in long-term water use habits in California's cities. As such, many WWTF operators and managers have been adept at updating and optimizing processes to address changes in flow and influent quality over time.

Mitigation and adaptation actions in wastewater treatment facilities to address future conditions will likely involve adapting and updating treatment processes. For instance, in a study from Southern California, planning models identified cost-effective mitigation actions to deal with influent flow and concentration changes. Across scenarios of climate and water use, cost-effective adaptation actions included blending influent combined with advanced treatment (Tran et al. 2017). New technologies that facilitate greater flexibility in operational parameters across flow rates are likely to be highly useful. These can include monitoring technologies, strategies to equalize changes in influent flows, and upgrading facilities with corrosion-resistant materials. Table F.2 describes multiple strategies that wastewater agencies can consider for adapting systems to future conditions that can result from lower influent flow rates.

Table F. 2: Strategies for managing reduced flows, increased concentrations, and mass loading at wastewater treatment facilities

Strategy	Description
Continuous monitoring	Monitoring is used to track and respond to process changes. Technology is available for the continuous monitoring of nearly any parameter, including toxicity, specific constituents, flowrates, concentration. Sensors can be placed throughout the wastewater management system for real time feedback on process performance.
Source control	Working with the public to eliminate certain materials from the wastewater flow. For example, it was common to dispose of expired pharmaceuticals by flushing them down a toilet. Modern wipes are an example of an incompatible material that is best controlled at the source.
Flow equalization	Because wastewater processes operate better at constant flowrate and loading, it is common to incorporate equalization facilities into the flow diagram. Reductions in flow and operation below design capacity may create tankage that is no longer required, e.g., extra clarifiers. These facilities can then be converted for use in flow and load equalization devices.
Corrosion resistant materials	Higher levels of hydrogen sulfide and TDS increase rates of corrosion. Using materials resistant to attack from the increasing salts, organic acid, and sulfide concentrations in wastewater can help reduce undesirable effects. The use of epoxy coatings, stainless steel, and plastic piping can last longer than traditional materials.
Pumping and metering systems with high turn-down capability	Facilities used for pumping wastewater or metering flows, such as chemical injection systems, can be specified to operate reliably over a wide range of conditions. The ability to adapt to low flows should be considered in all future designs.
Ability to take process units out of service to accommodate reduced flows	Many wastewater facilities are operating far below their design capacity. Modifications can be made to improve opportunities for taking processes in or out of service. For example, the addition of pumping or distribution piping could improve process flexibility.
Odor control structures and covered basins	As processes become more compact, enclosures are more feasible. Enclosed headworks and other facilities that cover open-air WWTF devices make it possible to contain and treat odors associated with septic conditions.
Influent filtration	Primary clarifiers use gravity separation to segregate settleable materials and may become less effective with septic wastewater. Influent filtration will make it possible achieve high level of influent treatment under variable loading conditions.
New Biological Nutrient Removal (BNR) processes	There are now a variety of biological processes available to remove residual nitrogen and phosphorus from municipal wastewater. The changes in wastewater characteristics need to be considered for any potential impacts on new biological process.
Enhanced side stream treatment	As more food waste and other organic commercial and municipal solid and liquid wastes are imported for processing by anaerobic digestion and energy recovery, there will be a greater need for side stream treatment to remove nutrients and specific constituents.

In additional to new technologies and processes, innovative management strategies are also essential for adapting to future conditions that WWTFs in California will likely face. Such strategies include:

- Working with local water supply retailers, update collection and treatment facility upgrades that align with demand forecasts and projected water use efficiency that considers past observed changes, including drought effects.
- Evaluate thresholds of changes in water use and wastewater influent changes that would instigate effects significant enough to require significant investments in adaptation actions. Such studies must consider site-specific factors of collection system layout, the portion of influent from resident and CII sources, and existing treatment processes.
- Facilitate collaboration and coordination between water and wastewater agencies on implementation of adaptation and mitigation actions to changes in the managed urban water cycle (Chappelle et al. 2019).
- Support specialized operator training in adapting to low flows and updating operations and maintenance guidance.
- Develop a long-term strategy for investments, upgrades, and funding sources to modernize WWTFs for changes in wastewater influent.
- Change ratings for WWTFs to be based on mass loading rather than flow.
- At regional and statewide scales, identify systems that reported quantifiable problems during a period of a water conservation “stress-test” such as drought. These systems may require upgrades to better manage future declines expected in flow and changes in wastewater characteristics.
- Prepare WWTFs to manage concurrent impacts from climate change, such as sea level rise, sea water intrusion into wastewater collection systems, flooding of coastal and inland treatment facilities, drought, and wildfire.
- Implement continuous and cloud-based monitoring systems to improve process reliability.

Table F. 3 summarizes how lower and/or more concentrated flows might impact WWTFs, and what mitigation actions operators can take.

Table F. 3: Effects of lower flows and associated management responses

Effects	Mitigation Actions
Management of solids scouring events at headworks	Increased labor
Increased sulfide at headworks	Increased chemical cost, upgrade structures
Grit removal less effective	Process upgrades
WWTFs with conventional trickling filter and activated sludge technology process performance deterioration	Increased energy and chemical usage, upgrade process, increased labor/consulting needs
WWTFs with nitrogen removal at or near discharge limits due to increasing ammonia concentrations	Increased energy and chemical usage, upgrade process, increased labor/consulting needs
Increased cost for disinfection	Increased energy (UV) and chemical (chlorine) usage
Capacity limitations for increased loading and co-digestion	Process upgrades, increased chemical and energy use, increased labor/consulting needs
Increasing dissolved solids (salts) and volumetric limitations impacting recycled water	Revenue losses, increased treatment costs
Wastewater fermentation and transformation	Process & operational modifications, energy

F.4. Wastewater Reuse Systems

A range of responses have been considered for managing effects of lower flows on recycled water systems.

Table F. 4: Summary of strategies to improve recycled water management

Strategy	Description
Need for side-stream reverse osmosis or some other method to control TDS	Given the challenges associated with attempting for source control of TDS, applying advanced treatment, including reverse osmosis, to a portion of the effluent flow which can then be blended to lower the overall effluent TDS is becoming more feasible.
Eliminate salt-based water softeners	The removal of salt-based water softeners has been shown to reduce chloride concentrations in wastewater (SCSA 2018).
Reduce TDS of water supply; Partial demineralization of water supply	In a study of wastewater discharges in Southern California, the Total Dissolved Solids (TDS) of the influent water supply was the dominant factor in controlling the wastewater TDS (SCSC 2018). Changes in water supply can have a direct and significant impact on WWTF TDS. Within the study that controlled for multiple factors, a decrease of 1 gpd in consumption resulted in a 1-2 mg/L increase in salinity.
Increased use of rainwater for indoor non-potable uses	Roof runoff has a very low TDS content, and if used for indoor water supply, would not contribute to overall wastewater TDS.
Flow equalization	Supplement wastewater influent with available freshwater sources. This may conflict with goals of water conservation. Opportunities to use alternative water supply sources such as commercial and industrial wastewater, groundwater that requires pumping and treating, or other sources can be explored to the extent feasible.
Upgrade treatment processes	Advanced treatment processes designed to remove dissolved constituents, such as adsorption and reverse osmosis, can be used to upgrade effluent quality prior to it entering the reuse system. Designing combined systems of tertiary and advanced wastewater treatment with reuse that are designed for lower influent flow rates may make it possible to better manage future droughts by offsetting demands on potable water systems.
Ozonation and other advanced oxidation processes	Advanced oxidation processes should be considered to control the discharge of trace constituents to water systems.

F.5. Effects on Wastewater Management Systems

Given the diversity of size and location in wastewater management systems across California, varying impacts from potential flow reductions from indoor water use efficiency with site-specific factors influencing potential impacts was expected. The condition of existing wastewater systems throughout the state varies significantly, with some systems being upgraded with new technology to meet advanced water quality standards, while other systems are decades old.

Population growth, region-specific regulatory requirements, and facility size are key drivers in evaluating the extent to which older systems may have undergone upgrades. Additionally, WWTFs are often designed to deal with the characteristics of local influent and incorporate assumptions of future growth that can influence susceptibility to influent flow rate changes from AB 1668-SB 606. Retrofitting facilities with additional infrastructure to upgrade effluent quality can present design challenges.

F.5.1. Overall Approach

A multistep procedure was used to evaluate effects on wastewater management systems, which included the following steps:

- Linked wastewater management systems with upstream suppliers
- Conducted outreach with wastewater managers to refine and calibrate modeling and shape interpretation of model results
- Estimated future baseline and objective-based wastewater generation and identified wastewater systems at risk of lower influent flows
- Evaluated effects on collection systems using process modeling with clustering analysis for statewide extrapolation
- Evaluated effects on wastewater treatment systems using process and simulation modeling with clustering analysis for statewide extrapolation
- Estimated the potential reduction in influent flow available for recycled water production available to current and planned reuse facilities

F.5.2. Linking Suppliers with Wastewater Management Systems

Many sources of data are available for wastewater management in California, but they are not integrated and are not exploited for systems analysis. A first step of the analysis of effects from AB 1668-SB 606 required identifying, cleaning, and merging data sources in order to estimate baseline operating conditions in recent years and project future effects. Key data sources used:

- **California Integrated Water Quality Systems (CIWQS)** includes a table of attributes with design flow for many facilities. Such attributes are available for a majority of the 1,300 facilities. The State Water Board collects CIWQS data. For a subset of facilities, CIWQS also includes historic monitoring data for flow and water quality, which can be used to assess trends in recent operations. For instance, the data can be used to examine changes in flow and water quality before, during, and after the 2011–2016 drought for facilities with available data. Historic monitoring data is available for over 200 facilities, but not all of these serve suppliers, and CIWQS provides no data to identify WWTFs of interest for effects from AB 1668-SB 606.
- **Annual Volumetric Reporting (AVR)** data includes reporting on wastewater influent, effluent, and reuse for approximately 700 wastewater treatment facilities in the state. Data is reported monthly. While the data is standardized for more facilities, it does not include key parameters such as design flow and cannot capture acute daily observations that impact treatment processes. The State Water Board collects AVR data.
- **Tables 6-2, 6-3, and 6-4 in Urban Water Management Plans** (not referring to this document) provide corroborative information on the managing agency for a WWTF, as well as connected collection systems and suppliers. Table 6-2 identifies approximately

470 WWTFs of interest that serve suppliers. Completed tables from 2015 UWMPs were available in the time frame of this project. Operations data from 2015 is provided at an annual time step. DWR collects and compiles data for Tables 6-2 through 6-4.

- **Sewer System Overflow (SSO)** database provides a rich source of information on collection systems attributes throughout the state, including design, layout, operations, annual spending, operator certifications and expertise, and other factors. The State Water Board collects SSO data.

Table F.5 describes the origins, parameters, and timeframes associated with key data sources used for the analysis.

Table F. 5: Key data sources used to evaluate recent trends in wastewater treatment across the state

Name	Source	Parameters	Timeframe
2017 Wastewater User Charge Survey	State Water Resources Control Board (file was given)	-Agency Information -Service Area -Name(s) and location(s) of the treatment facilities	06/22/2020 – 07/31/2020
California Integrated Water Quality System Project (CIWQS) eSMR Flat File	State Water Resources Control Board (file was given)	-Region -Location -Location_Place_ID -Location_Place_Type -Parameter -Result -Units -Sampling_Date -Facility_Name -Facility_Place_ID -Latitude/Longitude	02/14/2020 – 06/22/2020
California Integrated Water Quality System Project (CIWQS) eSMR Facility Export	State Water Resources Control Board (file was downloaded from the website)	-Agency -Agency Address -Facility Name -Facility Address -Latitude/Longitude -County -Region -WDID -Design Flow	06/22/2020 – 07/31/2020
Table 6-2 Retail: Wastewater Collected Within Service Area in 2015, and Table 6-3 Retail: Wastewater Treatment and Discharge Within Service Area in 2015 (compiled data associated with urban water management plans)	California Department of Water Resources	-DWR supplier Org ID -Water supplier Name -Wastewater Collection Agency -Volume of Wastewater Collected (2015) -Volume of Wastewater Treated (2015) -Volume of Wastewater Discharged (2015) -Wastewater Treatment Agency -Treatment Plant Name	2015

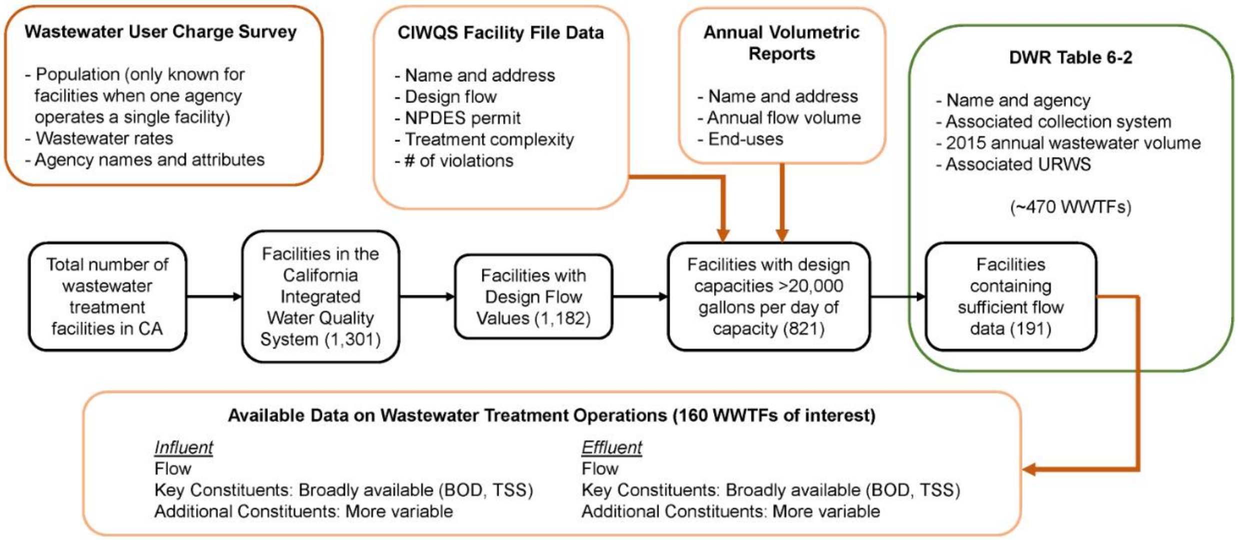
Name	Source	Parameters	Timeframe
Volumetric Annual Report (AVR)	California State Water Resources Control Board	-Facility name -Facility location -Volume of influent (monthly) -Volume of treated effluent (monthly) -Level of treatment -Volume of water reuse production	2019 (data may be available for some facilities as early as 2017)
Sewer System Overflow (SSO) database	California State Water Resources Control Board	-System name -System location -Length of pipes by type of pipe (gravity main, lateral line) -Number of pumps -Number of operators -Operator training levels -Operator certifications -Violation reports (Sewer System Overflows) and reported causes	Various, based on last year of available reporting

F.6 Network Modeling to Connect Suppliers with Wastewater Management Systems

No existing database identifies relationships or estimates flows between suppliers and wastewater management systems. The only sources of data for this purpose are Tables 6-2 through 6-4 of DWR's Urban Water Management Plans (UWMPs). These tables compile self-reported data from the UWMPs and link between water sector systems. Table 6-2 describes connections between urban water supply retailers, wastewater collection systems, and wastewater treatment facilities. The tables, however, are based on self-reported data and include errors. Further, the reported names do not match names in other state databases such as CIWQS, and common identifiers are not included. We converted the database in Table 6-2 into a network model representation to connect water supply agencies, collection systems, and wastewater treatment facilities.

A multistep procedure was used to link suppliers with wastewater management systems and identify systems of interest. First, we rectified name discrepancies between DWR's Table 6-2, CIWQS, and the AVR. Second, after identifying wastewater systems and facilities of interest, characteristics (attributes) of those systems and facilities were collected and compiled to create a database of attributes associated with both collection systems and treatment systems. Third, historical records for operations and monitoring were collected from CIWQS and DWR's Table 6-2 for collection systems and WWTFs with available data (Figure F.6). Fourth, using the AVR and data from DWR's Urban Water Management Plans, the volume of recycled water produced by a WWTF was estimated and linked to receiving suppliers.

Figure F. 1: Summarizing the process to develop time series records of operations and monitoring for WWTFs with available data in the California Integrated Water Quality Information System (CIWQS)



F.6.1. Systems at Risk

The section below describes the modeling approach used and some of its limitations. This section also summarizes how many Wastewater Treatment Facilities (WWTFs), and collections systems may be at risk under three different scenarios.

F.6.2. Risk Modeling Approach

Wastewater treatment systems with a WEO Impact Factor of less than 1 were deemed at risk of potential effects of lower flows originating from AB 1668-AB 606 demand reductions. However, the magnitude and likelihood of such effects is a function of not only flows, but also many site-specific factors including the current influent flow rates, facility design, existing system conditions, location, constitution of the upstream effluent, and other factors.

To better evaluate quantitative effects and describe qualitative outcomes for wastewater treatment facilities that serve suppliers, modeling with industry-standard software was used to identify key factors that would influence the magnitude of effects on operations associated with facilities of varying design and influent flow levels.

Wastewater treatment process impacts were evaluated using Biowin v 6.2. Biowin is a standard process model used in the analysis and design of wastewater treatment facilities. It simulates water flow, water quality, and treatment efficiency outcomes for varying configurations of wastewater treatment facilities based on input parameters. The model directly simulates changes in process outcomes such as constituent concentrations but can also evaluate changes in secondary outcomes such as energy use and cost.

A modeling framework was developed to evaluate key outcomes for treatment processes affected by changing influent flow rates, including changes within the headworks (processes such as grit screening and removal), changes in wastewater treatment processes that remove contaminants and nutrients, and effects on effluent such as reduced volumes for reuse or increased dissolved solids.

Potential effects of lower flows on water quality outcomes are closely related to a facility's design flow rate and the rate of per capita wastewater generation in the sewershed. Wastewater facilities are designed to operate within a range of operational parameters that link flow rates with water quality processes and outcomes. Two parameters influence outcomes. First, the volume of flow reaching a treatment facility in a day is the total volume of wastewater that must be treated. The total daily volume is used to calculate an influent flow rate.

F.6.3. Limitations and Caveats of Modeling Approach

Because not all facilities had reliable enough data to be included in the analysis, the summary below reflects information for 415 (92 percent) collection systems and 336 (93 percent) wastewater treatment facilities that serve the communities receiving water from suppliers.
Due to data limitations, the analysis does not contain detailed, facility level analyses.
These results are preliminary. By updating the water delivery data and improving the network modeling, we will be able to better estimate the magnitude of reductions at individual facilities.
The regulation does not affect the indoor water use of Commercial, Industrial, and Institutional (CII) customers. For collection systems, wastewater plants, and reuse facilities receiving a high proportion of wastewater from CII customers, the analysis suggests a greater potential for lower or more concentrated flows that what is likely.
This analysis assumed that, for each scenario and each supplier, 15 percent of all the water saved would be saved by reducing residential indoor water use.

- The analysis required forecasting water demand and population changes. The analysis assumed population growth in line with official Department of Finance estimates.
- Operational impacts to both wastewater collection systems and treatment facilities were modeled using available literature and standard industry tools but could not be fully verified with field data within the time frame of the project. Site-specific factors such as design flow and current influent (volume and rate) were considered to the greatest extent possible, but detailed modeling of operational changes for the hundreds of systems and facilities was not possible.
- Limited data existed to characterize extreme flow periods, such as minimum month values. Daily or monthly values of influent flow volume data were only available for a portion of the wastewater treatment facilities of interest.

F.7 Number of Potentially Affected Systems and Degree of Impact

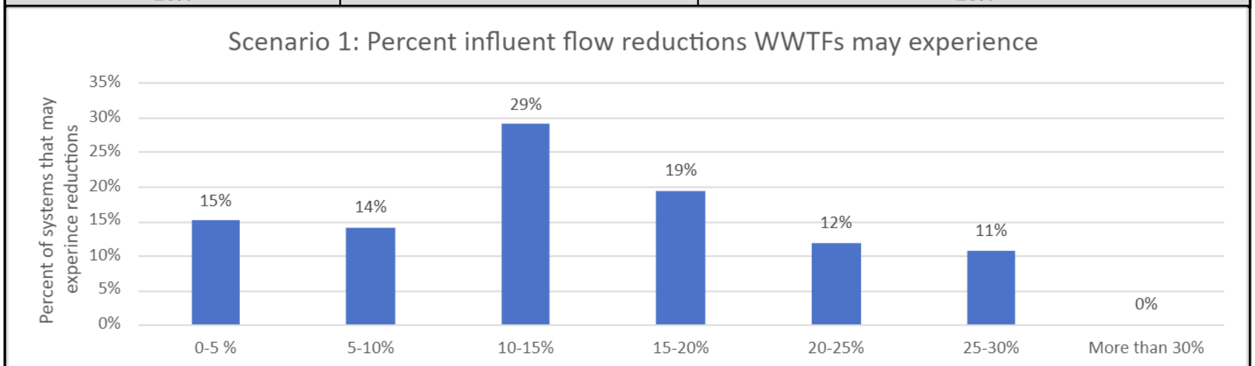
This section provides a summary of the staff analysis on how the efficiency standards may affect local wastewater management under several scenarios. Scenario 1 utilizes conservative efficiency standard with a per capita residential indoor water use of 50, and a residential outdoor evapotranspiration factor of 70 percent, applied to 100 percent of irrigable irrigated area and 20 percent of irrigable not irrigated area. 50 GPCD was set by the Legislature (2018) and was used as the upper limit. However, with the passing of SB 1157, the Legislature amended the per capita residential indoor water use standard to 47 GPCD in 2025; it declines to 42 CPCD by 2030. Scenario 2 utilize an indoor water use standard of 42 GPCD as set by SB 1157. Scenario 3 utilizes a more ambitious indoor water use standard of 35 GPCD.

Scenario 1: 50 GPCD and an LEF of 70 percent, applied to 100 percent II area + 20 percent of INI area

- WWTFs: Due to AB 1668-SB 606 implementation, 46 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.
    - 26 percent of all WWTFs may experience lower total influent volume; half of which may experience reductions of 13 percent or less.
    - 20 percent of all WWTFs may experience more concentrated flows, but not necessarily lower total influent volume.

Figure F. 2: Summary of impacts to WWTFs under scenario 1 (50 GPCD for residential indoor; 70% LEF for residential outdoor, applied to 100 of II area +20% of INI area)

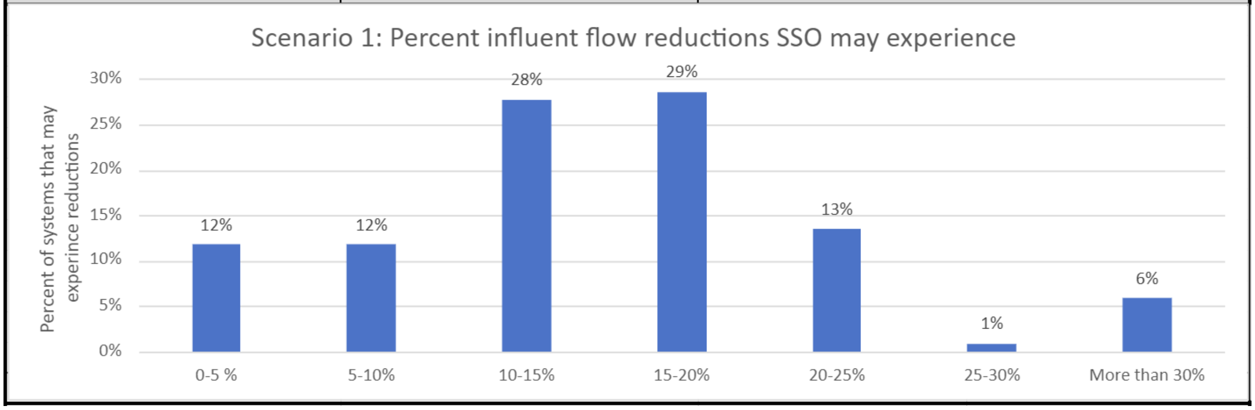
Percentage of systems that may experience lower/more concentrated flows		
46%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
26%	13%	**20%**



- Collection systems: Due to AB 1668- SB 606 implementation, 44 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.
    - 29 percent of may experience lower total influent volume; half of which may experience reductions of 15 percent or less.
    - 15 percent may experience more concentrated flows.

Figure F. 3: Summary of impacts to SSO under scenario 1 (50 GPCD for residential indoor; 70% LEF for residential outdoor, applied to 100 of II area + 20% of INI area)

Percentage of systems that may experience lower/more concentrated flows		
44%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
29%	15%	15%



Scenario 2: 42 GPCD and an LEF of 62 percent, applied to 100 percent of II area + 20 percent of INI area

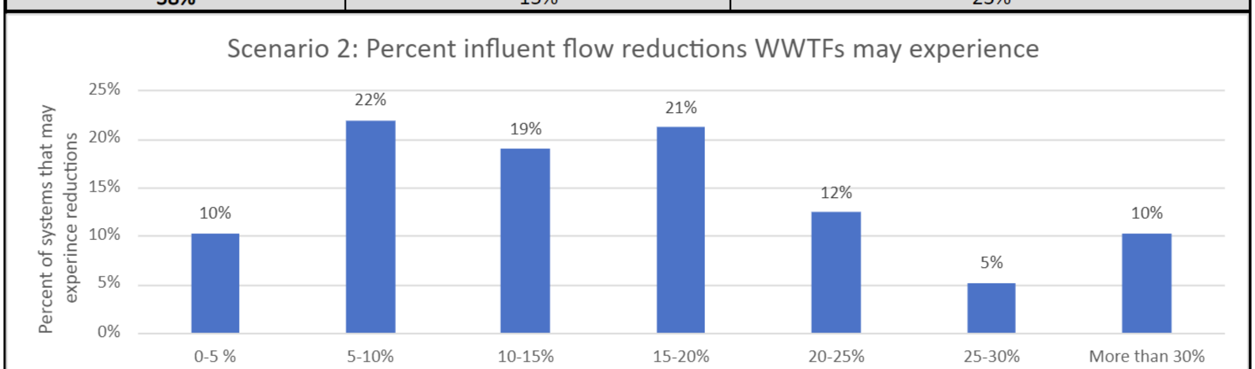
Wastewater Treatment Plants (WWTFs): Due to AB 1668- SB 606 implementation, 61 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.

38 percent may experience lower total influent volume; half of which may experience reductions of 15 percent or less.

23 percent may experience more concentrated flows.

Figure F. 4: Summary of impacts to WWTFs under scenario 2 (42 GPCD for residential indoor; 62% LEF for residential outdoor applied to 100 of II area + 20% of INI area)

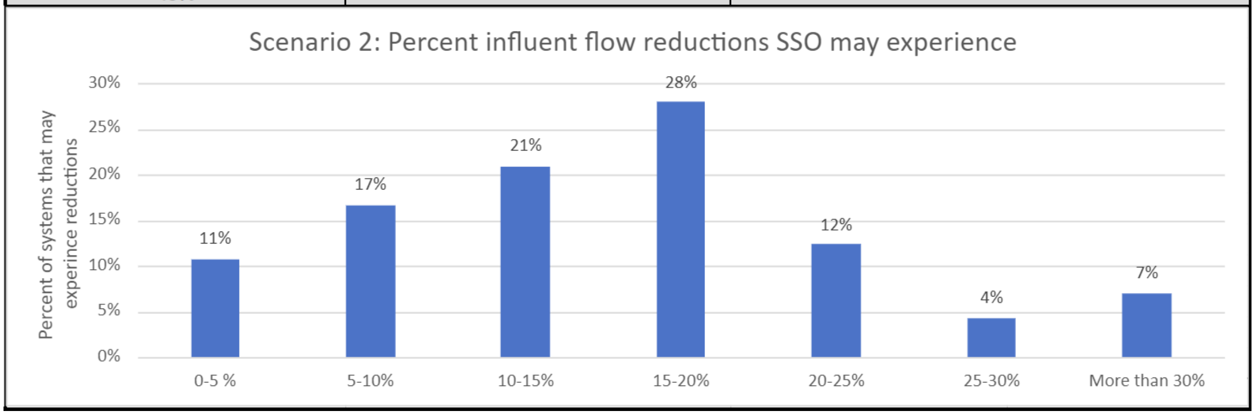
Percentage of systems that may experience lower/more concentrated flows		
61%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
38%	15%	23%



Collection systems: Due to AB 1668- SB 606 implementation, 62 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.
45 percent may experience lower total influent volume; half of which may experience reductions of 15 percent or less.
17 percent may experience more concentrated flows.

Figure F. 5: Summary of impacts to SSO under scenario 2 (42 GPCD for residential indoor; 62% LEF for residential outdoor applied to 100 of II area + 20% of INI area

Percentage of systems that may experience lower/more concentrated flows		
62%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
45%	15%	17%

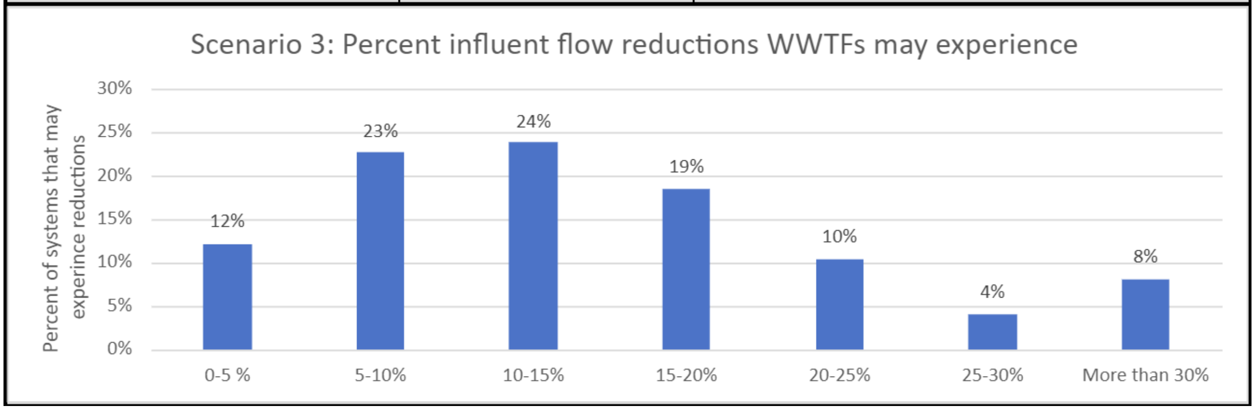


Scenario 3: 35 GPCD and an LEF of 55 percent, applied to 100 percent of II area + 20 percent of INI area

- WWTFs: Due to AB 1668- SB 606 implementation, 71 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.
  - 48 percent may experience lower total influent volume; half of which may experience reductions of 13 percent or less.
  - 23 percent may experience more concentrated flows.

Figure F. 6: Summary of impacts to WWTFs under scenario 3 (35 GPCD for residential indoor; 55% LEF for residential outdoor applied to 100 of II area + 20% of INI area)

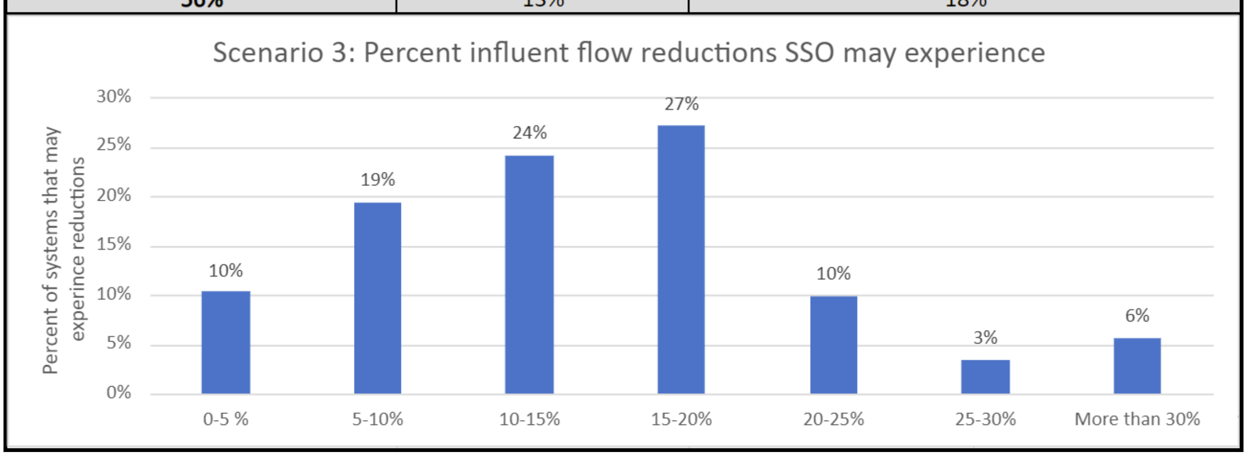
Percentage of systems that may experience lower/more concentrated flows		
71%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
48%	13%	23%



- Collection systems: Due to AB 1668- SB 606 implementation, 73 percent may experience lower or more concentrated flows than what was otherwise projected by 2030.
    - 56 percent may experience lower total influent volume; half of which may experience reductions of 13 percent or less.
    - 18 percent of all WWTFs may experience more concentrated flows.

Figure F. 7: Summary of impacts to SSO under scenario 3 (35 GPCD for r-indoor; 55% LEF for residential outdoor applied to 100 of II area + 20% of INI area)

Percentage of systems that may experience lower/more concentrated flows		
73%		
Percentage of systems that may experience lower flows	*median % reduction*	*Percentage of systems that may experience more concentrated flows*
56%	13%	18%

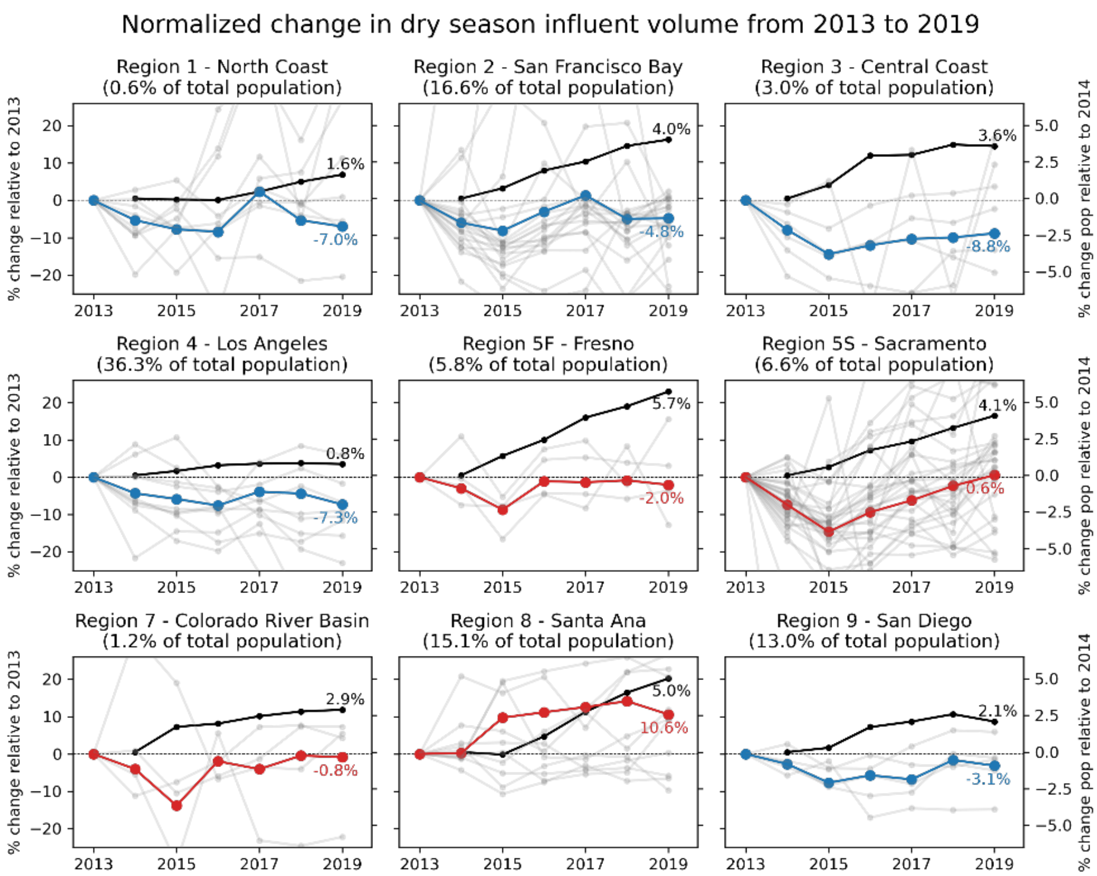


F.7.1. Additional Context

Wastewater treatment facilities and collections systems face multiple challenges resulting from the combined effects of an aging infrastructure, changing influent characteristics, topography, changing regulatory requirements, and climate change. Changes in influent flow and higher concentrations from water use efficiency and conservation can exacerbate operational challenges.

In most regions in the state, average dry-weather influent volumes have decreased since 2013, the onset of the last drought (Figure 6). This corresponds with observed urban water trends. For example, based on the State Water Board's monthly conservation and production data, urban water use has decreased 16 percent since 2013. While total influent volume has, for most regions, decreased since 2013, for some regions, the linear trend suggests an overall pattern of increasing influent, likely reflecting, in part, water use rebound after the last drought (red lines). Also relevant is that these regions (except the Colorado River region) have been growing faster than other regions in the state (black line), suggesting that while total influent flow may not be decreasing, it is likely becoming more concentrated. In other words, many collection systems and wastewater treatment facilities in California are already experiencing either lower or more concentrated flows. Both can pose challenges to the wastewater sector.

Figure F. 8: Percent change in dry season (June-August) influent volume



Notes: Blue lines indicate that the slope of the linear fit is negative, suggesting decreasing influent over time; red lines indicate that the slope of the linear fit is positive, suggesting increasing influent over time.

In evaluating the effects of AB 1668 and SB 606 implementation on local wastewater management, State Water Board staff compared projected total influent volume under each scenario to historic flows. Under scenario 2, data showed that 77 percent of wastewater agencies have experienced at least one year in which average annual and dry-weather influent volumes were equivalent to those expected as a result of AB 1668 and SB 606 implementation; 44 percent have experienced equivalent flow volumes for three years or longer. Absent the implementation of AB 1668 and SB 606, wastewater collection systems and treatment facilities will continue to experience lower or more concentrated flows. Californians are expected to continue to use water more efficiently indoors. Based on 2017, 2018, and 2019 water use data, DWR estimated that average residential indoor water use was 51 Gallons Per Capita per Day (GPCD); the statewide median was 48 GPCD. DWR projected that use would continue to fall due to "passive" conservation[3], estimating that half of California would be using 44 GPCD or less by 2030 (DWR 2021b).

Appendix G. Methods to Evaluate Affected Urban Trees and Parklands and Results

Water conservation and efficiency save water and energy, reduce the need for infrastructure investments, allow current water supplies to accommodate additional housing, and mitigate longer-term water rate increases. Transitioning to more efficiently irrigated, California-friendly landscapes can additionally protect water quality, protect human health, create healthy soils, reduce short-lived climate pollutants, protect air quality, reduce noise pollution, protect biodiversity, and support ecosystem health.

These benefits will be increasingly important as our climate changes. For these reasons and more, making conservation a California way of life is critical. Given the importance and complexity of potential impacts on urban landscapes resulting from changes in per-capita outdoor water use in the areas served by urban retail water suppliers, the Legislature directed the State Water Board to identify and consider the possible effects of proposed water use efficiency standards on urban tree health as well as natural and developed parklands and to allow for public comment on those potential effects (California Water Code §10609.2(c)).

This appendix summarizes key findings of an analysis of effects of potential water use efficiency standards on urban trees and parklands, provides context for the results, and summarizes the scope of the analysis done. The analysis was developed by a team of researchers for the State Water Board under contract number 19-058-240 to help inform the State Water Board's understanding of how potential water use efficiency standards could impact local wastewater management, developed and natural parklands, and urban tree health.

G.1. Methods to Evaluate Affected Urban Trees and Parklands

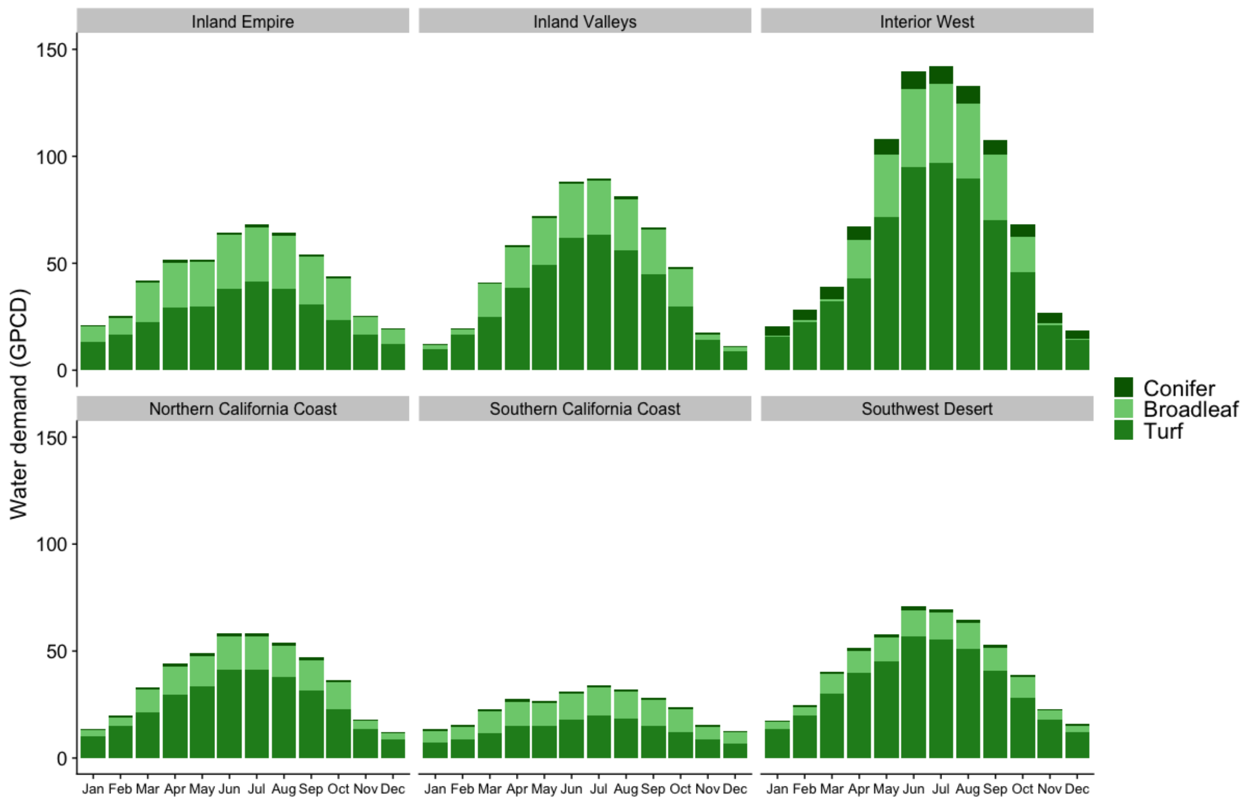
G.1.1. Urban Trees

To assess impacts to urban trees, the researchers first created an inventory of urban trees in California, measured the extent of tree coverage in suppliers' service areas, and estimated tree water demand. The research team estimated water demand for turf, conifers, broadleaf trees, and palms in the service area for each supplier.

This initial work resulted in the following key findings:

- Turf was the largest component of vegetation water demand for all months in all climate zones (Figure G. 1)
- Many of the most common urban tree species in California are rated as medium-water use, suggesting these trees may need substantial irrigation during dry summer months.
- In all climate zones, the greatest percentage of low water-use trees was in the largest (i.e., oldest) class size, suggesting that the planting low water-use trees has not been prioritized.

Figure G. 1. Median monthly water demand of different vegetation types for suppliers in each climate zone



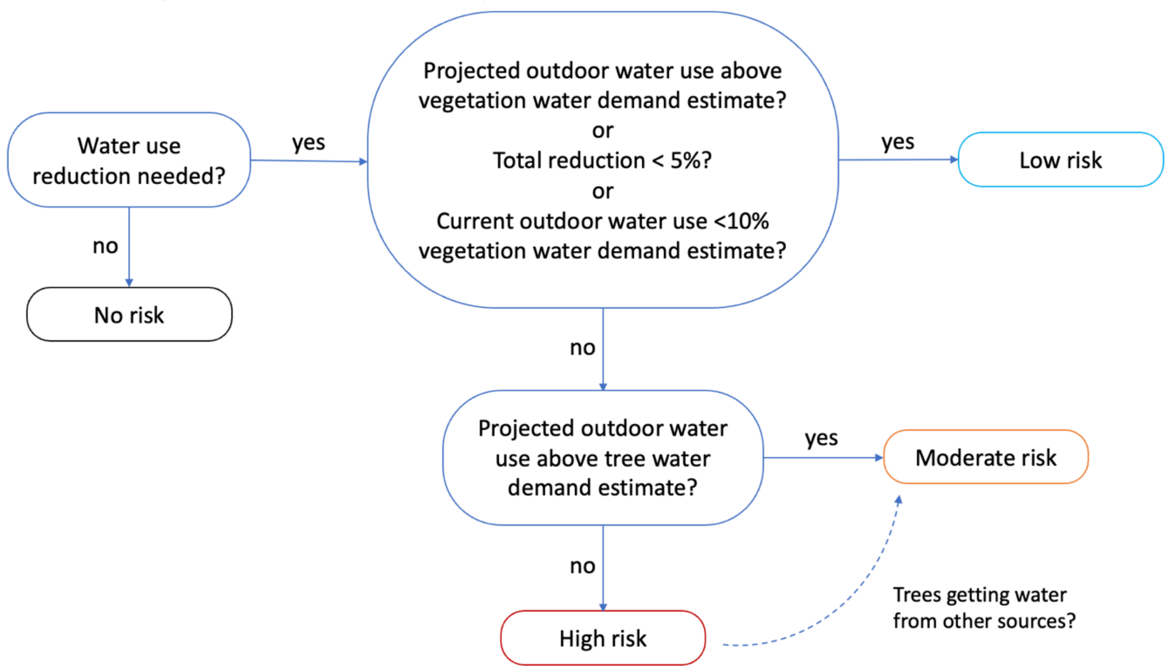
Once vegetation demand (e.g., water demand for turf, conifers, broadleaf trees, and palms) was estimated, three scenarios with varying indoor residential and outdoor residential parameters were analyzed to evaluate potential effects on urban trees. The three scenarios are summarized in Table G. 1.

Table G. 1. Indoor residential and outdoor residential parameters used for the three scenarios analyzed. 20 percent of Irrigable Not Irrigated (INI) area is included for Outdoor Residential in Scenario 1

Parameter	Scenario 1	Scenario 2	Scenario 3
Indoor Residential	Until 2025: 55 GPCD 2025 to 2030, 47 GPCD After 2030, 42 GPCD	Until 2025: 55 GPCD 2025 to 2030, 47 GPCD After 2030, 42 GPCD	Until 2025: 55 GPCD 2025 to 2030, 47 GPCD After 2030, 42 GPCD
Outdoor Residential	Until 2030: II at 70% LEF After 2030: II at 63% LEF	Until 2030: II at 70% LEF 2030 to 2035: II at 63% LEF After 2035: II at 55% LEF	Until 2030: II at 70% LEF After 2030: II at 55% LEF

The likelihood that suppliers would be at increased risk for negative impacts to their existing tree canopies was assessed based on projected changes in outdoor water use and whether projected outdoor water use levels would be below the needs of existing vegetation under different objective scenarios. For the 372 suppliers with both vegetation data and baseline water use projections, categories of risk were assigned following the decision tree in Figure G. 2. The many site-specific factors affecting tree responses to reduced water inputs and the anticipated variability of resident responses to the new standards make it infeasible to estimate the number of trees that could be affected by AB 1668-SB 606.

Figure G. 2. Decision tree for assigning suppliers to levels of risk facing their existing urban trees given new water use objectives under AB 1668-SB 606



For suppliers that are not expected to need reductions in water use to meet their objectives, urban trees will face no additional risks due to AB 1668-SB 606. However, once any reduction in water use is required to meet the new objectives, some risk exists for urban trees because it is possible that some residents will respond by reducing irrigation inputs that trees were relying on.

G.1.2. Parklands

The research team conducted semi-structured interviews with park managers throughout the state to understand how regulations, drought, climate change, and public preferences affect park management practices. Park managers were asked about issues and concerns around water management for parklands. The semi-structured interviews provide qualitative and quantitative data for a sample of parkland agencies. The analysis, however, did not evaluate qualitative data for urban parklands in California.

Because parkland areas will be deemed Special Landscape Areas under the proposed *Making Conservation A California Way of Life* regulation, they are unlikely to be significantly affected by the standard for CII landscapes with DIMs. However, AB 1668 and SB 606 directed the State Water Board to adopt Performance Measures for CII water use. It's possible that these Performance Measures, specifically the implementation of best management practices, could impact parklands by, for example, requiring irrigation systems to be better maintained which could increase maintenance costs.

G.2. Results

G.2.1. Urban Trees

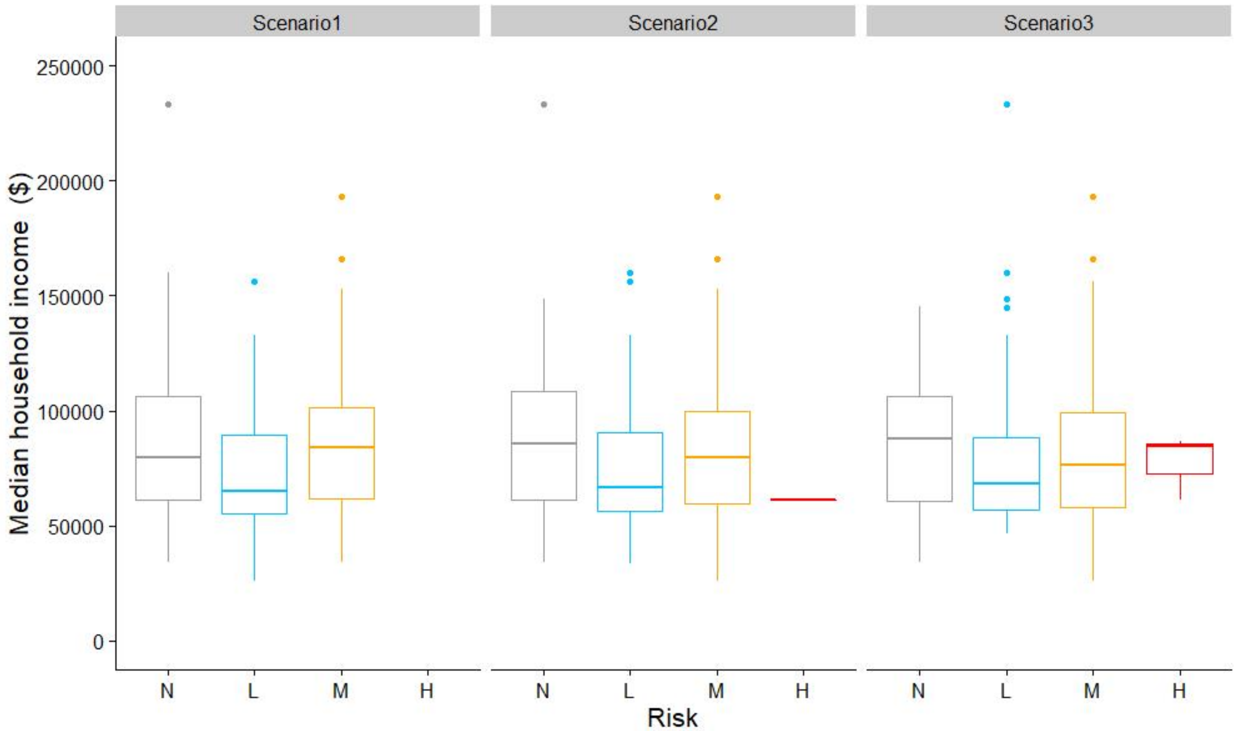
In Scenario 1, with a final indoor standard of 42 GPCD and outdoor standard of an LEF of 0.63 in 2030, 49 percent of suppliers would need no reductions in total water use, and their trees fall in the no risk category. No suppliers are in the high-risk category. In Scenario 2, with a final indoor standard of 42 GPCD and an outdoor standard of an LEF of 0.55 in 2035, the percentage of suppliers in the no risk category drops to 34 percent, and majority of suppliers (40 percent) fall in the moderate risk category. Under Scenario 2, one supplier is in the high-risk category. In Scenario 3, with a final indoor standard of 42 GPCD and an outdoor standard of an LEF of 0.55 in 2030, 30 percent of suppliers are in the no risk category. Most suppliers (52 percent) fall in the moderate risk category and three suppliers are at a high risk of negative impacts to urban tree health.

Table G. 2. Number of suppliers in each level of risk of negative impacts (e.g., reduced health, growth and/or survival) for urban trees under three objective scenarios

Risk Level	Scenario 1 Final year for outdoor standard: 2030 (Indoor standard = 42 GPCD, Outdoor standard = 0.63, buffer included)	Scenario 2 Final year for outdoor standard: 2035 (Indoor standard = 42 GPCD, Outdoor standard = 0.55, no buffer)	Scenario 3 Final year for outdoor standard: 2030 (Indoor standard = 42 GPCD, Outdoor standard = 0.55, no buffer)
No risk	181	127	113
Low risk	98	96	63
Moderate risk	93	148	193
High risk	0	1	3

Risks to urban trees may be amplified in low-income and disadvantaged communities with fewer resources for adaptation and mitigation practices such as installing efficient irrigation systems and replacing turf with low-water-use landscaping. Risk from AB 1668-SB 606 under the three considered scenarios does not appear to be skewed by income or to disproportionately affect low-income and disadvantaged communities. There were no clear trends in the distribution of median household income (MHI) for communities served by suppliers at different levels of risk, with wide ranges for all risk levels except the high-risk category, which included very few or no suppliers (Figure G. 3). MHI values were available for 360 of the suppliers included in the risk assessment.

Figure G. 3: Median household income for suppliers at different levels of risk of negative impacts to urban trees in the three objective scenarios



N = no risk, L = low risk, M = moderate risk, and H = high risk. Scenario 1: indoor standard = 50, outdoor standard = 0.7. Scenario 2: indoor standard = 42, outdoor standard = 0.62. Scenario 3: indoor standard = 35, outdoor standard = 0.55

Disadvantaged Communities (DACs) and Severely Disadvantaged Communities (SDACs) are defined as those with MHI less than $60,188 or $45,141, respectively. A slightly greater proportion of suppliers serving DACs and SDACs shifted into the moderate- or high-risk categories between Scenarios 1 and 3 (Table G. 1). For suppliers serving DACs and SDACs in the moderate- or high-risk categories, the percent increased from 19 percent to 54 percent between Scenarios 1 and 3, while that of other suppliers increased from 28 percent to 52 percent. However, a slightly greater proportion of suppliers serving SDACs fell into higher risk categories. In Scenario 3, 68 percent of suppliers serving SDACs were in moderate- or high-risk categories, compared to 49 percent of suppliers serving DACs and 52 percent of other suppliers. These communities are likely to face greater challenges to implementing water-saving measures that would protect trees. Thus, while DACs and SDACs are not affected in substantially greater proportions by AB 1668-SB 606, the consequences of water reductions for urban trees may be more severe in these areas.

Table G. 3. For the three objective scenarios, the number of suppliers in each level of risk serving communities with different income levels

	Scenario 1			Scenario 2			Scenario 3		
Risk Level	**SDAC**	**DAC**	**Other**	**SDAC**	**DAC**	**Other**	**SDAC**	**DAC**	**Other**
High	0	0	0	0	0	1	0	0	3
Moderate	5	14	71	15	23	106	19	36	131
Low	10	30	55	4	30	58	0	20	42
None	13	30	132	9	21	93	9	18	82
Total	28	74	258	28	74	258	28	74	258

Note: SDAC = Severely Disadvantaged Community, median household income < $45,141; DAC = Disadvantaged Community, median household income < $60,188.

G.2.2. Findings from Parklands Semi-structured Interviews

Semi-structured interviews, consisting of both specific and open-ended questions, were conducted with urban parks department managers and staff to serve as case studies. Interviews explored basic information about the parks and water management strategies including irrigation infrastructure and watering regimes, water sources, plantings, mitigation actions the park managers have used to deal with drought conditions, as well as any budgetary concerns related to water management and vegetation maintenance. In addition, impacts of water and vegetation management activities on park users were also discussed. The following themes emerged from the interview responses:

- The presence of dedicated outdoor meters depends on administrative organization, water source, and age of the park infrastructure.
- Automatic irrigation systems help save water and labor but must be supervised.
- In some locations, water delivery infrastructure needs repair.
- Anxiety over water rate increases in park departments that rely heavily on urban water retailers.
- Standard measures to reduce parklands water consumption—converting parks to “drought-tolerant landscaping,” installing drip/bubbler irrigation, switching to recycled water—are neither simple nor cheap.
- The public enjoys a variety of amenities and landscapes.
- Public perception of how to implement drought mitigation in parks is mixed.
- Climate change adaptation is taken very seriously by some parks departments, less so by others, but is not yet a budgetary priority for most.