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Title 20 Water Closets CASE Report and RFI Response FINAL THIS DOCUMENT SUPERSEDES TN 252109

Additional submitted attachment is included below.

Water Closets

Codes and Standards Enhancement (CASE) Initiative

For PY 2023: Title 20 Standards Development

FINAL Analysis of Standards Proposal and Response to Request for Information for

Water Closets

CEC Docket Number 22-AAER-05

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Prepared for:

Prepared by:

Steffi Becking, 2050 Partners
Bill Gauley, P. Eng., Gauley Associates Ltd., on behalf of Alliance for Water Efficiency
John Koeller, P.E., Koeller and Company, on behalf of Alliance for Water Efficiency
Mary Ann Dickinson, Dickinson Associates, on behalf of Alliance for Water Efficiency
Helen Davis, P.E., Energy Solutions
Kyle Garske, 2050 Partners
Kathleen Bryan, 2050 Partners

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Acknowledgments

The Statewide CASE Team appreciates assistance from Victor Post at GMP Research.

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1. Executive Summary

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (CEC) efforts to update California's Appliance Efficiency Regulations (Title 20) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor-Owned Utilities (IOUs) — Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – sponsored this effort (herein referred to as the CASE Team). The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve the energy and water efficiency of various products sold in California. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness analysis for potential appliance standards. This CASE Report covers a standards proposal for water closets.

The CASE team proposes stricter performance standards for all dual-flush water closets except for dual-flush flushometer valve and blowout water closets. The proposed standard is a maximum of 1.28 gallons per flush (gpf) for a full flush and 0.9 gpf for a reduced flush. The proposed language contains other recommended edits to clarify definitions related to water closets and to update the version of the reference test procedure. Furthermore, the proposed language captures recommended simplifications to the reporting requirements, specifically reporting full flush and reduced flush in gpf for all dual-flush water closet types and removing the requirement to report a waste extraction value.

The CASE Team estimates that during the first year the proposed standards are in effect (2025), the standards will result in annual savings of 104 million gallons (gal) of water and 0.56 gigawatt hours (GWh) from reduced embedded electricity use. After full stock turnover (end of year 2049), the CASE Team projects annual savings of 2.37 billion gallons of water and 12.9 GWh from reduced embedded electricity use.

Section 2 through Section 11 of this report cover the code change proposal for dual-flush water closets and the supporting analysis. Section 12 of this report provides answers to the questions in the Request for Information that the CEC docketed on December 14, 2022 (California Energy Commission, 2022).

2. Introduction

Water closet efficiency and performance have improved dramatically over the last few decades; however, opportunities exist for additional water savings. The CASE Team proposes a comprehensive approach to achieving water savings from the installation and use of more efficient water closets. This approach involves three equally important components:

- **Codes and Standards**: In Title 20, set stricter performance standards for all dual-flush water closets except those with a flushometer valve. The proposed standard for all tank-type dual-flush water closets is a maximum of 1.28 gpf for a full flush and 0.9 gpf for a reduced flush. Tank-type dual-flush water closets include dual-flush gravity tank-type water closets, dual-flush flushometer tank water closets (commonly known as pressure-assist water closets), dual-flush electromechanical hydraulic water closets (or power-assist water closets), and dual-flush vacuum type water closets (or vacuum-assist water closets).
- **Codes and Standards**: In California Plumbing Code (CPC) and CALGreen, set a stricter performance standard for single-flush tank-type water closets in new residential construction, i.e., a maximum of 1.1 gpf. Tank-type water closets include gravity tank-type, pressure-assist, power-assist, and vacuum-assist water closets. The code change proposal for CPC and CALGreen would allow California to tailor the stricter standard to residential new construction, thus avoiding potential plumbing issues from installing highly efficient water closets in the existing building stock with plumbing designed for higher water flows and in nonresidential new construction buildings that generally have less supplementary water (e.g., water from baths, showers, clothes washers) to keep the pipes flushed. Additionally, nonresidential applications warrant a flush volume of at least 1.28 gpf because of flushing of extra materials, e.g., wipes and seat covers (Plumbing Efficiency Research Coalition, 2012).
- **Compliance Improvement**: Improve compliance with California Civil Code, Section 1101.1-1101.9 “Installation of Water Use Efficiency Improvements” (promulgated by 2009 Senate Bill 407) that requires the installation of water-conserving plumbing fixtures in residential and commercial properties built before January 1, 1994.

This report provides supporting analysis for the first component of the comprehensive approach – Title 20 code change proposal, which focuses on stricter performance standards for all dual-flush water closet types except those with a flushometer valve.

3. Product and Technology Description

Water closets (also known as toilets) are sanitation fixtures used to dispose of human waste. In urban areas, water closets connect to building drain lines that carry waste to a sewage system connected to a wastewater treatment facility. Water closets in rural areas without municipal sewage collection and treatment facilities convey waste to a septic system.

Some water closet designs are more suitable for residential and others for commercial, industrial, and institutional applications. Water closets are categorized as tank-type or flushometer valve-type.

Tank-type water closets include:

- Gravity tank-type water closets,
- Pressure-assist water closets (also known as flushometer tank water closets),
- Power-assist water closets (or electromechanical hydraulic water closets), and
- Vacuum-assist water closets (or vacuum-type water closets).

Flushometer valve-type water closets include:

- Flushometer valve water closets and
- Blowout water closets.

Further, water closets are categorized as siphonic or wash-down. Most modern water closets found in U.S. residential and small commercial buildings are siphonic. In a siphonic water closet, the bowl and the trapway that lead from the bowl to the building drain line are carefully designed to create a siphon (in the trapway) that helps "pull" waste from the bowl when the water closet is flushed. Water must rapidly enter the bowl to trigger the siphoning effect. After most of the water from the bowl is evacuated, air enters the trapway, breaking the siphon. If water is slowly added to the bowl, as with leaking water closets, the water level in the bowl will gradually rise and the excess water will spill over the trapway weir and drain into the drain line. Siphonic water closets generally have a much larger water surface area in the bowl ("water spot") and, thus, require far less brushing or cleaning by the user.

The wash-down water closet differs from the siphonic water closet's combination of push-pull action. In a wash-down water closet, the water from the tank is released quickly into the bowl and pushes the waste into the trapway and out of the fixture. There is no siphonic action in the wash-down bowl. The wash-down design necessitates a smaller water spot in the bowl, which can lead to more scarring on the sides of the bowl after solids flush, a condition that may require subsequent brushing and additional flushing. Wash-down water closet design is common in Europe and Australia.

Water closets are also categorized as single-flush or dual-flush. The terms single-flush and dual-flush refer to the number of volumetric flushing options available to the product user. Gravity tank-type, pressure-assist, power-assist, vacuum-assist, and flushometer valve water closets can be either single- or dual-flush. Blowout water closets are currently not manufactured with a dual-flush feature. Many tank-type dual-flush models use the wash-down (non-siphonic) design.

3.1 Gravity Tank-Type Water Closets

Gravity tank-type water closets employ a tank (cistern) to hold flush water. The actuated flush quickly releases water from the tank into the bowl through a large flush valve, moving water and waste into the trapway and triggering a siphon that helps “pull” the waste from the bowl. Gravity water closets are the most common and least expensive tank-type model in the United States. They are common in residential and light commercial applications. The flush water is temporarily stored at atmospheric pressure in the tank until needed, i.e., the water stored in the tank is not pressurized.

3.2 Pressure-Assist Water Closets

Pressure-assist (flushometer tank) water closets are less common in residential applications than gravity models. Pressure-assist water closets contain a vessel inside the ceramic tank (Figure 1). Building water pressure from the water supply line pressurizes this vessel. As water refills, it enters the vessel and compresses the air. The flush action rapidly decompresses air and forces water from the vessel into the bowl and trapway, creating the siphon. Pressure-assist models generally require a minimum water supply pressure of 15-40 pounds per square inch (psi) to operate well. The downside to pressure-assist water closets is they are generally more expensive to purchase, and the flush action is often louder than in gravity models.

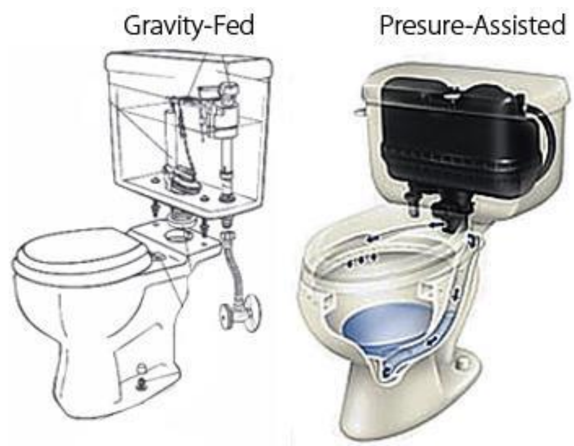

Figure 1: Gravity and Pressure-Assist Tank-Type Water Closets

Source: Upland Plumber 2013, reproduced from 2013 CASE Report on toilets and urinals (CASE Team, 2013)

3.3 Power-Assist Water Closets

Power-assist (electromechanical hydraulic) water closets use electricity for pumping or pressurization. These designs are less common. Title 20 defines electromechanical hydraulic models as water closets that use electrically operated devices, such as air compressors, pumps, solenoids, motors, or macerators in place of, or to aid, gravity in evacuating waste from the bowl. The disadvantages of power-assist water closets are that they consume electricity, require an electrical outlet near the water closet, and are more expensive to purchase than gravity water closets. However, they can offer a low-profile aesthetic that appeals to bathroom design professionals. Figure 2 provides a schematic of a power-assist model.

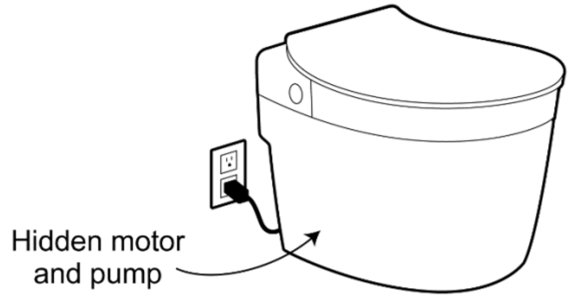

Figure 2: Power-Assist Water Closet

3.4 Vacuum-Assist Water Closets

The vacuum-assist water closet design uses a pressurized air pocket that suspends the water in the bowl within a trapway between the bowl and the exit to the drain line. When the water closet is flushed, the air in the trapway depressurizes and creates a suction force that pulls wastewater out of the bowl. Figure 3 provides a schematic of a vacuum-assist model.

Figure 3: Vacuum-Assist Water Closet

Source: Niagara Conservation, reproduced from 2013 CASE Report on toilets and urinals (CASE Team, 2013)

3.5 Flushometer Valve Water Closets

Flushometer valve water closets are common in medium- to high-usage commercial and industrial applications. The flush water comes directly from the building water supply instead of a pressurized tank. The flush valve controls the volume of water that enters the bowl to activate the flush and restore the water level following the flush. Flushometer valve water closets typically require water supply pressures of between 20 and 80 psi and a one-inch diameter water supply line. Flushometer valve water closets provide a quick flush and a rapid recovery but are also generally quite noisy. They can be wall- or floor-mounted, as shown in Figure 4. The bowl and the matched valve are frequently sold separately.

Figure 4: Wall- and Floor-Mounted Flushometer Valve Water Closets

Source: American Standard, reproduced from 2013 CASE Report on toilets and urinals (CASE Team, 2013)

3.6 Blowout Water Closets

Blowout water closets do not employ siphonic technology and are used exclusively in nonresidential applications. These water closets rely on high building water pressure and large water volume to rapidly remove waste from the bowl. Blowout water closets are currently not manufactured with a dual-flush feature.

Figure 5 illustrates a blowout bowl. Some key distinguishing features of the blowout bowl include the unrestricted (without bends) trapway and the three-bolt mounting pattern for wall-mounted fixtures. Blowout water closets are best suited for heavy-use applications, e.g., airports, stadiums, and prisons, because these toilets are more durable, less susceptible to clogging, and faster in recovery.

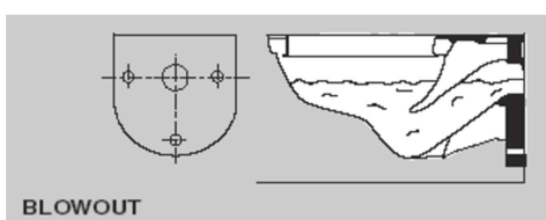

Figure 5: Blowout Bowl

Source: Jay R. Smith Mfg. Co., reproduced from 2013 CASE Report on toilets and urinals (CASE Team, 2013)

4. Proposed Standards

4.1 Proposal Description

The CASE Team proposes a comprehensive approach to achieving water savings from the installation and use of more efficient water closets. This approach involves three equally important components:

- **Codes and Standards**: In Title 20, set stricter performance standards for all dual-flush water closets except those with a flushometer valve. The proposed standard for all tank-type dual-flush water closets is a maximum of 1.28 gpf for a full flush and 0.9 gpf for a reduced flush. Tank-type dual-flush water closets include dual-flush gravity tank-type water closets, dual-flush flushometer tank water closets (commonly known as pressure-assist water closets), dual-flush electromechanical hydraulic water closets (or power-assist water closets), and dual-flush vacuum type water closets (or vacuum-assist water closets).
- **Codes and Standards**: In California Plumbing Code (CPC) and CALGreen, set a stricter performance standard for single-flush tank-type water closets in new residential construction, i.e., a maximum of 1.1 gpf. Tank-type water closets include gravity tank-type, pressure-assist, power-assist, and vacuum-assist water closets. The code change proposal for CPC and CALGreen would allow California to tailor the stricter standard to residential new construction, thus avoiding potential plumbing issues from installing highly efficient water closets in the existing building stock with plumbing designed for higher water flows and in nonresidential new construction buildings that generally have less supplementary water (e.g., water from baths, showers, clothes washers) to keep the pipes flushed. Additionally, nonresidential applications warrant a flush volume of at least 1.28 gpf because of flushing of extra materials, e.g., wipes and seat covers (Plumbing Efficiency Research Coalition, 2012).
- **Compliance Improvement**: Improve compliance with California Civil Code, Section 1101.1-1101.9 “Installation of Water Use Efficiency Improvements” (promulgated by 2009 Senate Bill 407) that requires the installation of water-conserving plumbing fixtures in residential and commercial properties built before January 1, 1994.

This report provides supporting analysis for the first component of the approach – Title 20 code change proposal, which focuses on stricter performance standards for all dual-flush water closet types except those with a flushometer valve. Additional analysis is required to assess if the proposed standards could extend to water closets with a flushometer valve. This additional analysis should include technical feasibility assessment, calculations of per unit and statewide water and energy savings, and cost-effectiveness analysis. Hence, the CASE Team has not included flushometer valve water closets in the scope.

Reducing the maximum full flush for tank-type dual-flush toilets from 1.6 gpf to 1.28 gpf would align California with ASHRAE/ICC/USGBC/IEC 189.1-2020 Standard for the Design of High-Performance Green Buildings, 2021 International Green Construction Code (IgCC), and the voluntary Maximum Performance (MaP) specification for MaP PREMIUM water closets (Maximum Performance (MaP) Testing, 2023). The ASHRAE 189.1 standard, 2021 IgCC, and MaP PREMIUM specification set the full flush volume limit for dual-flush toilets to 1.28 gpf but do not specify the limit for the reduced flush. The CASE Team recommends setting the maximum for a reduced flush to 0.9 gpf based on the market availability of qualifying products. The CASE Team does not recommend setting Title 20 standard for a reduced flush below 0.9 gpf to avoid possible design restrictions against siphonic dual-flush water closets. Siphonic dual-flush toilets tend to require less brush cleaning than wash-down models due to a larger water spot, thus offering an important advantage in product usability. At the same time, it is challenging to design siphonic toilets to operate at very low flush volumes.

4.2 Proposed Changes to the Title 20 Code Language

4.2.1 Proposed Definitions

The CASE Team proposes two substantive changes to definitions:

- Add a new definition for the term "flushometer valve water closet." The term is used in Title 20, Section 1606, in the table with data submittal requirements but is currently not defined in Section 1602 Definitions.
- Revise the definition for the term "flushometer tank" to address possible misinterpretation that the definition of "flushometer valve water closet" (that uses the term "flushometer tank") includes a water closet with a flushometer tank.

The CASE Team also proposes the following clarifying, non-substantive updates:

- Replace the term "blowout toilet" with "blowout water closet" to be consistent with the definitions of other water closet types as well as to be consistent with the use of the term "blowout water closet" from the table with data submittal requirements located in Title 20, Section 1606.
- Note commonly used industry terms for electromechanical hydraulic, flushometer tank, and vacuum-type water closets.

4.2.2 Proposed Test Procedure

The CASE Team does not propose any changes to the existing test procedures. The team recommends updating the current reference to the waste extraction test in the 2013 ASME A112.19.2/CSA B45.1 standard to the latest 2018 version of the same standard. Note that the section number for the waste extraction test was updated from 7.10 in 2013 version to 7.9 in the 2018 version. The only substantive change relevant to water closets between the 2013 and 2018 versions was removing Section 7.5 Granule and Ball Test.

4.2.3 Proposed Standard Level

The CASE Team proposes setting a maximum for a full flush to 1.28 gpf and for a reduced flush to 0.9 gpf for tank-type dual-flush water closets manufactured on or after January 1, 2025.

4.2.4 Proposed Reporting Requirements

The CASE Team proposes updating the reporting requirements for dual-flush water closets as follows:

- Remove the requirement to report dual-flush effective volume (defined in Title 20 as the average flush volume of two reduced flushes and one full flush) for all dual-flush water closet types manufactured after January 1, 2025,
- Require reporting full flush and reduced flush volumes in gpf for all dual-flush water closet types manufactured after January 1, 2025, and
- Remove the requirement to report a waste extraction value.

Consistent reporting requirements for all dual-flush water closet types should simplify compliance and generate valuable data on full flush and reduced flush volumes for all dual-flush water closets, including those with a flushometer valve.

The CASE Team recommends removing the requirement to report a waste extraction value. Since the extraction test prescribes a fixed mass for pass-fail testing, reporting a waste extraction value adds no additional benefit. The fixed mass includes 350 grams plus/minus 10 grams of seven soybean paste cylinders and four loosely crumpled balls of toilet paper. Based on the current product listings in Title 20 MAEDbS, all listed water closet products report 350 grams, the amount required for the test's waste extraction value.

4.2.5 Proposed Marking and Labeling Requirements

The CASE Team does not propose any changes to the existing marking and labeling requirements.

5. Market Analysis

5.1 Scope

The CASE Team proposal covers the following:

- Dual-flush gravity tank-type water closets,
- Dual-flush flushometer tank water closets (commonly known as pressure-assist water closets),
- Dual-flush electromechanical hydraulic water closets (or power-assist water closets), and
- Dual-flush vacuum-type water closets (or vacuum-assist water closets).

5.2 Product Efficiency Opportunities

The introduction of dual-flush water closets in 1999 to the California marketplace reduced water consumption by providing a lower volume liquid-only flush option and incited single-flush toilet manufacturers to improve their products. As a result, some single-flush toilet models now provide equal or better water efficiency and flush performance than many dual-flush models. Moreover, efficient single-flush water closets offer more certain and persistent water savings than dual-flush designs because water savings from single-flush designs are not dependent on users selecting a reduced flush option for liquid-only waste.

Currently, the standard for dual-flush models sold and installed in California requires no more than 1.6 gpf for full flush compared to the 1.28 gpf for single-flush models. Setting a stricter standard for the dual-flush model's full flush to match the 1.28 gpf standard for single-flush models provides an opportunity for water savings in California.

5.3 Technical Feasibility

5.3.1 Future Market Adoption of Qualifying Products

The CASE Team reviewed product listings in California MAEDbS, United States Environmental Protection Agency WaterSense Program (WaterSense), and MaP PREMIUM Program to assess the availability of products meeting the proposed standards (i.e., qualifying products).

In early 2023, the California MAEDbS database included 1,578 dual-flush model listings with an effective flush volume ranging from 0.6 to 1.28 gpf. MAEDbS database does not specify ratings for full and reduced flush beyond the combined metric of the effective flush volume.

As of July 2023, WaterSense website listed 1,941 unique tank-type dual-flush water closet models (EPA WaterSense®, 2023b), all certified to the current WaterSense version 1.2 specification for tank-type water closets (EPA WaterSense®, 2014). Of the 1,941 WaterSense-certified dual-flush models, 474 models (24 percent) have a full flush volume of 1.28 gpf or less, and 414 models (21 percent) have both a full flush of 1.28 gpf or less and a reduced flush of 0.9 gpf or less. Thus, 414 models meet the proposed flush volume requirements. See Table 1 for more details.

Table 1: Distribution of WaterSense Labeled Dual-Flush Water Closets

WaterSense Dual-Flush Models	Number of Models	Percentage of WaterSense Labeled Dual-Flush Models	Number of Distinct Manufacturers Offering Products
Models with a full flush greater than 1.28 gpf	1,467	76%	-
Models with a full flush of 1.28 gpf or less	474	24%	-
Qualifying models with a full flush of 1.28 gpf or less and a reduced flush of 0.90 gpf or less	414	21%	23

Source: The U.S. EPA WaterSense data retrieved in July 2023. Toilet manufacturers sometimes differentiate toilet models based solely on aesthetic differences such as product color, location of flush handle, or design of toilet tank lid.

MaP PREMIUM listings for dual-flush water closets require 1.28 gpf or less for a full flush. As of March 2023, 14 distinct manufacturers (eight of which are major manufacturers) offer 89 distinct MaP PREMIUM models in the United States with a maximum full flush of 1.28 gpf and a reduced flush of 0.9 gpf or less. Currently, 11 MaP PREMIUM models offered in the United States have a reduced flush of 0.92-0.93 gpf, thus those models almost qualify to meet the proposed standards. For further context, the test procedure to measure water consumption of water closets requires the volumetric calibration to not exceed 0.07 gallon and instructs to round down the total flush volume being measured to the nearest 0.07 gallon. The test procedure is codified in 10 CFR 430, Subpart B, Appendix T and incorporated by reference in Title 20. Table 2 presents the breakdown of MaP PREMIUM dual-flush water closets.

Table 2: Distribution of Reduced Flush Volumes of MaP PREMIUM Dual-Flush Water Closets

Reduced Flush Volume for MaP PREMIUM Listings	Number of Models in the United States and Canada (rated 1.28 gpf for full flush)	Number of Models in the United States (rated 1.28 gpf for full flush)[1]	Number of Distinct Manufacturers Offering Products in the United States
≤ 0.8 gpf	81	61	11
> 0.80 gpf and ≤ 0.90 gpf	28	28	7
> 0.9 gpf and ≤ 1.0 gpf	12[1]	11[2]	4
> 1.0 gpf and ≤ 1.1 gpf	0	0	0
Total	**121**	**100**	**-**

Source: The CASE Team analysis 2023. The MaP PREMIUM data retrieved in February and March 2023.

Notes:

[1] Authors' best estimate at the time of report's writing.

[2] These models are rated for a reduced flush of 0.92 or 0.93 gpf.

Given the variety of dual-flush water closets meeting the proposed standards, the CASE Team anticipates the continued market adoption of these models in the standards and the non-standards case.

5.3.2 Consumer Utility and Acceptance

This section discusses consumer utility and acceptance from two aspects: dual-flush over single-flush toilets and qualifying dual-flush over non-qualifying dual-flush models.

Dual-flush toilet models do not necessarily provide consumers with the expected additional water efficiency compared to single-flush toilet models because of: (a) the occasional need to remove bowl scarring due to the small water spot in many wash-down dual-flush models, which may require scrubbing with a toilet brush and a second flush to remove the remaining waste, and (b) dependence on consumer behavior to select the reduced flush for liquid-only waste.

The CASE Team is unaware of any consumer utility or acceptance issues for dual-flush toilets with a maximum flush of 1.28 gpf as compared to models with a maximum flush of 1.6 gpf. In March 2023, the CASE Team interviewed three major plumbing manufacturers to gather further insights. None of these manufacturers were aware of any consumer utility or acceptance issues for qualifying dual-flush models as compared to non-qualifying models.

5.3.3 Manufacturer Structure and Supply Chain Timelines

In late 1999, a manufacturer (Caroma) introduced the first dual-flush water closets into the California marketplace, followed quickly by other manufacturers. Table 3 summarizes counts of WaterSense tank-type dual-flush models by major manufacturer. Based on the report authors' best estimate and the interviews with three major manufacturers in January and July 2023, the CASE Team estimates that approximately half of tank-type dual-flush models offered by the major manufacturers in the United States have wash-down bowl design and the other half – siphonic bowl design.

Table 3: Major Manufacturers of Dual-Flush Water Closets for North American Market

Manufacturer	Number of Tank-Type Dual-Flush Models
Toto	251
Duravit	160
Foremost/Contrac	74
Caroma	70
American Standard	59
Kohler	38
Gerber	37
Tynan	33
Total	**722**

Source: The CASE Team analysis 2023. The presented numbers are based on the U.S. EPA WaterSense data retrieved in July 2023. Toilet manufacturers sometimes differentiate toilet models based solely on aesthetic differences such as product color, location of flush handle, or design of toilet tank lid.

Table 4 reflects the distribution of water closet sales in the United States in 2022 between single- and dual-flush models. Dual-flush fixtures comprised 19.2 percent of these sales. The 80.8 percent of single-flush models sold highlights the consumers' preference for these models.

Table 4: 2022 Water Closet Sales in the United States (millions of water closets)

Water Closet Type	Single-Flush	Dual-Flush	Total
Wall-mount residential	0.540	0.190	0.730
One-piece models	2.162	1.123	3.285
Two-piece models	15.077	3.178	18.255
Smart toilets	0.029	0.006	0.035
Commercial toilets	1.397	0.058	1.455
Total	**19.204**	**4.556**	**23.760**
Percent of Total	**80.8%**	**19.2%**	**100%**

Source: (GMP Research Inc., 2022)

Notes:

One-piece model: toilet style with the tank molded with the bowl.

Two-piece model: toilet style with individual bowl and tank being separate units that are connected to become one unit.

Smart toilets: water closets with built-in "smart" technology capable of interacting/connecting with the user. This category includes power-assist water closets.

The plumbing industry's current manufacturing and distribution structure is well established, supplying water closets and support throughout the United States for decades. Dual-flush water closets are distributed through four primary channels:

- Retail stores, e.g., Home Depot, Ferguson, Lowe's, small outlets, and online retailers,
- Wholesale plumbing distributors,
- Direct sales from manufacturers to volume buyers, and
- Showrooms.

Large retailers (Lowe's, Home Depot, and Ferguson) process most transactions and significantly influence the products that reach the mainstream market. The stocked models have a distinct sales advantage; however, the large chain stores accept special orders for products not displayed.

Some manufacturers use wholesale plumbing distributors with a tailored distribution strategy for different regions, e.g., a wholesale plumbing distributor working directly with a particular builder.

Some manufacturers sell directly to home builders or other volume buyers.

Showrooms are a secondary retail distribution channel. Manufacturers that offer high-efficiency products may target green building showrooms.

The CASE Team does not anticipate that the code change proposal will significantly impact the existing manufacturer structure or supply. If the proposed standards are adopted, providing at least one year between the adoption date and the effective date would allow manufacturers and supply chains sufficient time to adjust their operations to comply with the changes.

6. Per Unit Water and Energy Savings

6.1 Key Assumptions

The CASE Team considered only the residential application when calculating per unit water and energy savings. The residential application is the primary market for tank-type dual-flush toilets; light commercial applications (e.g., a hotel, a gas station, a restaurant) are the secondary market. Table 5 presents the assumptions for calculating the per unit water and energy savings for the residential application.

Table 5: Key Assumptions for Calculating Per Unit Water and Embedded Energy Savings

Metric	Value	Sources and Notes
Effective flush ratio of dual-flush water closets, reduced flush to full flush	1.5:1	See discussion below.
Number of flushes per capita per day at a residential dwelling	5 flushes per capita per day	1999 and 2016 Residential End Uses of Water published by Water Research Foundation.
Number of toilets per capita	0.867 toilet per capita	The CASE Team derived the number of residential toilets per capita by dividing 2022 stock of California residential toilets (33,887,000) by the 2022 California population of 39,078,674 million (as reported by State of California Department of Finance).
Embedded energy factor	5,440 kWh per million gallons	Based on research conducted for CPUC Rulemaking 13-12-011. See Appendix B: Embedded Electricity Usage Methodology.

Source: The CASE Team analysis 2023.

The effective or average flush ratio assumption listed in Table 5 warrants further discussion. The CASE Team assumed a 1.5:1 ratio for reduced flush to full flush based on the available studies (conducted from 2000 to 2011) and the report authors' best estimate of the future consumer behavior. The assumed ratio is slightly higher than the average ratio identified in the field studies (see Table 6) but lower than the current assumption of 2:1 ratio in Title 20 and WaterSense. To further compare, the flush ratio used for MaP PREMIUM designation is 1:1, i.e., one reduced flush for every full flush. The higher the assumed flush ratio, the larger the estimate of water savings.

As user behavior determines the average flush ratio in a dual-flush model, water efficiency circles disagree on the appropriate flush ratio and durability of water savings associated with using these models. According to estimates, the average person generates liquid-only waste in four of every five bathroom trips. Therefore, consumers using dual-flush water closets could theoretically select the reduced flush option 80 percent of the time (flush ratio of 4:1). Field studies on dual-flush usage in the United States (California, Oregon, Washington, Utah), Canada, and Australia found that consumers select the reduced flush option on average 1.28 times for every time they choose the full flush option (approximately equivalent to an average of five reduced flushes for every four full flushes) (Luettgen, 2008). Table 6 summarizes the details of these studies.

Table 6: Overview of Flush Ratios in Studies on Dual-Flush Water Closets

Study	Sample Size	Geographic Area	Flush Ratio (Reduced Flushes /Full Flushes)
Aquacraft Follow up Analysis of 2004 Field Data (2010)	33 dual-flush toilets	San Francisco Bay Area, California	0.51
	32 dual-flush toilets	Seattle, Washington	1.19
Pacific Northwest National Laboratories Study (2001)	100 dual-flush toilets installed in 50 single family homes	Lafayette and Wilsonville, Oregon	1.86
Jordan Valley Water Conservancy District Residential Ultra-Low-Flush Toilet Replacement Program (2003)	13 dual-flush toilets in single family homes	Jordan Valley, Utah	1.48
Canada Mortgage and Housing Corporation and Veritec Consulting Dual-flush Toilet Project (2002)	10 dual-flush toilets installed in single family homes and 15 dual-flush toilets installed in one multifamily building	Various locations in Canada (in Alberta, British Columbia, Newfoundland, Manitoba, Ontario, Quebec, and Saskatchewan provinces)	1.6
Queensland Residential End Use Study (2011)	87 single family homes	Gold Coast, Queensland, Australia	1.16
	61 single family homes	Brisbane, Queensland, Australia	1.16
	37 single family homes	Ipswich, Queensland, Australia	1.72
	67 single family homes	Sunshine Coast, Queensland, Australia	1.37
Yarra Valley Residential End Use Study (2005)	56 single family homes	Yarra Valley, Australia	0.75
		Non-Weighted Average	**1.28**

Sources:

Funk, A., Mayer P., and Luettgen M., 2010. Dual Flush Savings – An Analysis of Field Data. https://www.waterworld.com/home/article/14069782/dual-flush-savingsan-analysis-of-field-data https://efiling.energy.ca.gov/GetDocument.aspx?tn=71107 (a full version of the article with a table that lists flush ratios)

Pacific Northwest National Laboratories, 2001. The Save Water and Energy Education Program: SWEEP – Water and Energy Savings Evaluation. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-13538.pdf

Jordan Valley Water Conservancy District, 2003. Residential Ultra-Low-Flush Toilet Replacement Program. http://ufdcimages.uflib.ufl.edu/WC/10/49/28/52/00001/WC10492852.pdf

Canada Mortgage and Housing Corporation and Veritec Consulting, 2002. Dual-flush Toilet Project. https://publications.gc.ca/collections/collection_2011/schl-cmhc/nh18-1-3/NH15-397-2002-eng.pdf

Beal, C. and Steward, R., Urban Water Security Research Alliance, 2011. South East Queensland Residential End Use Study: Final Report, Technical Report No. 47. http://www.urbanwateralliance.org.au/publications/UWSRA-tr47.pdf

Roberts, P., Yarra Valley Water, 2005. Residential End Use Measurement Study. https://efiling.energy.ca.gov/GetDocument.aspx?tn=71104&DocumentContentId=8003

Notes:

The studies are ordered by geographic proximity to California. The sample size is specific to the determination of the listed flush ratio.

6.2 Methodology

This section describes the CASE Team's methodology to estimate water and embedded energy savings for the proposed code change. Water savings were calculated by comparing non-qualifying products to qualifying products. Non-qualifying products do not meet the proposed standards, and qualifying products meet the proposed standards. For the purposes of calculating potential savings:

- Non-qualifying products mean dual-flush models operating with a full flush volume of 1.6 gpf and a reduced flush volume of 1.1 gpf (or models with the effective flush volume of 1.28 gpf as defined in Title 20 based on a 2:1 ratio of reduced to full flush use) (California Public Utilities and Energy Division, 2023).
- Qualifying products mean dual-flush models operating with a maximum full flush volume of 1.28 gpf and a reduced flush volume of 0.9 gpf.

Table 7 presents the equations and the calculation results of the per unit water and energy savings for the residential application.

Table 7: Equations and Results for Per Unit Water and Embedded Energy Savings

Metric	Value	Equation
Effective flush volume of a non-qualifying dual-flush water closet (1.6/1.1 gpf)	1.30 gpf	(1.5 flushes x 1.1 gpf + 1.0 flushes x 1.6 gpf) ÷ 2.5 flushes = 1.30 gpf
Effective flush volume of a qualifying dual-flush water closet (1.28/0.9 gpf)	1.05 gpf	(1.5 flushes x 0.9 gpf + 1.0 flushes x 1.28 gpf) ÷ 2.5 flushes = 1.05 gpf
Annual water use for a non-qualifying dual-flush model (1.6/1.1 gpf)	2,738 gal/year	(1.30 gpf x 5 flushes/day/capita x 365.24 days/year) ÷ 0.867 toilets/capita = 2,738 gal/year per toilet
Annual water use for a qualifying dual-flush model (1.28/0.9 gpf)	2,215 gal/year	(1.05 gpf x 5 flushes/day/capita x 365.24 days/year) ÷ 0.867 toilets/capita = 2,215 gal/year per toilet
Annual water savings per unit	522 gal/year	2,738 gal/year - 2,215 gal/year = 522 gal/year per toilet
Annual embedded electricity savings per unit	2.84 kWh/year	522 gal/year x 5,440 kWh ÷ 1,000,000 million gal = 2.84 kWh /year per toilet

Source: The CASE Team analysis 2023. Some calculated values may appear slightly off due to rounding error.

6.3 Per Unit Water and Energy Saving Results

Tables 8 and 9 summarize the annual per unit water and embedded energy impacts for the residential application of the tank-type dual-flush toilets. The CASE Team estimates 522 gallons per year for water savings per unit and 2.84 kWh per year for embedded electricity savings per unit.

Table 8: Annual Per Unit Water and Energy Use for Qualifying and Non-Qualifying Products

	Annual Water Use (gal/year)	Annual Embedded Energy Use (kWh/year)
Non-qualifying models (1.6/1.1 gpf)	2,738	14.9
Qualifying models (1.28/0.9 gpf)	2,215	12.1

Source: The CASE Team analysis 2023.

Note: Per unit water and energy use is per toilet.

Table 9: Annual Per Unit Water and Energy Savings

	Water Savings (gal/year)	Annual Embedded Energy Savings (kWh/year)
Savings	522	2.84

Source: The CASE Team analysis 2023.

Note: Per unit water and energy savings are per toilet.

7. Cost-Effectiveness

7.1 Incremental Cost

Based on the review of retail prices, the CASE Team assumed a $0 incremental cost for consumers choosing a qualifying dual-flush over a non-qualifying dual-flush water closet and for consumers choosing a qualifying dual-flush over a single-flush water closet.

Dual-flush (qualifying and non-qualifying) and single-flush water closets are available at wide price ranges. A March 2023 review of a major retailer's water closet prices identified an average price of $345 for qualifying dual-flush toilets (based on 27 offered models), an average price of $346 for non-qualifying dual-flush toilets (based on 91 models), and an average price of $355 for single-flush toilets (based on 198 models). The average and median price for the reviewed qualifying dual-flush toilets is lower than the average and median price, respectively, for non-qualifying dual-flush and single-flush toilets. However, the CASE Team acknowledges that a consumer interested in the least expensive qualifying product may face a steeper first cost compared to first cost of the least expensive single-flush or non-qualifying dual-flush toilet. A consumer sensitive to first cost may need to invest more time in shopping for a better deal. Table 10 summarizes the results of the retail price review.

Table 10: Availability and Retail Price of Water Closets at a Major Retailer

Fixture Type	Number of Models	Average Price	Median Price	Range of Prices
Tank-type single-flush	198	$355	$361	$119 - $500
Non-qualifying tank-type dual-flush	91	$346	$354	$99 - $486
Qualifying tank-type dual-flush	27	$345	$311	$253 - $482

Source: The CASE Team analysis 2023.

Notes: The CASE Team compiled the pricing data from Home Depot retail website for Anaheim, California, store location in March 2023. Water closets costing more than $500 were excluded from the analysis to eliminate the impact of specialty or luxury models. For dual-flush toilets, the team only included models that listed volumes for full and reduced flushes on the website. Reviewed dual-flush models are tank-type that tend to be installed in residential and light commercial applications.

The CASE team expects the same maintenance costs for qualifying dual-flush models as compared to non-qualifying dual-flush models. Maintenance costs may be slightly higher for dual-flush water closets as compared to single-flush toilets because the dual flushing mechanisms are more complex than those used in single-flush models. Thus, the maintenance costs for parts and labor are likely to be higher. This proposal recommends mandating more efficient dual-flush toilets over less efficient dual-flush toilets and does not recommend mandating the shift from single-flush to dual-flush toilets. Hence, for this analysis, the team assumed $0 incremental cost in maintenance costs.

7.2 Design Life

The CASE Team assumed a 25-year lifetime for a dual-flush water closet. Most water conservation professionals use a 25-year lifecycle for residential gravity water closets (Vickers, The Future of Water Conservation: Challenges Ahead, 1999). Plumbing Manufacturers International (PMI) uses a 30-year average lifetime for gravity water closets. According to Amy Vickers, author of the *Handbook of Water Use and Conservation* and an internationally recognized water conservation authority, the economic life varies significantly:

> The useful life of a toilet depends on several factors, including the frequency and type of use, quality of mechanical parts, and water quality. Gravity-flush toilets made of porcelain can have a life span of 25 to 50 years with normal maintenance (replacement of flapper valves and ballcocks and related leak repair as needed) (Vickers, Handbook of Water Use and Conservation, Waterplow Press, 2001).

While toilets have a long design life, the team expects that bathroom remodels that include toilet replacement shorten the product average lifetime in residential applications.

7.3 Lifecycle Cost / Net Benefit

The CASE Team considered only the residential application when calculating lifecycle benefit per unit. Residential application is the primary market for tank-type dual-flush toilets; light commercial applications (e.g., a hotel, a gas station, a restaurant) are the secondary market.

The incremental cost for a qualifying product is $0, so there is no benefit-to-cost ratio. The code change proposal will realize cost savings through lower water and sewer bills. The water savings over 25 years equate to a present value benefit of $177 per unit. This estimate is based on the calculated volume of per unit water savings from 2025 to 2049 multiplied by the volumetric water/sewer rates forecasted for 2025 to 2049. Please refer to Table 23 for details on the forecasted water/sewer rates. The analysis does not include cost savings associated with embedded energy savings.

Table 11 illustrates the 25-year benefit cost ratio associated with purchasing a 1.28/0.9 gpf vs. a 1.6/1.1 gpf dual-flush water closet for the residential application.

Table 11: Cost and Benefits per Unit for Qualifying Products

	Product Lifetime (years)	**Incremental Cost per Unit (2023 PV $) [a, b]**	**Lifecycle Benefits per Unit (2023 PV $) [a, c]**	**Benefit Cost Ratio [d]**
Dual-flush water closet 1.28/0.9 gpf	25	$0	$177	N/A

Source: The CASE Team analysis 2023.

Notes:

Per unit lifecycle benefit is per toilet.

[a] PV = Present Value. The CASE Team assumed a 3-percent discount rate based on the guidance in the Building Energy Efficiency Measure Proposal Template from the CEC for 2025 code cycle.

[b] Incremental cost is the difference between the baseline non-qualifying and the qualifying products.

[c] Based on cost saving from saving on water/sewer bills using a volumetric water/sewer rate of $12.47 per thousand gallons in 2023; forecasted 2025-2049 water and sewer rates by applying annual water and sewer rate increase of 3.2 percent and 4.2 percent, respectively, based on 2023 PNNL report and by applying a 3-percent annual discount rate to display results in 2023 $. The effective water escalation rate is 0.2 percent, the effective sewer escalation rate is 1.2 percent.

[d] Benefit cost ratio is total present value benefits divided by present value incremental cost. A ratio higher than 1.0 is deemed cost-effective.

8. Statewide Impacts

8.1 Annual Sales and Stock

The estimated 2025 stock of tank-type dual-flush water closets installed in California residential buildings is 3.43 million. The CASE Team estimates annual California sales in 2025 of approximately 0.27 million tank-type dual-flush water closets for the residential market, including approximately 0.16 million fixtures per year to meet the growing demand for dual-flush toilets and approximately 0.12 million per year to replace older existing dual-flush toilets. This annual replacement rate estimate is based on the expected product lifetime of 25 years and estimated annual sales in 2000 (25 years prior to 2025). For replacement sales, the team assumed that all dual-flush toilets are replaced with dual-flush toilets, without switching to single-flush models.

Table 12 presents the estimated annual sales and stock of residential dual-flush water closets from 2025 through 2049. The estimates are based on an average of 0.867 residential water closets per capita, a growth in the percentage of residential dual-flush water closets in California from 0 percent in 2000 to 19 percent in 2049, and an increase in California population from 33.87 million in 2000 to 44.01 million in 2049. Note that some reports show that California's population is currently declining. Assuming an increase in California population using the projections of California Department of Finance is not a conservative assumption. This non-conservative assumption is countered by the fact that the presented analysis does not include potential water savings from light commercial applications for the proposed measure.

The estimate for the number of residential toilets per capita (0.867) is based on the data gathered by GMP Research (GMP Research Inc., 2022). This study estimates the stock of residential water closets in California, including single-flush and dual-flush, to be approximately 33.887 million units, or 93 percent of total installed base of tank-type toilets. For comparison, the study estimates the stock of commercial tank-type toilets to be approximately 2.584 million units, or seven percent of total installed base of tank-type toilets. The number of residential toilets per capita (0.867) is derived by dividing 2022 stock of California residential toilets by the 2022 California population of 39.08 million (as reported by State of California Department of Finance).

Table 12: California Annual Sales and Stock of Residential Dual-Flush Water Closets (2025-2049)

Year	Annual Sales (million)	Stock (million)
2025	0.27	3.43
2026	0.27	3.59
2027	0.28	3.74
2028	0.28	3.90
2029	0.28	4.06
2030	0.29	4.22
2031	0.29	4.38
2032	0.29	4.54
2033	0.29	4.71
2034	0.30	4.87
2035	0.30	5.03
2036	0.30	5.19
2037	0.30	5.35
2038	0.30	5.51
2039	0.31	5.67
2040	0.30	5.83
2041	0.31	5.99
2042	0.30	6.15
2043	0.30	6.31
2044	0.28	6.47
2045	0.27	6.63
2046	0.27	6.78
2047	0.28	6.94
2048	0.42	7.10
2049	0.31	7.25

Source: The CASE Team analysis 2023.

8.2 Statewide Water and Energy Savings – Methodology

This section describes the methodology for estimating the statewide water and energy savings associated with the proposed standards. Statewide savings estimates were calculated by multiplying the per unit water and energy savings by the statewide estimates of annual sales and stock forecast. When calculating statewide impacts, it was assumed that the percentage of dual-flush water closets sold each year that meet the proposed standards would increase from 25 percent in 2023 to 50 percent of total residential dual-flush toilet annual sales in 2049, even without adoption of the proposed standards into Title 20.

Table 13 presents the assumptions for calculating the statewide water and energy savings.

Table 13: Key Assumptions for Calculating Statewide Water and Embedded Energy Savings

Metric	Value	Sources and Notes
2025 California population	40.81 million	California Department of Finance, Demographic Research Unit https://dof.ca.gov/Forecasting/Demographics/projections/
2049 California population	44.01 million	California Department of Finance, Demographic Research Unit https://dof.ca.gov/Forecasting/Demographics/projections/
Growth rate for residential dual-flush toilet stock	Linear increase of residential dual-flush toilet stock from 0% in 2000 to 19% of total residential toilets in 2049	• Assumed the stock of dual-flush toilets was zero in 2000 since this is approximately when dual-flush toilets were introduced in California. • Assumed that the stock of residential dual-flush toilets increases linearly from zero in year 2000 to 19% of total residential toilet stock in California in year 2049. The team assumed 19% based on the market share of dual-flush toilets in 2022 annual sales as reported by GMP Research. Please refer to Table 4 for more details. The CASE Team does not anticipate the stock of dual-flush toilets growing beyond 19% of total stock of residential toilets installed in California. Informal communications with two large plumbing manufacturers in March 2023 support this forecast. • The CASE Team applied the assumed growth rate of dual-flush toilet stock for non-standards and standards case.
Naturally occurring adoption rate	Linear increase of annual sales of qualifying products from 25% in 2023 to 50% of total residential dual-flush toilet annual sales in 2049	This assumption has a high level of uncertainty. Justification for this best estimate: • Informal communications with four large plumbing manufacturers in March and summer 2023. • Recently WaterSense staff signaled the intent to revise its specification for dual-flush toilets to limit a maximum full flush volume to 1.28 gpf. This potential revision will be a market driver to shift product offering towards qualifying products.

8.3 Statewide Water and Energy Use – Non-Standards and Standards Case

Table 14 and Table 15 present the statewide annual water and energy use associated with residential dual-flush water closets if the proposed standards are not adopted (i.e., non-standards case) and if the proposed standards are adopted (i.e., standards case), respectively.

The annual sale values in Table 14 and Table 15 represent the water or energy use associated with products sold during a given year. The replaced stock values represent the water or energy use associated with all products that are installed and operational during a given year and that are part of the replaced stock.

Table 14: California Statewide Water and Energy Use – Non-Standards Case for Dual-Flush Water Closets (after Effective Date)

	Annual Sales		Replaced Stock	
Year	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**	**Water Use (million gal /yr)**	**Embedded Electricity Use (GWh/yr)**
2025	705	3.83	705	3.83
2049	772	4.20	18,780	102.2

Source: The CASE Team analysis 2023.

Table 15: California Statewide Water and Energy Use – Standards Case for Dual-Flush Water Closets (after Effective Date)

	Annual Sales		Replaced Stock	
Year	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**
2025	601	3.27	601	3.27
2049	691	3.76	16,410	89.3

Source: The CASE Team analysis 2023.

8.4 Statewide Water and Energy Savings for Standards Case

Table 16 presents the statewide annual water and energy savings if the proposed standards are adopted. The stock values represent the water or energy savings associated with all products that are installed and operational during a given year and that are part of the replaced stock. The statewide savings from tank-type dual-flush toilets in the light commercial applications are not included in this analysis.

The CASE Team estimates that during the first year of the proposed standards being in effect (2025), they will result in the annual water savings of 104 million gallons and an annual embedded electricity savings of 0.56 GWh. After full stock turnover (2049), the projected annual savings are 2,370 million gallons of water and 12.9 GWh from reduced embedded electricity use.

Table 16: California Statewide Water and Energy Savings – Standards Case for Dual-Flush Water Closets (after Effective Date)

	Annual Sales		Replaced Stock	
Year	Water Savings (million gal/yr)	Embedded Electricity Savings (GWh/yr)	Water Savings (million gal/yr)	Embedded Electricity Savings (GWh/yr)
2025	104	0.56	104	0.56
2049	81	0.44	2,370	12.9

Source: The CASE Team analysis 2023.

8.5 Impact on California's Economy

The CASE Team considered only the residential application when calculating lifecycle benefits. The Statewide CASE Team predicts that lifecycle benefits for first-year sales will equal or exceed $35 million and that cumulative lifecycle savings will reach $840 million once the stock completely turns over in 2050 as summarized in Table 17. These estimates are based on the calculated volume of water savings multiplied by the volumetric water/sewer rates forecasted for 2025 to 2049. Please refer to Table 23 for details on the forecasted water/sewer rates.

Table 17: Statewide Total Lifecycle Costs and Benefits for Standards Case

	Measure Lifecycle Cost for First-Year Annual Sales (2023 PV $)	Measure Lifecycle Benefit for First-Year Annual Sales (million 2023 PV $)	Net Present Value for First-Year Sales (million 2023 PV $)	Net Present Value for Cumulative Annual Sales through Stock Turnover (million 2023 PV $)
Tank-type dual-flush water closets	$0	$35.1	$35.1	$840.2

Source: The CASE Team analysis 2023.

Notes:

The analysis does not include cost savings associated with embedded energy savings.

Net Present Value = Total Benefit – Incremental Cost

Stock turnover net present value (NPV) is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year (i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable). For example, for a standard effective in 2015 applying to a product with a 5-year design life, the NPV of the products purchased in the 5th year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

8.6 Environmental and Societal Impacts

More efficient dual-flush water closets will benefit homeowners by reducing their water bills. Most costs associated with building and operating a water and wastewater system are fixed. Therefore, the overall water agency costs should remain relatively constant even if using dual-flush water closets decreases the volume of water treated and distributed daily. Significant reductions in municipal water demands (and sales) may increase water rates; however, the magnitude of the water savings associated with this proposal is unlikely to lead directly to increased water rates.

This proposal is unlikely to have significant impact on the wastewater conveyance and treatment system infrastructure. However, the water industry is generally concerned about potential adverse impacts on the public water and wastewater conveyance and treatment systems from reduced water demands and flush volumes. A 2017 study (CASA, WRF, WateReuse California, CWEA, CUWA, 2017) of those impacts was sponsored and conducted by five major partnering organizations in California:

- California Association of Sanitation Agencies (CASA),
- Water Research Foundation (WRF),
- WateReuse California,
- California Water Environment Association (CWEA), and
- California Water Urban Agencies (CUWA).

The study aimed to provide decision-makers, water and wastewater system managers, and other stakeholders an understanding of the impacts of declining flows resulting from substantial reductions in indoor water use. The four main impact areas covered include:

- Impacts on water distribution systems: With declining water system flows, drinking water has a longer residence time in pipes, leading to chemical, biological, and physical water quality issues and potentially compromising public health and compliance with the Safe Drinking Water Act, particularly for disinfection by-products, coliform bacteria, chlorine residual, and lead and copper action levels.
- Impacts on wastewater conveyance: Declining system flows decrease wastewater flows and may increase pollutant and solids concentrations, leading to blockages, odors, and corrosion in pipes. This decline leads to more operation and maintenance costs, odor complaints, and accelerated infrastructure degradation.
- Impacts on wastewater treatment plant operation: Declining flows change the wastewater characteristics, including the quantity and quality of wastewater treatment plant influent. These changes cause impacts that stress the treatment processes as salinity, ammonia, and biochemical oxygen demand concentrations increase beyond design specifications. Many operators face challenges in meeting compliance requirements concerning effluent quality.
- Impacts on recycled water projects: As indoor residential water use decreases, the availability of treated wastewater for water reuse decreases, thus reducing production potential.

9. Implementation Plan

The CASE Team does not anticipate any unusual steps to implement the proposal. The team also encourages the decision-makers to pursue the other two components of the comprehensive approach detailed in Section 4.

10. Other Legislative and Regulatory Considerations

10.1 Federal Legislative and Regulatory Background

In the 1980s, most water closets in the United States used 3.5 gpf or more. Individual states, including California, in the early 1990s, began to adopt maximum flush volume thresholds for water closets. The federal government enacted the Energy Policy Act of 1992 (EPAct92) to reduce water demands and achieve requirement uniformity across the country. With a few exceptions, this legislation required a no greater than 1.6 gpf for all water closets sold in the United States by 1994. These 1.6 gpf models were called ultra-low flush toilets.

The United States Department of Energy (DOE) regulates water closets in 10 CFR 430.32(q), setting the maximum flush volume at 1.6 gpf for all water closets except for blowout toilets. The DOE regulation contains no additional language or requirements for dual-flush models.

In December 2010, the DOE officially waived federal preemption for energy conservation standards for any state regulation concerning the water use or water efficiency of faucets, showerheads, water closets, and urinals (75 Fed. Reg.245, 22 December 2010). This waiver allows states to set standards for the relevant plumbing products if the state standard is more stringent than the federal standard.

10.2 California Legislative and Regulatory Background

In 1977, California was the first state to legislate a maximum of 3.5 gpf for all water closets in new residential construction. The law went into effect on January 1, 1980, and was amended a few years later to apply to all commercial and residential water closets for sale or installation.

Effective January 1, 1992, all new buildings, additions, and renovations of existing buildings (where substantial modification of the existing plumbing system is necessary) constructed in California must install toilets and associated flushometer valves using no more than 1.6 gpf. These plumbing devices were required to meet ANSI performance standards (ANSI ASME, 2018). Blowout water closets were exempted and remained at 3.5 gpf (California Assembly Bill 2355 (1989) (Filante) amended California Health and Safety Code, Section 17921.3).

Effective January 1, 1994, all water closets sold or installed in California had to use no more than an average of 1.6 gpf. Exemptions remained for blowout water closets and other miscellaneous situations (California Senate Bill 1224 (1992) (Killea) amended California Health and Safety Code, Section 17921.3).

In 2007, Governor Arnold Schwarzenegger signed Assembly Bill 715 into law (California Assembly Bill 715 (2007) (Laird), affecting Title 20, Section 1605.3). Beginning January 1, 2014, Assembly Bill 715 required all water closets sold or installed in the state to use no more than 1.28 gpf for single-flush models and no more than an average of 1.28 gpf for dual-flush models based on two reduced flushes for every full flush (flush ratio of 2:1). The extended lead time for the effective date allowed manufacturers, distributors, and retailers to ramp up deliveries of 1.28 gpf models to California.

In 2010, mandatory toilet standards were introduced to CALGreen (California Building Standards Commission, 2022). The 2013 CALGreen standards, which took effect in January 2014, included requirements that newly constructed residential buildings install toilets meeting a minimum efficiency level of 1.28 gpf, consistent with AB 715 (CALGreen 2013a).

In 2015, the CEC adopted its current Title 20 standard for dual-flush water closets to conform with AB 715, setting an effective flush volume of 1.28 gpf. The effective flush volume is defined based on a 2:1 ratio of reduced to full flush use, resulting in compliant models using a maximum of 1.6 gpf for full flush and 1.1 gpf for reduced flush.

California Plumbing Code (Title 24, Part 5) contains water efficiency standards for water closets consistent with AB 715 levels.

10.3 International Regulatory Background

In response to water shortages, other countries adopted mandatory performance standards related to the performance of dual-flush water closets. This section provides an overview of requirements in Australia, Singapore, and the United Kingdom.

10.3.1 Australia

The 2019 Plumbing Code of Australia (provision B1.2 Sanitary flushing) mandates dual-flush water closets with a minimum 3-star Water Efficiency Labelling and Standards (WELS) rating or a maximum of 1.72 gpf for full flush and 0.92 gpf for reduced flush (Australian Building Codes Board, 2019).

Table 18 summarizes Australian WELS ratings for dual-flush water closets codified in AS/NZS 6400:2016 (Australian/New Zealand Standard, 2016).

Table 18: Australian WELS Performance Standards for Dual-Flush Water Closets

WELS Rating	Full Flush Max (liters per flush)	Full Flush Max (gpf)	Half Flush Max (liters per flush)	Half Flush Max (gpf)
1 Star	9.5	2.51	4.5	1.19
2 Star	9.5	2.51	4.5	1.19
3 Star	6.5	1.72	3.5	0.92
4 Star	4.7	1.24	3.2	0.85
5 Star	4.7	1.24	Not defined	Not defined
6 Star	4.7	1.24	Not defined	Not defined

Source: AS/NZS 6400:2016, Section 6.4 Water Consumption and Rating, Table 6.1 Water Rating Table.

In addition to national requirements, Queensland Development Code requires the installation of dual-flush toilets with a 4-star WELS rating in residential new construction, i.e., 1.24 gpf for full flush and 0.85 gpf for reduced flush (Australian Government, Queensland, 2020).

Furthermore, New South Wales, Australia, adopted a requirement for dual-flush toilets in rented dwellings. Beginning in March 2025, landlords wanting to pass water charges on to tenants must install dual-flush toilets with a minimum 3-star WELS rating in their rental properties; the onus to install a 3-star or better toilet is on the landlord (Australian Government, New South Wales, 2019).

10.3.2 Singapore

Singapore is exceptionally water-stressed due to the lack of natural water resources and limited land water storage facilities and is dependent on rainfall (Singapore Public Utilities Board, 2016). Singapore has aggressively regulated water use in plumbing fixtures and has required a mandatory water efficiency labeling scheme (Mandatory WELS) since 2009 (Singapore Public Utilities Board, 2022). That same year, Singapore set minimum water efficiency standards to complement the labels (Singapore Public Utilities Board, 2021). Table 19 summarizes Mandatory WELS requirements for dual-flush water closets and water closet flush valves.

Table 19: Mandatory WELS Requirements for Dual-Flush Water Closets and Flush Valves

Product	**2-tick Rating (gpf)**	**3-tick Rating (gpf)**
Dual-flush cisterns	>0.92 and up to 1.06 (full flush) > 0.66 and up to 0.79 (reduced flush)	0.92 or less (full flush) 0.66 or less (reduced flush)
Water closet flush valves (effective January 1, 2022)	>0.92 and up to 1.06	0.92 or less

Notes:

From April 1, 2019, only 2-ticks and above fittings are allowed for sale and installation.

From January 1, 2022, Mandatory WELS shall be extended to include water closet flush valves with a flush volume of not more than 4.0 liters (1.06 gal) per flush, and only water closet flush valves of 2-tick ratings or more shall be allowed for sale.

From January 1, 2023, water closet flush valves installed at premises shall be of minimum 2-ticks or more under the Mandatory WELS.

The current requirements for a 2-tick water closet (as defined by Mandatory WELS) include a maximum of 1.06 gpf for a full flush and 0.79 gpf for a reduced flush. For a 3-tick dual-flush, a maximum is 0.92 gpf for a full flush and 0.66 gpf for a reduced flush.

10.3.3 The United Kingdom

The United Kingdom last updated its maximum flush volumes in The Water Supply (Water Fittings) Regulations 1999 (The United Kingdom Legislation, 1999). The UK Statutory Instruments of 1999 Section 1148, Schedule 2: “WC's, flushing devices and urinal,” states:

> (d) no flushing device installed for use with a WC pan shall give a single flush exceeding 6 litres;
>
> (e) no flushing device designed to give flushes of different volumes shall have a lesser flush exceeding two-thirds of the largest flush volume;

These standards equate to a maximum full flush volume of 1.59 gpf and a maximum reduced flush of 1.06 gpf for dual-flush water closets.

10.4 Model Codes and Voluntary Standards

Caroma introduced the dual-flush water closet to the California marketplace in late 1999, followed quickly by other manufacturers. Work began in 2000 on a national product standard directed at water closets with an inside dual flushing device. The draft ASME A112.19.14 standard (ANSI ASME, 2000) included a 1.1 gpf limitation on the reduced flush volume. The standard also required all dual-flush water closets to comply with the provisions of the primary ASME (ANSI ASME, 2018) product standard in effect at that time. The most current version of the ASME A112.19.14 standard reaffirmed in 2018 – ASME A112.19.14-2013 (R2018) – still sets a maximum of 1.1 gpf for a reduced flush.

As dual-flush water closet models entered the marketplace, new product development began to improve single-flush models. As early as 2000, the water efficiency community evaluated models with flush volumes as low as 1.0 gpf. With the USGBC's LEED Program encouraging a 20 percent water use reduction using plumbing fixtures, the plumbing industry introduced the first high-efficiency water closets flushing at 1.28 gpf or less. By 2006, WaterSense program allowed manufacturers to label and market high-efficiency water closets.

Currently, the voluntary WaterSense program specification sets the maximum flush volumes for tank-type gravity water closets as follows (EPA WaterSense®, 2014):

- Single-flush water closets at 1.28 gpf and
- Dual-flush water closets at 1.6 gpf full flush and 1.1 gpf reduced flush.

In June 2023, WaterSense released a Notice of Intent (NOI) (EPA WaterSense®, 2023a) proposing to limit the maximum full flush volume for dual-flush water closets to 1.28 gpf in their specification. The NOI does not contain a proposal to limit a reduced flush volume.

In ASHRAE/ICC/USGBC/IEC 189.1-2020 – Standard for the Design of High-Performance Green Buildings and in 2021 IgCC, the limit for the full flush volume for dual-flush toilets is set to 1.28 gpf (ASHRAE ICC USGBC IEC, 2020) (International Code Council, 2021).

11. Proposed Revisions to Code Language

The proposed changes to the existing Title 20 standards are provided below. Changes to the standards are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

Section 1601. Scope.

This Article applies to the following types of new appliances, if they are sold or offered for sale in California, except those sold wholesale in California for final retail sale outside the state and those designed and sold exclusively for use in recreational vehicles, or other mobile equipment. Unless otherwise specified, each provision applies only to units manufactured on or after the effective date of the provision.

…

(i) Plumbing fixtures, which are water closets and urinals.

Section 1602. Definitions.

…

(i) Plumbing Fixtures.

“Blowout ~~toilet~~ water closet” means a water closet that uses a non-siphonic bowl with an integral flushing rim, a trap at the rear of the bowl, and a visible or concealed jet that operates with a blowout action.

“Dual-flush effective flush volume” means the average flush volume of two reduced flushes and one full flush.

“Dual-flush water closet” is a water closet incorporating a feature that allows the user to flush the water closet with either a reduced or a full volume of water.

“Electromechanical hydraulic water closet” means a water closet that utilizes electrically operated devices, such as, but not limited to, air compressors, pumps, solenoids, motors, or macerators in place of or to aid gravity in evacuating waste from the toilet bowl. An electromechanical hydraulic water closet is commonly known as a power-assist water closet.

“Flushometer tank” means a ~~flushometer~~ valve that is integrated within an accumulator vessel affixed and adjacent to a plumbing fixture inlet so as to cause an effective enlargement of the supply line immediately before the fixture.

“Flushometer tank water closet” means a water closet utilizing a flushometer tank. A flushometer tank water closet is commonly known as a pressure-assist water closet.

“Flushometer valve” means a valve that is attached to a pressurized water supply pipe and that is designed so that when actuated it opens the line for direct flow into the fixture at a rate and predetermined quantity to properly operate the fixture, and then gradually closes in order to provide trap reseal in the fixture and to avoid water hammer. The pipe to which the device is connected is, in itself, of sufficient size that when open shall allow the device to deliver water at a sufficient rate of flow for flushing purposes.

“Flushometer valve water closet” means a water closet utilizing a flushometer valve.

“Gallons per flush (gpf)” means gallons per flush as determined using the applicable test method in section 1604(i) of this Article.

“Gravity tank-type water closet” means a water closet that includes a storage tank from which water flows into the bowl by gravity.

"Plumbing fixture" means an exchangeable device, which connects to a plumbing system to deliver and drain away water and waste. A plumbing fixture includes a water closet or a urinal.

…

"Prison-type water closet" means a water closet designed and marketed expressly for use in prison-type institutions.

…

"Vacuum-type water closet" means a water closet whose bowl is evacuated by the application of a vacuum. A vacuum-type water closet is commonly known as a vacuum-assist water closet.

"Water closet" means a plumbing fixture having a water-containing receptor that receives liquid and solid body waste through an exposed integral trap into a gravity drainage system.

"Water use" means the quantity of water flowing through a water closet or urinal at point of use, determined in accordance with test procedures under Appendix T of subpart B of 10 C.F.R. part 430.

…

Section 1604. Test Methods for Specific Appliances.

…

(i) Plumbing Fixtures.

The test methods for plumbing fixtures are:

(1) Water Closets. The test method for testing gallons per flush of water closets is 10 C.F.R. Section 430.23(u) (Appendix T to subpart B of part 430). See section 1604(i)(3) of this Article for the required waste extraction test.

…

(3) Waste Extraction Test for Water Closets. The waste extraction test for water closets is Section ~~7.10 of ASME A112.19.2/CSA B45.1-2013~~ 7.9 of ASME A112.19.2/CSA B45.1-2018.

Section 1605.3. State Standards for Non-Federally Regulated Appliances.

…

(i) Plumbing Fixtures.

(1) The water consumption of water closets and urinals sold or offered for sale on or after January 1, 2016, other than those designed and marketed exclusively for use at prisons or mental health care facilities, shall be not greater than the values shown in Table I.

Table I

Standards for Plumbing Fixtures

Appliance	***Maximum Gallons per Flush or Dual-flush effective flush volume***
	Sold or Offered for Sale On or After January 1, 2016 [1]
All water closets	1.28
Trough-Type Urinals	Trough length (inches)
	16
Wall-Mounted Urinals	0.125
Other Urinals	0.5

[1] For the items identified in Table I, noncompliant products may not be sold or offered for sale on or after the designated date, regardless of manufacture date.

(2) Water closets sold or offered for sale on or after January 1, 2016, shall pass the Waste Extraction Test (Section ~~7.10) of ASME A112.19.2/CSA B45.1-2013~~ 7.9) of ASME A112.19.2/CSA B45.1-2018.

(3) The water consumption of dual-flush water closets manufactured on or after January 1, 2025, shall not be greater than 1.28 gallons per flush for a full flush and 0.9 gallons per flush for a reduced flush.

EXCEPTION to section 1605.3(i)(3) of this Article:

Section 1605.3(i)(3) does not apply to dual-flush flushometer valve water closets and dual-flush blowout water closets, which must continue to comply with sections 1605.3(i)(1).

…

Section 1606. Filing by Manufacturers; Listing of Appliances in the MAEDbS.

…

Data Submittal Requirements

	Appliance	Required Information	Permissible Answers
I	Plumbing Fixtures	*Type	Blowout water closet, gravity tank type water closet, dual-~~duel~~-flush water closet, electromechanical hydraulic water closet, flushometer tank water closet, prison-type urinal, prison-type water closet, flushometer valve water closet, trough-type urinal, wall-mounted urinal, waterless urinal, other type urinal, vacuum type water closet
		Water Consumption (dual-flush effective volume for dual-flush water closets manufactured before January 1, 2025) (full flush in gpf and reduced flush in gpf for dual-flush water closets manufactured on or after January 1, 2025)	
		Passes waste extraction test	True, False
		~~Waste extraction value~~	~~grams~~

Section 1607. Marking of Appliances.

…

(b) Name, Model Number, and Date.

Except as provided in section 1607(c) of this Article, the following information shall be permanently, legibly, and conspicuously displayed on an accessible place on each unit;

(1) manufacturer's name or brand name or trademark (which shall be either the name, brand, or trademark of the listed manufacturer specified pursuant to section 1606(a)(2)(A) of this Article;

(2) model number; and

(3) date of manufacture, indicating (i) year and (ii) month or smaller (e.g. week) increment. If the date is in a code that is not readily understandable to the layperson, the manufacturer shall immediately, on request, provide the code to the Energy Commission.

(c) Exceptions to Section 1607(b).

(1) For plumbing fixtures and plumbing fittings, the information required by section 1607(b) of this Article shall be permanently, legibly, and conspicuously displayed on an accessible place on each unit or on the unit's packaging.

12. Response to Request for Information

This section is in the question-and-answer format and presents the 22 questions reprinted without modifications from the Request for Information that the CEC docketed on December 14, 2022, to Docket 22-AAER-05 (California Energy Commission, 2022). The answers are from the CASE Team.

1) Based on Table 1, are there additional examples that should be considered in scope or out-of-scope? Based on what factors?

Table 1: Scope

Appliance	Classifications
Water Closets	• Gravity tank-type water closets o Single-flush water closets o Dual-flush water closets

Source: California Energy Commission

Only dual-flush water closets, excluding water closets with a flushometer valve, should be in scope. Please refer to Section 4, Section 5 and Section 5.2 for more details.

2) Is it necessary to update existing terms and definitions for water closets for added clarification or to align with existing terminology from other entities? For example, should the definition of water closets as defined in Section 1602, CCR, Title 20, align with the federal definition of water closets as defined in section 420.2, Code of Federal Regulations, Title 10?

Please refer to Section 4.2.1 for the proposed changes to definitions.

3) Are there additional terms that should be considered and defined in section 1602, CCR, Title 20 for water closets to cover new features in the current market or for added clarification?

Please refer to Section 4.2.1 for the proposed changes to definitions.

4) Are there new efficient technologies available on the market? Are there new upcoming developments?

The CASE Team is unaware of any specific new efficient technologies or developments.

Water closet designs have generally improved over the last 25 years. As such, current models can significantly outperform earlier models in flushing performance and water efficiency.

5) Are there new technologies or features available on the market that extend the lifetime of the product or that allows for less maintenance during the lifetime of the product?

The CASE Team is unaware of recent developments in technologies or features. The improvements made in the 1990s to the durability of the flush valve seal (e.g., flapper) were primarily due to research that improved elastomer chemistry. Metropolitan Water District of Southern California sponsored this research to correct water closet flapper leakage. The team expects no further changes to extend the gravity tank-type water closet's average lifetime beyond the nominal 25 years.

6) Have design improvements been made to reduce toilet leaks? If so, can any of these design improvements be included in amended performance standards for gravity tank-type water closets?

There are at least two aftermarket fill valves developed to prevent toilet leakage in gravity tank-type water closets with a flush handle. This type of device shuts down tank refill when a flapper develops a leak. The requirement to pre-install this type of device on new gravity tank-type toilets being sold in California should be evaluated for suitability as a Title 20 standard.

The CASE Team is unaware of any other design improvements for gravity tank-type water closets suitable for inclusion in the performance standards.

The two main types of toilet leakage are the flush valve (flapper) and the over-filling of the toilet tank. Although improvements to the toilet have reduced these leaks, leaking flappers and over-filling tanks may be problematic for older, legacy toilets, i.e., toilets flushing with 1.6 gpf or more. As with any product with moving parts, especially valves in a wet system, water closet maintenance and repair are required.

Flapper Leakage

In the early 1990s, many consumers began experiencing problems with flapper degradation, even in relatively new toilets. The water closet manufacturers attributed the flapper leakage to the trend of consumers using certain chemically based in-tank bowl cleaners. Consumers previously used in-bowl cleaners hanging from the bowl's side to dispense chemical(s) directly into the flushing toilet. The new trend began with chemical manufacturers successfully marketing an in-tank drop-in tablet that slowly dissolved in the tank water. Consumers dropped the tablet in the tank and were no longer required to touch the bowl. The chlorine dissolved in the tank water degraded the flappers more quickly than the prior method.

Since then, issues with leaking flappers have significantly improved. In 2004, a study by a collaboration of California water providers under the direction of the California Urban Water Conservation Council (CUWCC) concluded that less than six percent of the aging water closets leaked through the flush valve seal (California Urban Water Conservation Council, 2004). The study attributed the low leakage rate to the improved flush valve seal materials and the reduced use of chlorine-based in-tank bowl cleaning tablets.

The current product standard for water closets (ASME A112.19.2/CSA B45.1-2018) requires flush valves to comply with ASME A112.19.5/CSA B125.12-2017 Flush Valves and Spuds for Water Closets, Urinals, and Tanks. ASME A112.19.5/CSA B125.12-2017 sets the performance standards on leakage for flush valve seals using an accelerated chemical resistance test procedure (first introduced into ASME A112.19.5 in 2005 standard version).

Over-filling Water Closet Tank Leakage

Historically, many non-flapper-based water closet leaks occurred because of float arm-type fill valves used in early water closet models. Increased water pressure in system mains during times of lower demand such as during nighttime caused those water closets to overfill and release water through the overflow tube into the bowl and then to drain. Residents were unaware of these leaks that only occurred in the predawn hours and were generally noiseless. The amendment to the ANSI product performance standard to eliminate float arm fill valves in favor of pilot valves resolved this issue (California Urban Water Conservation Council, 2004).

7) Are there any other technology-specific issues to consider?

When considering water efficiency targets, it is essential to consider water closets in the larger context of a building and its drainage system.

8) For dual-flush water closets, can design improvements be made to encourage end users to use the low-flush option more often?

Improving the ergonomic design of dual-flush push buttons may increase the acceptance of dual-flush water closets. Some dual-flush water closet models have a traditional style flush handle that the user may lift or depress to select a full or reduced flush. Many models use two push buttons instead of a flush handle, making activating a flush difficult to operate for children, the elderly, the infirm, or those with large hands or longer fingernails.

About a half of all dual-flush gravity models use a wash-down design; the volume of water visible in the toilet bowl is less, and the area of the water surface or water spot is small. This design leads to waste scarring on the sides of the bowl more frequently than a toilet with a large water spot (siphonic bowl design), requiring undesirable bowl cleaning with a brush.

9) Are there any sanitation issues or plumbing issues with existing water closets? If so, what are they? Do those issues vary in residential settings versus commercial settings?

No known sanitation issues (with premise plumbing pathogens) are associated with existing water closets. There are plumbing issues with existing water closets. See the response to Question 10 below.

10) Do low-flush toilets and low-flow appliances contribute to drain line blockages? Are blockages of particular concern for commercial applications where the slope of the drain line may be low? Are drain line blockages currently a significant issue in California? What remedies are available for people or businesses experiencing drain line blockages?

Water closets and appliances have experienced sizeable reductions in water use over the past 40 years. The table below, extracted and reproduced from the original PERC study (Plumbing Efficiency Research Coalition, 2012) and updated by John Koeller and Pete DeMarco in 2023, displays the magnitude of these reductions. As noted in the 2017 report from the wastewater and water industry associations (CASA, WRF, WateReuse California, CWEA, CUWA, 2017), these combined reductions have significantly impacted building and municipal infrastructure.

Water Consumption by Water-Using Plumbing Products and Appliances (1980 to 2023)

Water-using Fixture or Appliance	1980s Water Use (typical)	1990 Requirement (maximum)	EPAct 1992 Maximum	Baseline Model Plumbing Codes (maximum)	Green Code Maximums (Calgreen)	% Redution in typical water use since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.2 gpm	66%
Kitchen Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.8 gpm*	49%
Showerhead	3.5+ gpm	3.5 gpm	2.5 gpm	2.5 gpm	1.8 gpm	49%
Residential ("private") Toilet	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	74%
Commercial ("public") Toilet	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	74%
Urinal	1.5 to 3.0+ gpf	1.5 to 3.0+ gpf	1.0 gpf	1.0 gpf	0.125 gpf	96%
Commercial Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	0.5 gpm	0.5 gpm	86%
Food Service Pre-Rinse Spray Valve	5.0+ gpm	No requirement	1.6 gpm *(EPAct 2005)*	No requirement	1.28 gpm	74%
Residential Clothes Washing Machine	51 gallons per load	No requirement	26 gallons per load *(2012 std)*	No requirement	14 gallons per load *(Energy Star)*	73%
Residential Dishwasher	14 gallons per cycle	No requirement	6.5 gallons per cycle *(2012 std)*	No requirement	3.5 gallons per cycle *(Energy Star)*	75%

***Kitchen faucets may have a manual override that temporarily increases flow to 2.2 gpm max, and must default back to 1.8 gpm when the manual override is released.**

Source: Modified from The Drainline Transport of Solid Wastes Buildings, by the Plumbing Efficiency Research Coalition (PERC), 2012. Chart updated by John Koeller and Peter DeMarco, 2018 and 2023.

The reduction in the flush volume for water closets, appliances, and other plumbing fixtures listed above negatively impacts building drain lines, as decreased water use can lead to line blockages. Residential drain lines may also have blockages caused by improperly installed drain piping, degraded installation in older buildings (line dips and sags), foreign objects deposited in the bowl by a user, tree root incursion, disposal of fats, oils, and grease, and other factors. Installing highly efficient water closets in new construction will likely not cause these obstructions; but the same installation may create blockages in older buildings.

However, the collective reduction effects on municipal infrastructure are a greater concern. Section 8.6 of this report summarizes a study sponsored by five stakeholder organizations associated with water and wastewater infrastructure in California (CASA, WRF, WateReuse California, CWEA, CUWA, 2017). The report identifies the impact of the reduction in liquid flows on sewage systems and wastewater treatment facilities.

A remedy is to reevaluate the current standards in new construction for drain line diameters and slopes, wastewater conveyance and treatment in light of the reduced flows. Continuing education on household materials that should not be flushed through the water closet or discharged down the drain is also recommended.

11) Are there other regulatory or voluntary approaches available? Please include references to publicly available sources.

Rebate programs for purchasing and installing efficient water closets exist throughout California. The programs, funded and administered by water providers, are designed to incentivize consumers to replace old non-efficient (legacy) water closets with the latest high-efficiency products.

12) Is there current research or advancements in standards for water closets?

The current product standard for water closets, ASME A112.19.2/CSA B45.1-2018, is not undergoing any proposed changes due to advancements designed to reduce flush volumes. See Section 4.2.2 for more details.

13) What is the market share of each identified classification in Table 1?

Table 1: Scope

Appliance	Classifications
Water Closets	• Gravity tank-type water closets ◦ Single-flush water closets ◦ Dual-flush water closets

Source: California Energy Commission

Table 4 of the report presents the best available and most relevant market share data.

14) What is the market share of gravity tank-type water closets based on flush volume?

Table 20 summarizes the best available data from GMP Research 2022 market penetration study on the distribution of installed residential water closets in California based on flush volumes. The CASE Team does not have market share data based on flush volume for the gravity tank-type water closet stock installed in light commercial applications. The team is unaware of readily available data on gravity tank-type water closet annual sales based on flush volume.

Table 20: Distribution of Installed Residential Water Closets in California Based on Flush Volumes (millions of installed water closets)

Region of California	3.5 gpf or more	1.6 gpf	1.28 gpf or less	Total
Northern California	0.211 (5%)	2.828 (72%)	0.886 (23%)	3.925 (100%)
San Francisco Bay Area	0.360 (6%)	3.993 (71%)	1.251 (22%)	5.604 (100%)
Central California	0.327 (6%)	3.708 (68%)	1.411 (26%)	5.446 (100%)
Los Angeles and Orange Counties	0.730 (6%)	8.674 (71%)	2.745 (23%)	12.149 (100%)
Southern California	0.455 (7%)	4.819 (71%)	1.489 (22%)	6.763 (100%)
Total	**2.083 (6%)**	**24.022 (71%)**	**7.782 (23%)**	**33.887 (100%)**

Source: (GMP Research Inc., 2022). The study was commissioned by PMI, and these results reproduced with the permission from PMI.

Notes:

Values may not add to 100 percent due to rounding.

Northern California: 4.1 million population. Includes: Butte, Colusa, Del Norte, El Dorado, Glenn, Humboldt, Lake, Lassen, Mendocino, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Sonoma, Sutter, Tehama, Trinity, Yolo, and Yuba counties.

San Francisco Bay Area: 6.3 million population. Includes: Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, and Solano counties.

Central California: 6.6 million population. Includes: Alpine, Amador, Calaveras, Fresno, Inyo, Kern, Kings, Madera, Mariposa, Merced, Mono, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Cruz, Stanislaus, Tulare, Tuolumne, and Ventura counties.

Los Angeles and Orange Counties: 13.0 million population. Includes: Los Angeles and Orange counties.

Southern California: 8.1 million population. Includes: Imperial, Riverside, San Bernardino, and San Diego counties.

15) What sources of information are available to estimate current and projected stock in California?

The 2022 GMP Research market penetration study funded by PMI provides current information on California water closet stock (GMP Research Inc., 2022). Please refer to Section 8 for more details.

16) What are the retail costs per unit or differences in costs among the various types of water closets listed in Table 1?

Table 1: Scope

Appliance	Classifications
Water Closets	• Gravity tank-type water closets o Single-flush water closets o Dual-flush water closets

Source: California Energy Commission

Please refer to Section 7 for information on per unit retail costs.

17) What are the installation costs? What are the repair costs versus replacement costs?

The CASE Team does not have data on typical installation cost for water closets charged by plumbers in California. Homeowners often choose to install new water closets without hiring a plumber.

Repair costs may be slightly higher for dual-flush water closets because the flushing mechanisms are more complex than those used in single-flush models. Replacement dual-flush parts are usually more expensive than the single-flush equivalent. Moreover, complicated mechanisms make dual-flush models more difficult for consumers to repair and adjust properly to achieve the design flush volumes.

18) Staff estimates the product lifetime of water closets is 25 years. Are there alternative assumptions for product lifetime that staff should consider and why? How do product lifetimes vary by product type? Please provide sources of information for those alternative assumptions.

The CASE Team used a 25-year lifetime for the gravity-tank water closet in the analysis presented in this report. See Section 7.2 for more details.

19) Which sources should be considered to estimate commercial water and electricity utility rates?

Commercial Water Utility Rates

The CASE Team compiled data on commercial, industrial, and institutional water utility rates for the 2025 CASE Report on nonresidential cooling towers; the summary of data can be found at https://title24stakeholders.com/measures/cycle-2025/cooling-towers/.

Black and Veatch published a high-level overview of water and wastewater rate data for the 50 largest U.S. cities in their publicly available report titled "2021 50 Largest Cities Water and Wastewater Report," available at https://www.bv.com/resources/2021-50-largest-cities-water-and-wastewater-report.

The California Department of Water Resources (DWR) compiles annual water loss audit data including customer retail unit cost (CRUC) reported by urban retail water utilities that serve more than 3,000 connections or supplying more than 3,000 acre-feet of water per year (California Department of Water Resources, 2023). The data is publicly available at https://wuedata.water.ca.gov/awwa_export. The CRUC reported to the DWR by a water utility generally represents a composite volumetric water rate paid by various customers classes within the service territory of the water utility. Residential, commercial, institutional, and industrial customer classes might be used to determine the CRUC (American Water Works Association, 2016). Disaggregating reported CRUC values to isolate commercial volumetric water rates is not feasible. Appendix D of a report that was published by the American Water Works Association (AWWA) in 2019 documented an assessment of the accuracy of reported CRUC based on the sample of 30 utilities in the state of Georgia, and found an overall error rate of 20 percent (American Water Works Association, 2019). Similar to California, water utilities in Georgia are using the AWWA Water Audit Software to report water loss data, including CRUC values. This type of assessment was not completed for California.

Commercial Electricity Utility Rates

The CASE Team supports local energy ordinance adoption and implementation of code enhancement initiatives. Electric utility rate schedules (CA IOU and Publicly Owned Utility rate tariffs) are compiled in an appendix of the 2022 Cost-effectiveness Studies, publicly available at https://localenergycodes.com/content/resources.

Senate Bill (SB) 695 (Kehoe, 2009) requires the CPUC to prepare an annual report addressing electric and gas cost and rate trends. This evaluation includes a review of historical cost and rate trends and a 10-year forecast. The 2021 evaluation report is publicly available at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf.

20) Do some manufacturers provide broad product offerings while others focus on specialty products?

Some gravity tank-type water closet manufacturers offer a wide range of toilet designs. For example, as of this report's writing, based on WaterSense listings, Toto produces 448 WaterSense certified water closet models, American Standard produces 350 water closet models, and Kohler produces 190 models for various types of applications. Other manufacturers offer only a few models. For example, Grohe only produces six different water closet models, mostly for the high-end market, and Hennessy & Hinchcliffe produces six different models, all rated at 0.8 gpf. Please refer to Table 3 for the list of major manufacturers of toilets (those manufacturers are major producers of single-flush and dual-flush toilets).

21) How many small businesses are involved in the manufacturing, sale, or installation of these products in California? And how might small businesses be affected by any changes to existing water closets?

The CASE Team does not have relevant insights into this question.

22) What are the potential impacts and benefits that proposed standards may have on low-income customers and disadvantaged communities?

The CASE Team anticipates some impacts, at least initially, on low-income customers from the proposal presented in this report given that the low-end price for a qualifying product is higher compared to the low-end price for a non-qualifying product at a major retailer. Please refer to Section 7.1 for more information on incremental cost and Section 7.3 for more information on the per unit benefits for the proposal presented in this report.

The GMP Research 2022 market penetration study also examined the installed plumbing fixtures and fittings in all SB535 disadvantaged low-income California communities, as shown in Table 21.

Table 21: Distribution of Installed Residential Water Closets in SB535 Disadvantaged Communities in California (thousands of installed water closets)

Region of California	3.5 gpf or more	1.6 gpf	1.28 gpf or less	Total
Northern California	12	145	39	196
San Francisco Bay Area	30	320	86	436
Central California	103	1,183	368	1,654
Los Angeles and Orange Counties	242	2,992	794	4,028
Southern California	82	802	215	1,099
Total	**469 (6%)**	**5,442 (73%)**	**1,502 (20%)**	**7,413 (100%)**

Source: (GMP Research Inc., 2022). The study was commissioned by PMI, and these results reproduced with the permission from PMI.

Notes:

Values may not add to 100 percent due to rounding.

Northern California: 4.1 million population. Includes: Butte, Colusa, Del Norte, El Dorado, Glenn, Humboldt, Lake, Lassen, Mendocino, Modoc, Napa, Nevada, Placer, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Sonoma, Sutter, Tehama, Trinity, Yolo, and Yuba counties.

San Francisco Bay Area: 6.3 million population. Includes: Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, and Solano counties.

Central California: 6.6 million population. Includes: Alpine, Amador, Calaveras, Fresno, Inyo, Kern, Kings, Madera, Mariposa, Merced, Mono, Monterey, San Benito, San Joaquin, San Luis Obispo, Santa Barbara, Santa Cruz, Stanislaus, Tulare, Tuolumne, and Ventura counties.

Los Angeles and Orange Counties: 13.0 million population. Includes: Los Angeles and Orange counties.

Southern California: 8.1 million population. Includes: Imperial, Riverside, San Bernardino, and San Diego counties.

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Appendix A: Residential Water and Sewer Rates

The data on residential volumetric (also referred to as usage-based) rates for potable water and sewer service for single family dwellings was compiled in August of 2023 for California's 20 largest retail water service providers and 25 corresponding sewer service providers. Main sewer service providers were identified within each service territory covered by the considered water service providers. In some areas, the same entity provides water and sewer services, and different entities provide these services in other areas. In areas with multiple sewer providers serving in a single water provider's territory, each sewer service provider treating at least 10 percent of the volume collected (in acre-feet) was included in a weighted-average calculation to determine the composite sewer rate, with a rate of $0 per one hundred cubic feet (HCF) applied to any non-volumetric rates. The total population served by the considered water service providers was about 14 million as reported in 2020 Urban Water Management Plans (California Department of Water Resources), or 36 percent of total 2020 California population. The total California population in 2020 was about 39.5 million (California Department of Finance). The population-weighted combined water and sewer volumetric rate is $12.47 per 1,000 gallons. Table 22 summarizes this data.

Table 22: 2023 Volumetric Water and Sewer Rates for Single Family Dwellings in California

		Single Family Volumetric Rates (in 2023 $)			
Retail Water Service Provider / Sewer Service Provider (if different) [a]	**Population Served by Water Service Provider [b]**	**Water Rate $/HCF [c, d]**	**Sewer Rate $/HCF [c, e]**	**Water + Sewer Rate $/HCF [c]**	**Water + Sewer Rate $/1,000 gal**
Los Angeles Department of Water and Power / LA Sanitation & Environment	4,041,284	$8.36	$5.80	$14.16	$18.93
City of San Diego	1,430,489	$6.22	$4.98	$11.19	$14.96
East Bay Municipal Utility District / two sewer service providers [f]	1,405,000	$6.32	$0.93	$7.25	$9.69
San Jose Water Company	997,817	$6.52	$0	$6.52	$8.72
San Francisco Public Utilities Commission	899,732	$11.47	$16.91	$28.38	$37.94
Eastern Municipal Water District	603,950	$3.75	$0	$3.75	$5.01
City of Fresno	550,217	$1.74	$0	$1.74	$2.33
City of Sacramento	510,931	$1.46	$0	$1.46	$1.95
City of Long Beach	472,217	$4.91	$0.39	$5.30	$7.09
Irvine Ranch Water District / two sewer service providers [g]	418,163	$2.52	$0	$2.52	$3.37
City of Anaheim	365,987	$3.86	$0	$3.86	$5.16
Alameda County Water District [e] / Union Sanitary District	356,823	$4.78	$0	$4.78	$6.39
City of Santa Ana	335,086	$2.41	$0	$2.41	$3.22
City of Riverside	310,554	$1.30	$0	$1.30	$1.74
California Water Service Company Bakersfield / City of Bakersfield	286,310	$1.92	$0	$1.92	$2.56
Golden State Water Company - Southwest / Los Angeles County Sanitation Districts	278,787	$4.54	$0	$4.54	$6.07
Helix Water District / four sewer service providers [h]	277,294	$6.14	$3.68	$9.82	$13.12
City of Modesto	270,974	$2.02	$0	$2.02	$2.70
Coachella Valley Water District	268,952	$0.99	$0	$0.99	$1.32
San Gabriel Valley Water Company / Los Angeles County Sanitation Districts	256,335	$4.17	$0	$4.17	$5.58
Total	14,336,902				
		Water Rate	**Sewer Rate**	**Water + Sewer Rate**	
Population-Weighted Rate ($/HCF)		$5.96	$3.37	$9.33	
Population-Weighted Rate ($/1,000 gal)		**$7.97**	**$4.50**	**$12.47**	

Source: Publicly available data compiled by Natural Resources Defense Council (NRDC) staff and the CASE Team and updated in August of 2023.

Notes:

[a] The CASE Team used the 2020 Urban Water Management Plans, Table 6-2 Retail to map sewer service providers for a given water service provider (source: https://wuedata.water.ca.gov/uwmp_export_2020.asp) and to calculate a weighted-average volumetric flow rate based on the volume collected (in acre-feet), where necessary.

[b] The CASE Team used 2020 Urban Water Management Plans, Table 3-1 Retail, for the "population served" data (source: https://wuedata.water.ca.gov/uwmp_export_2020.asp).

[c] HCF is one hundred cubic feet, or CCF, the unit of measure water and sewer service providers use; 1 HCF = 748 gal.

[d] Tier 1 water rate is listed in this table. The CASE Team used the tier 1 rate when tier 1 applied to at least, up to and including the first 8 HCF/month of water use. The team used the tier 2 rate when tier 1 covered less than the first 8 HCF/month of water use. Some water service provider have a uniform use rate for water. For context, California's average residential water use in 2022 was 86 gal per person per day (source: https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/conservation_reporting.html), equivalent to 2,614 gal per person per month or 3.5 HCF per month per person. Using 2.92 for the average household occupancy in California (source: https://www.census.gov/quickfacts/CA), monthly water use for a single family dwelling is 10 HCF/month.

[e] Volumetric sewer rate is listed as $0 in this table when a sewer service provider has a non-volumetric rate structure.

[f] Two sewer service providers include EBMUD Special District No. 1 ($1.55 per HCF) and Central Contra Costa Sanitary District (non-volumetric sewer rate). The volume-collected-weighted sewer rate for the two providers is $0.93 per HCF.

[g] Two sewer service providers include Irvine Ranch Water District and Orange County Sanitation District. Irvine Ranch Water District customers can save on sewer bills based on past water use; savings vary based on the customer. Given the rate structure, deriving savings in units of $/1,000 gal applicable to all customers within the service boundary is not feasible, so the assumed volumetric sewer rate is $0. Orange County Sanitation District has a non-volumetric sewer rate.

[h] Four sewer service providers include the City of La Mesa ($4.25 per HCF), the City of El Cajon ($6.51 per HCF), Lemon Grove Sanitation District (non-volumetric sewer rate), and San Diego County Sanitation District (non-volumetric sewer rate). The volume-collected-weighted sewer rate for the four providers is $3.68 per HCF.

Table 23 summarizes forecasted statewide average residential volumetric water and wastewater rates from 2025 to 2049 to assess the statewide lifecycle benefits of the measure over 25 years. Table 23 presents the forecasted rates based on the population-weighted water and sewer rates. The CASE Team made a simplifying assumption that the population-weighted rates for 20 water service providers and 25 sewer service providers are representative statewide. The team assumed these rates are appropriate for the code change proposal presented in this report, even though some of the qualifying dual-flush water closets installed in multifamily residential application and light commercial applications may be subject to rates different than those compiled for single family dwellings. The CASE Team forecasted 2025-2049 water and sewer rates by applying the following:

- Annual water rate increase of 3.2 percent for West-Pacific region based on the 2023 report prepared by the Pacific Northwest National Laboratory (PNNL) (U.S. DOE Office of Scientific and Technical Information, 2023),
- Annual sewer rate increase of 4.2 percent for West-Pacific region based on 2023 report prepared by the PNNL, and
- Annual discount rate of 3.0 percent based on the guidance in the Building Energy Efficiency Measure Proposal Template from the California Energy Commission for 2025 code cycle (California Energy Commission, 2023).

Table 23: Estimated Statewide Average Residential Volumetric Water and Sewer Rates 2025 – 2049

Year	Volumetric Water Rate (2023 $/1,000 gal)	Volumetric Sewer Rate (2023 $/1,000 gal)	Total Volumetric Water/Sewer Cost (2023 $/1,000 gal)
2025	$8.00	$4.61	$12.61
2026	$8.02	$4.67	$12.69
2027	$8.03	$4.72	$12.76
2028	$8.05	$4.78	$12.83
2029	$8.07	$4.84	$12.91
2030	$8.08	$4.90	$12.98
2031	$8.10	$4.96	$13.06
2032	$8.11	$5.02	$13.13
2033	$8.13	$5.08	$13.21
2034	$8.15	$5.14	$13.29
2035	$8.16	$5.20	$13.37
2036	$8.18	$5.27	$13.45
2037	$8.20	$5.33	$13.53
2038	$8.21	$5.40	$13.61
2039	$8.23	$5.46	$13.69
2040	$8.25	$5.53	$13.77
2041	$8.26	$5.59	$13.86
2042	$8.28	$5.66	$13.94
2043	$8.29	$5.73	$14.03

Year	Volumetric Water Rate (2023 $/1,000 gal)	Volumetric Sewer Rate (2023 $/1,000 gal)	Total Volumetric Water/Sewer Cost (2023 $/1,000 gal)
2044	$8.31	$5.80	$14.11
2045	$8.33	$5.87	$14.20
2046	$8.34	$5.94	$14.29
2047	$8.36	$6.01	$14.38
2048	$8.38	$6.09	$14.47
2049	$8.40	$6.16	$14.56

Source: The CASE Team analysis 2023.

Notes: 2025-2049 water and sewer rates are forecasted by applying a 3.2-percent and 4.2-percent annual rate increase for water and sewer, respectively, based on 2023 PNNL report and by applying a 3-percent annual discount rate to display results in 2023 $. The effective water escalation rate is 0.2 percent, the effective sewer escalation rate is 1.2 percent.

Appendix B: Embedded Electricity Usage Methodology

The Statewide CASE Team assumed the following embedded electricity in water values: 5,440 kWh/million gallons of water for indoor water use and 3,280 kWh/million gallons for outdoor water use.[1] Embedded electricity for indoor water use includes electricity used for water extraction, conveyance, treatment to potable quality, water distribution, wastewater collection, and wastewater treatment. Embedded electricity for outdoor water use includes all energy uses upstream of the customer; it does not include wastewater collection or wastewater treatment. The embedded electricity values do not include on-site energy consumption associated with water use, e.g., the energy required for water heating or on-site pumping.

These embedded electricity values were derived from research conducted for CPUC Rulemaking 13-12-011. The CPUC study aimed to quantify the embedded electricity savings associated with IOU incentive programs that result in water savings. The findings represent the CPUC's most up-to-date research on embedded energy in water throughout California.[2] This study resulted in the Water-Energy (W-E) Calculator 1.0, updated to Version 2.0 (SBW Consulting, Inc. 2022) in February 2022. The CPUC analysis was limited to evaluating the embedded electricity in water and did not include embedded natural gas in water use. For this reason, this CASE Report does not include estimates of embedded natural gas savings associated with water reductions.

For the code change proposal presented in this report, the CASE Team used embedded electricity value for indoor water use only.

[1] SBW Consulting, Inc. 2022. Water-Energy Calculator 2.0 Project Report. Project Report, San Francisco: California Public Utility Commission.

[2] Water/Energy Cost-Effectiveness Analysis: Revised Final Report. Prepared by Navigant Consulting, Inc. http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5360. Water/Energy Cost-Effectiveness Analysis: Errata to the Revised Final Report." http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5350