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Title 20 Water Closets CASE Report and RFI Response

Additional submitted attachment is included below.

Water Closets

Codes and Standards Enhancement (CASE) Initiative

For PY 2023: Title 20 Standards Development

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

Water Closets

CEC Docket Number 22-AAER-05

March 30, 2023

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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 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 123 million gallons of water and 0.67 gigawatt hours (GWh) from reduced embedded electricity use. After full stock turnover (2054), the CASE Team projects annual savings of 1.9 billion gallons of water and 10.3 GWh from reduced embedded electricity use. These are preliminary estimates.

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 (Docket Number 11-AAER-05, TN# 248095, 2022).

2. Introduction

The 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 extra materials, e.g., wipes and seat covers (PERC, 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 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 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 spot and 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. The wash-down design necessitates a smaller visible water surface area ("water spot") in the bowl, resulting in more scarring on the sides of the bowl after solids flush, a condition that usually requires subsequent brushing and additional flushing to remove. 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. Most 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, 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, and the flush is louder than gravity models.

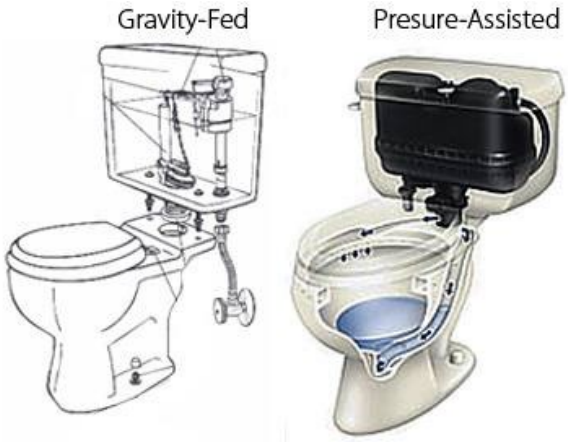

Figure 1: Gravity and Pressure-assist Tank-type Water Closets

Source: Upland Plumber 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 than gravity water closets. However, they offer a low-profile aesthetic that appeals to bathroom design professionals.

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 2 provides a schematic of a vacuum-assist model.

Figure 2: Schematic of Vacuum-assist Water Closet

Source: Niagara Conservation

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. The water pressure for this design is between 20 and 80 psi and usually requires a one-inch plumbing line. Flushometer valve water closets provide quick flush and rapid recovery but are also quite noisy. Flushometer valve water closets can be wall or floor mounted, as shown in Figure 3. The bowl and the matched valve are frequently sold separately.

Figure 3: Wall- and Floor-mounted Flushometer Valve Water Closets

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 4 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.

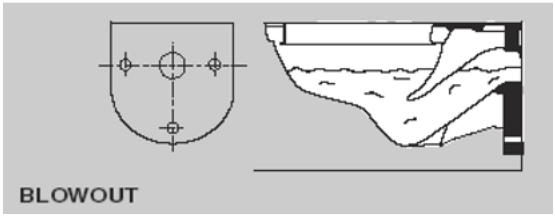

Figure 4: Blowout Bowl

Source: Jay R. Smith Mfg. Co.

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 of extra materials, e.g., wipes and seat covers (PERC, 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 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 and with the voluntary Maximum Performance (MaP) specification for MaP PREMIUM water closets (Maximum Performance (MaP) Testing). The ASHRAE 189.1 standard 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 that tend to require less brush cleaning than wash-down models.

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 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 water closets with a flushometer valve.

The CASE Team recommends removing the requirement to report waste extraction value because the extraction test prescribes a fixed mass for pass-fail testing, which adds no additional benefit. The fixed mass includes 350 grams plus/minus 10 grams for 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 the dual-flush design in 1999 to the California marketplace reduced water consumption with the liquid-only flush and incited single-flush toilet manufacturers to improve their products. As a result, many single-flush toilet models now provide equal or better water efficiency and flush performance than most 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, U.S. EPA WaterSense Program, and MaP PREMIUM Program to assess the availability of products meeting the proposed standards (i.e., qualifying products).

As of this report's writing, the California MAEDbS database includes 1,578 dual-flush model listings with an effective flush volume ranging from 0.6 to 1.28 gpf. MAEDbS database does not offer ratings for full and reduced flush beyond the combined metric of the effective flush volume.

The United States EPA's WaterSense (WaterSense) website lists 1,848 unique tank-type dual-flush water closet models, all certified to the current WaterSense version 1.2 specification for tank-type water closets (WaterSense®, 2014). Of the 1,848 WaterSense-certified dual-flush models, 430 models (23 percent) have both a full flush of 1.28 gpf or less and a reduced flush of 0.9 gpf or less and therefore 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	1,376	74%	-
Models with a full flush of 1.28 gpf or less	472	26%	-
Qualifying models with a full flush of 1.28 gpf or less and a reduced flush of 0.90 gpf or less	430	23%	23

Source: The U.S. EPA WaterSense data retrieved in February 2023.

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 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 comparison, the test procedure to measure water consumption of water closets requires the volumetric calibration to not exceed 0.07 gal and instructs to round down the total flush volume being measured to the nearest 0.07 gal. The test procedure is codified in 10 CFR 430, Subpart B, Appendix T and incorporated by reference in Title 20. Table 2 presents the MaP PREMIUM dual-flush water closet breakdown.

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)	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[1]	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.

Note:

[1] 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.

The dual-flush toilet does not necessarily provide consumers with the expected water efficiency of a single-flush toilet because of: (a) the occasional need to remove bowl scarring due to the small water spot and (b) dependence on consumer behavior to select the reduced flush for liquid-only waste. The dual-flash toilet's small water spot leads to bowl scarring, which may require scrubbing with a toilet brush and a second flush to remove the remaining waste, negating the fixture's water efficiency and impeding consumer utility and acceptance of this product. In contrast, the single-flush siphonic water closet does not need significant cleaning because of the larger water spot.

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 the ones with a maximum flush of 1.6 gpf. In March 2023, the CASE Team interviewed two major plumbing manufacturers to gather further insights. Both interviewed manufacturers are also unaware of any consumer utility or acceptance issues for dual-flush toilets with a maximum flush of 1.28 gpf as compared to the ones with a maximum flush of 1.6 gpf.

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 by offering of hundreds of these models in the early 2000s by many manufacturers. As of January 2023, approximately 106 manufacturers produce tank-type dual-flush water closets for the North American market, with ten manufacturers offering approximately 50 percent of all tank-type dual-flush models. Based on the report authors' best estimate and the interviews with three major manufacturers in January 2023, the CASE Team estimates that approximately 90 percent of tank-type dual-flush models offered by the major manufacturers in the United States have wash-down (non-siphonic) design. The CASE Team recommends conducting additional outreach to the major manufacturers of tank-type dual-flush toilets to refine this estimate. Table 3 summarizes counts of tank-type dual-flush models by major manufacturer.

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

Manufacturer	Number of Tank-Type Dual-Flush Models
OVE Decors	166
Duravit	118
Toto	101
Laufen Bathrooms	46
American Standard	42
Geberit Group / Chicago Faucets	40
Foremost/Contrac	35
Kohler	31
Caroma	21
Gerber	13
Total	**613**

Source: The CASE Team analysis 2023.

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 approximately 19.2 percent of these sales, including mostly wash-down designs with a small water spot. 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	Total	Single-flush	Dual-flush
Wall-mount residential	0.730	0.540	0.190
One-piece models	3.285	2.162	1.123
Two-piece models	18.255	15.077	3.178
Smart toilets	0.035	0.029	0.006
Commercial toilets	1.455	1.397	0.058
Total	**23.760**	**19.204**	**4.556**
Percent of Total	**100%**	**80.8%**	**19.2%**

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. Applying the proposed standards to products manufactured on or after January 1, 2025, 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	1999 and 2016 Residential End Uses of Water published by Water Research Foundation
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, effective 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% 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://www.map-testing.com/assets/reports/YarraValley-Residential-End-Use%20Study-2005-06.pdf

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).
- 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.

To calculate the annual per unit water use, the effective flush volumes for both non-qualifying and qualifying dual-flush water closets were multiplied by five flushes per day (the average number of flushes per capita while in the home) and then multiplied by 365 days per year.

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)	2,374 gal/year	1.30 gpf x 5 flushes/day x 365.24 days/year = 2,374 gallons/year
Annual water use for a qualifying dual-flush model (1.28/0.9 gpf)	1,921 gal/year	1.05 gpf x 5 flushes/day x 365.24 days/year = 1,921 gallons/year
Annual water savings per unit per capita	453 gal/year	2,374 gallons/year - 1,921 gallons/year = 453 gallons/year
Annual embedded electricity savings per unit per capita	2.46 kWh/year	453 gallons/year x (5,440 kWh) ÷ 1,000,000 million gallons) = 2.46 kWh /year

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 453 gallons per year for water savings per unit and 2.46 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)	2,374	12.91
Qualifying models (1.28/0.9 gpf)	1,921	10.45

Source: The CASE Team analysis 2023.

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

Table 9: Annual Per Unit Water and Energy Savings

	Water Savings (gal/year)	Annual Embedded Energy Savings (kWh/year)
Savings	453	2.46

Source: The CASE Team analysis 2023.

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

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, 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
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. Data was compiled in March 2023 from a retailer's website.

Notes: The CASE Team compiled the pricing data from Home Depot retail website for Anaheim, California, store location. 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.

7.2 Design Life

The CASE Team assumed a 30-year lifetime for a dual-flush water closet. Plumbing Manufacturers International (PMI) uses a 30-year average lifetime for gravity water closets. Most water conservation professionals use a 25-year lifecycle for residential gravity water closets (Vickers, The Future of Water Conservation: Challenges Ahead, 1999). However, these numbers are arbitrary as the toilet's lifetime depends on the homeowner's needs or wants. 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).

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 30 years equate to a present value benefit of $154 per unit. This estimate is based on the calculated volume of per unit water savings from 2025 to 2054 multiplied by the volumetric water/sewer rates forecasted for 2025 to 2054. 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 30-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 $) [c]	Benefit Cost Ratio [d]
Dual-flush Water Closet 1.28/0.9 gpf	30	$0	$154	N/A

Source: The CASE Team analysis 2023.

Notes:

Per unit lifecycle benefit is per toilet per capita.

[a] PV = Present Value. Calculated using the CEC's average statewide PV statewide energy rates that assume a 3 percent discount rate (CEC 2012).

[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 $12.26 per thousand gallons in 2023; forecasted 2025-2054 water and sewer rates by applying annual water and sewer rate increase of 2.5 percent based on 10-year average in CORE CPI in the U.S. economy.

[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 3.04 million. The CASE Team estimates annual California sales in 2025 of approximately 0.23 million tank-type dual-flush water closets for the residential market, including approximately 0.14 million fixtures per year to meet the growing demand for dual-flush toilets and approximately 0.10 million per year to replace older existing dual-flush toilets. This annual replacement rate estimate is based on the 2025 stock estimate for dual-flush water closets and the expected product lifetime of 30 years. Based on a 30-year lifetime, approximately 0.10 million currently installed residential dual-flush toilets will be replaced annually until 2054. Some research indicates that the replacement rate is twice the assumed rate based on bathroom remodels that include toilet replacement, effectively shortening the product lifetime. The CASE Team is conducting additional stakeholder outreach to determine whether the estimate of replacement rate should be revised.

Table 12 presents the estimated annual sales and stock of residential dual-flush water closets from 2025 through 2054. The estimates are based on an average of 0.844 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 2054, and an increase in California population from 40.81 million in 2025 to 44.16 million in 2054. Note that some reports show that California's population is currently declining. The estimate for the number of residential toilets per capita (0.844) 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 (0.844) is derived by dividing 2022 stock of California residential toilets by 2022 California population of 40.15 million (as reported by State of California Department of Finance).

Table 12: California Annual Sales and Stock of Residential Dual-Flush Water Closets (2025-2054)

Year	Annual Sales (million)	Stock (million)
2025	0.23	3.04
2026	0.23	3.18
2027	0.24	3.31
2028	0.24	3.45
2029	0.24	3.59
2030	0.24	3.73
2031	0.24	3.87
2032	0.24	4.01
2033	0.24	4.15
2034	0.24	4.29
2035	0.24	4.43
2036	0.24	4.57
2037	0.24	4.71
2038	0.24	4.85
2039	0.24	4.99
2040	0.24	5.13
2041	0.24	5.27
2042	0.24	5.41
2043	0.24	5.55
2044	0.24	5.69
2045	0.24	5.83
2046	0.24	5.97
2047	0.23	6.11
2048	0.23	6.25
2049	0.23	6.38
2050	0.23	6.52
2051	0.23	6.66
2052	0.23	6.80
2053	0.23	6.94
2054	0.23	7.08

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 based on the per unit water and energy savings. 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 2054, 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	Source/Notes
2025 California population	40.81 million	https://dof.ca.gov/Forecasting/Demographics/projections/
2054 California population	44.16 million	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 2054	• 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 2054. 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. The interviews conducted in March 2023 with two large plumbing manufacturers 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 2054	Justification for this best estimate: • In personal communications in March 2023, two large plumbing manufacturers stated that they expect continued demand growth for qualifying dual-flush products (1.28/0.9 gpf or better) over non-qualifying. • 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 another 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 preliminary 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 water use values in Table 14 and Table 15 represent the change in water use of the entire stock of residential dual-flush toilets in 2025 and 2054 from to the entire stock in 2024 and 2053 respectively. The stock values represent the water or energy use associated with all products installed and operational during a given year.

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

	Annual Sales		Stock	
Year	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**	**Water Use (million gal /yr)**	**Embedded Electricity Use (GWh/yr)**
2025	343	1.87	8,069	43.9
2054	343	1.87	18,019	98.0

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		Stock	
Year	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**	**Water Use (million gal/yr)**	**Embedded Electricity Use (GWh/yr)**
2025	282	1.53	7,947	43.2
2054	282	1.53	16,119	87.7

Source: The CASE Team analysis 2023.

8.4 Statewide Water and Energy Savings for Standards Case

Table 16 presents the preliminary 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 installed and operational during a given year. The statewide savings from tank-type dual-flush toilets in the light commercial applications are not included in this analysis. Therefore, the presented statewide savings are conservative.

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 123 million gallons and in annual embedded electricity

savings of 0.67 GWh. After full stock turnover (2054), the projected annual savings are 1,900 million gallons of water and 10.3 GWh from reduced embedded electricity use.

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

	Stock	
Year	**Water Savings (million gal/yr)**	**Embedded Electricity Savings (GWh/yr)**
2025	123	0.67
2054	1,900	10.3

Source: The CASE Team analysis 2023.

8.5 Impact on California's Economy

The Statewide CASE Team predicts that lifecycle benefits for first-year sales will equal or exceed $1.49 million and that cumulative lifecycle savings will reach $335 million once stock completely turns over in 2055 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 2054. Please refer to Table 23 for details on the forecasted water/sewer rates.

Table 17: Statewide Total Lifecycle Costs and Benefits for Standards Case (2023 $)

	Measure Lifecycle Cost for First-Year Shipments	**Measure Lifecycle Benefit for First-Year Shipments, (million 2023$)**	**Net Present Value for First-Year Shipments, (million 2023$)**	**Net Present Value for Cumulative Shipments through Stock Turnover (million 2023$)**
Tank-type Dual-flush Water Closets	$0	$1.49	$1.49	$335

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 on January 1, 2025, applied to a product with 30-year design life, the stock turnover NPV includes the NPV of products purchased from January 1, 2025, through December 31, 2054.

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, 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. Declining flows can also generate more concentrated wastewater streams, with elevated concentrations of total dissolved solids, nitrogen species, and organics.

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 4.1.

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 flush volume of 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 align with AB 715, setting an effective flush volume of 1.28 gpf. The effective flush volume is defined based on a 2:1 ratio on 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 (Commonwealth of Australia and the States and Territories, 2019).

Table 18 summarizes Australian WELS ratings for dual-flush water closets codified in AS/NZS 6400:2016.

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

WELS Rating	Full flush max (liters per flush)	Full flush max (gallons per flush)	Half flush max (liters per flush)	Half flush max (gallons per flush)
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 (Queensland Government, 2020) 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.

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 (New South Wales Government, 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 (Public Utilities Board, Singapore, 2016). Water shortages are common due to prolonged dry spells, the most recent in 1990 (Tortajada, Joshi, & Biswas, 2014). Singapore has aggressively regulated water use in plumbing fixtures and has required a mandatory water efficiency labeling scheme (Mandatory WELS) since 2009 (Singapore's National Water Agency, 2022). That same year, Singapore set minimum water efficiency standards to complement the labels (OPUB Singapore's National Water Agency, 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 (gallon per flush)**	**3-tick Rating (gallon per flush)**
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 supply 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 litres (1.06 gallons) per flush, and only water closet flush valves of 2-tick ratings or more shall be allowed for supply.

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 (UK 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

Manufacturers introduced the dual-flush water closet to the California marketplace in late 1999. 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, the U.S. EPA WaterSense Program allowed manufacturers to label and market high-efficiency water closets.

Currently, the voluntary U.S. EPA WaterSense Program specification sets the maximum flush volumes for tank-type gravity water closets as follows (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.

The WaterSense staff recently indicated the intent to revise their specification limiting the maximum full flush volume for dual-flush water closets to 1.28 gpf.

In ASHRAE/ICC/USGBC/IEC 189.1-2020 – Standard for the Design of High-Performance Green Buildings, the limit for the full flush volume for dual-flush toilets is set to 1.28 gpf.

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.[1]

…

(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. Electromechanical hydraulic water closet is commonly known as 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. Flushometer tank water closet is commonly known as 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.

[1] Title 20 CCR § 1602. Definitions. (California Public Utilities and Energy Division, 2022)

"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. Vacuum-type water closet is commonly known as 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. [2]
…
(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. [3]
…
(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] Title 20 CCR § 1604. Test Methods for Specific Appliances. (California Public Utilities and Energy Division, 2022)
[3] Title 20 § 1605.3. State Standards for Non-Federally Regulated Appliances. (California Public Utilities and Energy Division, 2022)

(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 full flush and 0.9 gallons per flush for 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. [4]

…

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

[4] Title 20 CCR § 1606. Filing by Manufacturers; Listing of Appliances in the MAEDbS. (California Public Utilities and Energy Division, 2022)

(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 (Docket Number 11-AAER-05, TN# 248095, 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 ○ Single-flush water closets ○ 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 4.1, Section 5.1 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 30 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?

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.

There are no known recent design improvements to reduce water closet leaks. The CASE Team is unaware of design improvements for gravity tank-type water closets needing inclusion in the performance standards.

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 for 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. A new trend began with chemical manufacturers successfully marketing a more "convenient" product, 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 mains 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. 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 for children, the elderly, the infirm, or those with large hands or longer fingernails to operate.

Most 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 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 30 years. The table below, extracted and reproduced from the original PERC study (PERC, 2012) and updated by John Koeller and Pete DeMarco in 2018, 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.

Table 2. Water Consumption by Water-Using Plumbing Products and Appliances (1980 to 2017)

Water-using Fixture or Appliance	1980s Water Use (typical)	1990 Requirement (maximum)	EPAct 1992 Requirement (maximum)	2009 Baseline Plumbing Code (maximum)	"Green Code" Maximums (2017 CALGreen)	% Reduction in avg water use since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.2 gpm	66%
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	1.3 gpm	74%
Residential Clothes Washing Machine	51 gallons per load	No requirement	26 gallons per load *(2012 std)*	No requirement	12.6 gallons per load *(Energy Star)*	75%
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%

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

The reduction in the flush volume for water closets, appliances, and other plumbing fixtures listed above negatively impacts building drain lines, as the decreased water use leads 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, 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 product.

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 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%)
Totals	**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% 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 8.1 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
	  ○ Single-flush water closets
	  ○ Dual-flush water closets

Source: California Energy Commission

An online review of water closet retail prices at Home Depot (Anaheim location) concluded that there was no additional cost associated with purchasing a qualifying dual-flush water closet versus a non-qualifying dual-flush or single-flush water closets.s. See Section 7.1 for more details.

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.

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 30-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 expects the publication of the recently compiled data on commercial water utility rates in the 2025 CASE Report on nonresidential cooling towers in Spring 2023 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 .

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?

Yes, some gravity tank-type water closet manufacturers offer a wide range of toilet designs (e.g., as of this report's writing, American Standard produces over 445 water closet models, Gerber produces over 330 models, and Kohler produces over 230 models for various types of applications), while other manufacturers offer only a few models (e.g., as of this report's writing, Grohe only produces eight different water closet models, mostly for the high-end market, and Niagara produces 16 different models, primarily focusing on 0.8 gpf fixtures). 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
Totals	**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% 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 January and February of 2023 for California's 20 largest retail water service providers and 22 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. The total population served by the considered water service providers is 14,336,902. The population-weighted combined water and sewer volumetric rate is $12.26 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)	**Population Served by Water Service Provider [a]**	**Water Rate $/HCF [b]**	**Sewer Rate $/HCF [b]**	**Water + Sewer Rate $/HCF [b]**	**Water + Sewer Rate $/1,000 gal**
Los Angeles Department of Water and Power [c] / Los Angeles Sanitation	4,041,284	$8.36	$5.80	$14.16	$18.93
City of San Diego [d]	1,430,489	$6.07	$4.79	$10.85	$14.51
East Bay Municipal Utility District [d]	1,405,000	$6.32	$1.43	$7.75	$10.36
San Jose Water Company [d, f]	997,817	$5.94	$0	$5.94	$7.93
San Francisco Public Utilities Commission [d]	899,732	$10.71	$15.97	$26.68	$35.67
Eastern Municipal Water District [d, f]	603,950	$3.75	$0	$3.75	$5.01
City of Fresno [e, f]	550,217	$1.74	$0	$1.74	$2.33
City of Sacramento [e, f]	510,931	$1.46	$0	$1.46	$1.95
City of Long Beach [d]	472,217	$4.91	$0.39	$5.30	$7.09
Irvine Ranch Water District [d, g]	418,163	$2.42	$0	$2.42	$3.24
City of Anaheim [e, f]	365,987	$3.86	$0	$3.86	$5.16
Alameda County Water District [e] / Union Sanitary District [f]	356,823	$4.60	$0	$4.60	$6.14
City of Santa Ana [c, f]	335,086	$2.36	$0	$2.36	$3.15
City of Riverside [c, f]	310,554	$1.30	$0	$1.30	$1.74
California Water Service Company Bakersfield [c] / City of Bakersfield [f]	286,310	$1.84	$0	$1.84	$2.47
Golden State Water Company - Southwest [c] / Los Angeles County Sanitation Districts [f]	278,787	$4.54	$0	$4.54	$6.07
Helix Water District [c] / four sewer service providers [h]	277,294	$5.56	$3.60	$9.16	$12.25
City of Modesto [e, f]	270,974	$2.02	$0	$2.02	$2.70
Coachella Valley Water District [c, f]	268,952	$0.94	$0	$0.94	$1.26

San Gabriel Valley Water Company [c] / Los Angeles County Sanitation Districts [f]	256,335	$3.89	$0	$3.89	$5.21
Total	14,336,902				
		Water Rate	**Sewer Rate**	**Water + Sewer Rate**	
Population-Weighted Rate ($/HCF)		$5.83	$3.34	$9.17	
Population-Weighted Rate ($/1,000 gal)		**$7.79**	**$4.46**	**$12.26**	

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

Notes:

[a] 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).

[b] HCF is one hundred cubic feet, or CCF, the unit of measure water providers use; 1 HCF = 748 gallons.

[c] 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. For context, California's average residential water use in 2016 was reportedly 85 gallons per person per day (source: https://lao.ca.gov/Publications/Report/3611), equivalent to 2,550 gals per person per month or 3.4 HCF per month per person. Using 2.92 for the average household occupancy (source: https://www.census.gov/quickfacts/CA), monthly water use for a single family dwelling is 9.9 HCF/month.

[d] Tier 2 water rate is listed in this table. The team used the tier 2 rate when tier 1 covered less than the first 8 HCF/month of water use.

[e] Water service provider has a uniform use rate for water.

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

[g] 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.

[h] Four sewer service providers include the City of La Mesa ($4.20 per HCF), the City of El Cajon ($5.97 per HCF), Lemon Grove Sanitation District (non-volumetric sewer rate), and San Diego County Sanitation District (non-volumetric sewer rate). The population-weighted sewer rate for the four providers is $3.60 per HCF.

Table 23 summarizes forecasted statewide average residential volumetric water and wastewater rates from 2025 to 2054 to assess the statewide lifecycle benefits of the measure over 30 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 22 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 may be subject to rates different than those compiled for single family dwellings. The CASE Team forecasted 2025-2054 water and sewer rates by applying the following:

- Annual water and sewer 2.5 percent rate increase based on the CORE CPI 10-year average in the U.S. economy and
- Annual discount rate of 3.0 percent to display results in 2023$.

Table 23: Estimated Statewide Average Residential Volumetric Water and Sewer Rates 2025 – 2054

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	$7.72	$4.42	$12.13
2026	$7.68	$4.40	$12.07
2027	$7.64	$4.37	$12.01
2028	$7.60	$4.35	$11.95
2029	$7.56	$4.33	$11.89
2030	$7.53	$4.31	$11.84
2031	$7.49	$4.29	$11.78
2032	$7.45	$4.27	$11.72
2033	$7.41	$4.24	$11.66
2034	$7.38	$4.22	$11.60
2035	$7.34	$4.20	$11.54
2036	$7.30	$4.18	$11.49
2037	$7.27	$4.16	$11.43
2038	$7.23	$4.14	$11.37
2039	$7.20	$4.12	$11.32
2040	$7.16	$4.10	$11.26
2041	$7.12	$4.08	$11.20
2042	$7.09	$4.06	$11.15
2043	$7.05	$4.04	$11.09
2044	$7.02	$4.02	$11.04
2045	$6.98	$4.00	$10.98
2046	$6.95	$3.98	$10.93
2047	$6.91	$3.96	$10.87
2048	$6.88	$3.94	$10.82
2049	$6.85	$3.92	$10.77
2050	$6.81	$3.90	$10.71
2051	$6.78	$3.88	$10.66
2052	$6.74	$3.86	$10.61
2053	$6.71	$3.84	$10.55
2054	$6.68	$3.82	$10.50

Source: The CASE Team analysis 2023.

Note: 2025-2054 water and sewer rates are forecasted by applying a 2.5% annual water and sewer rate increase based on the CORE CPI 10-year average in the U.S. economy (https://fred.stlouisfed.org/series/CPILFESL) and by applying a 3% annual discount rate to display results in 2023$.

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.[5] 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.[6] 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.

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

[6] 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