# Toilets & Urinals Water Efficiency

Codes and Standards Enhancement (CASE) Initiative
For PY 2013: Title 20 Standards Development

Analysis *of* Standards Proposal for
**Toilets & Urinals Water Efficiency**

Docket #12-AAER-2C

CASE Report
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## *A*cknowledgements

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# 1 Executive Summary

The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas & Electric (SDG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy and water efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE Report covers standard options for toilets (also known as water closets) and urinals.

California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger & Luch 2012). Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks. The 2.9 trillion gallons of water is associated with approximately 26.4 terawatt hours of embedded electricity, which is required for water supply, conveyance, potable water treatment and distribution, and wastewater collection and treatment.

Flushing toilets are the largest single use of residential indoor water use. It is estimated that water used in toilets accounts for 28 to 40 percent of all indoor water use. For this reason, reducing the amount of water used in toilets is a key component of California's water reduction strategy. Establishing efficiency standards for toilets and urinals will have a significant impact on California's overall water and embedded energy use.

Through the enactment of AB 715 in 2007, California has already adopted water efficiency standards for toilets and urinals that exceed the federal efficiency requirements. However, these legislated standards have not been incorporated into Title 20, which dictates the allowable water consumption values for products available for sale in California. CEC has an opportunity to confirm California's commitment to water efficiency by revising the Title 20 standards for toilet and urinals such that the Title 20 standards are at least as stringent as the standards enacted by AB 715.

The proposed Title 20 code change would set the efficiency level for toilets at 1.28 gallons per flush (gpf), the same level that was enacted by AB 715. Given the strong evidence that urinals exceeding the standard level enacted via AB 715 are readily available, the proposed efficiency standard for urinals is 0.125 gpf. This is more stringent than the 0.5 gpf standard adopted through AB 715. In addition to modifying the minimum flush volumes, the proposed standard would establish minimum performance standards (waste extraction standards) for water closets and would establish new water conservation standards for replacement valves sold after January 1, 2019.

Table 1.1 presents the water and energy savings estimates achieved through the adoption of the proposed standards. The proposed standards water closet and urinals are estimated to save 631 million gallons of water the first year the standard is in effect, which is associated with an embedded electricity savings of 6.3 gigawatt hours (GWh) per year.

**Table 1.1 Estimated Energy and Water Savings**

| Product Class | Annual Sales: Water Savings (Mgal/yr) | Annual Sales: Embedded Electricity Savings (GWh/yr) | Stock: Water Savings (Mgal/yr) | Stock: Embedded Electricity Savings (GWh/yr) |
|---|---|---|---|---|
| 2015 (first year standard is in effect) | | | | |
| Residential Toilets | 358 | 3.6 | 358 | 3.6 |
| Commercial Toilets | 63 | 0.6 | 63 | 0.6 |
| Urinals | 210 | 2.1 | 210 | 2.1 |
| **Total** | **631** | **6.3** | **631** | **6.3** |
| 2026 (year commercial toilet and urinal stock turns over) | | | | |
| Commercial Toilets | 69 | 0.7 | 792 | 8.0 |
| Urinals | 226 | 2.3 | 2,614 | 26.3 |
| **Total** | **295** | **3.0** | **3,406** | **34.2** |
| 2038 (year residential toilet stock turns over) | | | | |
| Residential Toilets | 485 | 4.9 | 10,441 | 104.9 |

Source: CASE Team analysis 2013

# 2 Background

## 2.1 Regulatory Background

### 2.1.1 Federal Regulatory Background

Prior to 1970, most toilets consumed 6 gpf or more. Effective January 1, 1978, California law required all toilets to consume no more than 3.5 gpf. In the 1980s and early 1990s several states, including California, had established water efficiency standards for toilets and urinals. Congress used these state-level standards as the basis for the first federal standards that were enacted by the Energy Policy Act of 1992 (EPAct 1992) that took effect in 1994 and set the maximum flush volumes at 1.6 gpf for toilets and 1.0 gpf for urinals. In addition, all low-flush toilets and urinals must be labeled with specified language by the retailer identifying the fixtures as low-flush models. The federal standards have not been revised since EPAct 1992 was enacted.

EPAct 1992 states that if the American Society of Mechanical Engineers (ASME) revises its standards for plumbing fixtures and fittings, the United States (U.S.) Department of Energy (DOE) must review ASME's action and consider adjusting the federal standards. If ASME does not revise its standards within five years, states are allowed to set more stringent state-level standards. To date, ASME has not revised the toilets or urinal standards. Since ASME did not revise the standard within five years of the first effective date, states were eligible to set their own standard after 1999.

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

### 2.1.2 California Regulatory Background

***Impetus to Pursue Water Efficiency and Water Conservation***

On February 28, 2008 Governor Schwarzenegger outlined key elements of a comprehensive water conservation plan to address water issues in the Sacramento-San Joaquin Delta. From this effort, the California Environmental Protection Agency State Water Resources Control Board (SWRCB) began developing the 20x2020 Water Conservation Plan, which called for a 20 percent reduction in per capita urban water use by 2020. In turn, the draft Plan laid the foundation for The Water Conservation Act of 2009 (Senate Bill X7-7, Steinberg 2009), which was enacted in November 2009 and codified the 20x2020 goal. In February 2010, the AWRCB released the Final 20x2020 Water Conservation Plan, which details how the State will achieve its 20x2020 goal. The Plan includes a recommendation to establish more stringent water efficiency standards for plumbing fixtures and fittings. Specifically, the Plan states, "Given the state's water supply challenges, appliance efficiency codes must remain ahead of the rest of the nation" (SWRCB 2010).[1]

Pursuant to California Public Resources Code, Section 25402, the CEC is required to address the reduction of wasteful, uneconomic, inefficient or unnecessary consumption of energy, including the

[1] More information about California's 20x2020 goal and the plan to achieve this goal is available on the State Water Recourses Conservation Board website: http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/ and the Department of Water Resources website: http://www.water.ca.gov/wateruseefficiency/sb7/.

energy associated with the use of water. Section 25402 gives the CEC authority to set water efficiency standards for appliances. Thus, the CEC is mandated to establish and enforcing standards that will reduce statewide water consumption (Cal. PRC §25402).

***History of Toilet and Urinal Regulation in California***

The EPAct 1992 standard preempted California from establishing more stringent standards for plumbing products. As mentioned above, states were eligible to establish their own standards starting in 1999. However, California did not take advantage of the opportunity to revise the standard until 2007 when the California Legislature enacted Assembly Bill 715 (Laird 2007). AB 715 made water conservation standards for certain types of toilets and urinals more stringent than the EPAct standards. Specifically, after January 1, 2014 toilets cannot use more than 1.28 gpf and urinals cannot use more than 0.5 gpf (AB 715, 2007).

From an implementation perspective, AB 715 temporally adds the toilet and urinal efficiency standards to the Health and Safety Code. The standards in the Health and Safety code will remain operative only until January 1, 2014, or until the California Building Standards Commission (BSC) includes the standards in the Building Standards Code, whichever date is later. In general, California's building code does not include efficiency standards for appliances. Rather, appliance standards that dictate minimum energy and water efficiency requirements are contained in California's Appliance Efficiency Standards (Title 20). AB 715 does allow the BSC or the CEC to reduce the quantity of the water per flush requirements if deemed appropriate.

Two other bills that were enacted in 2007 changed the CEC's directive on how to approach water efficiency standards. Assembly Bill 662 (Ruskin 2007) and Assembly Bill 1560 (Huffman 2007) gave the CEC authority to set water efficiency standards for appliances. Further, the bills required the CEC to incorporate water efficiency standards into the existing building efficiency standards (Title 24, Part 6).

In 2010, mandatory toilet and urinal standards were introduced to the California Green Building Code, which is also known as CALGreen or Part 11 of Title 24. The 2013 CalGreen standards, which take effect in January 2014, include requirements that newly constructed residential buildings install toilets and urinals that meet a minimum efficiency level. The CalGreen standards are consistent with the AB 715 efficiency levels: toilets have to be 1.28 gpf or less, and urinals have to be 0.5 gpf or less (CalGreen 2013a, CalGreen 2013b).

Finally, California's Plumbing Code (Part 4 of Title 24) includes water efficiency standards for toilets and urinals. The 2013 Plumbing Code includes efficiency standards that are consistent with AB 715 levels.

## 2.2 Importance of Water Efficiency in California

Water is essential to supporting and sustaining the environmental, economic, and public health needs of the State. Ongoing drought, shifts in regional climate patterns, and the State's population growth have increased demand for water. In addition, the demand for more energy also increases the demand for water used to produce electricity. Without reductions in water use, water-related energy use is projected to continue increasing (California Sustainability Alliance 2013). Thus, the installation of water-saving devices in residential, commercial, and industrial applications is extremely crucial for addressing California's water resource needs. Water use efficiency and conservation protects the future of our State's water supply for communities, businesses, industry, and the environment.

Multiple benefits come from using less water and from using it more efficiently. In addition to reducing the demand of available and shrinking water supplies—which enhances water supply security—use water use efficiency and conservation help to decrease the need to invest in costly, large-scale infrastructure projects (e.g., dams, canals, reservoirs) while also reducing operating costs for water utilities (e.g., pumping and treatment) (U.S. EPA 2013). Furthermore, decreasing the amount of water that is wasted improves water quality and helps us maintain higher water levels in lakes, rivers and streams, which protect human health and the environment (WaterSense 2013c). On the demand side, water use efficiency lowers household energy and water bills. And efficient water use also has indirect benefits, such as improved air quality through reduced energy requirements for pumping (The Alliance for Water Efficiency 2012) and a reduction in the amount of greenhouse gases emitted in the production of energy and the conveyance, treatment, and heating of California's water.

## 2.3 Embedded Energy in California's Potable Water

California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger & Luch 2012). Urban uses include outdoor and indoor residential water use; water used in commercial, institutional, and industrial applications; and unreported water use, which is primarily attributed to leaks. The 2.9 trillion gallons of water is associated with approximately 26.4 terawatt hours of embedded electricity. As shown in Figure 2.1 and Figure 2.2 below, residential toilets consume about 196 billion gallons of water per year, which is associated with an embedded energy use of 1,966 GWh of electricity. Water use from commercial toilets and urinals is in the range of 20 billion gallons per year, which is associated with about 200 GWh of electricity.

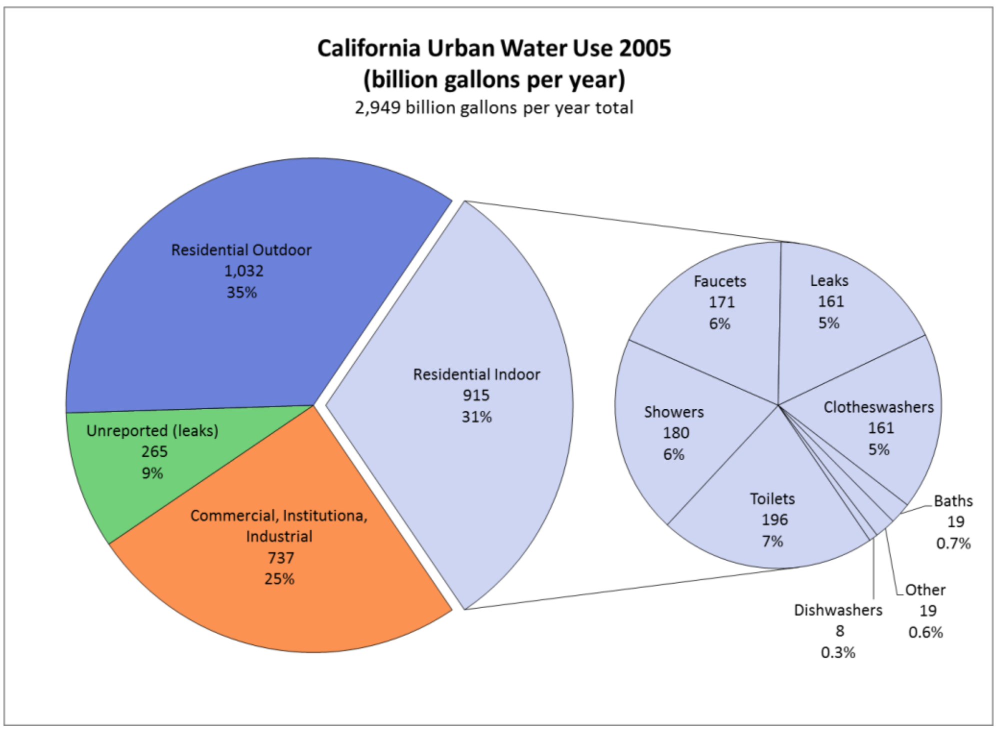



**Figure 2.1 California Urban Water Uses (2005)**

Source: Christian-Smith, Heberger, Luch (2012).

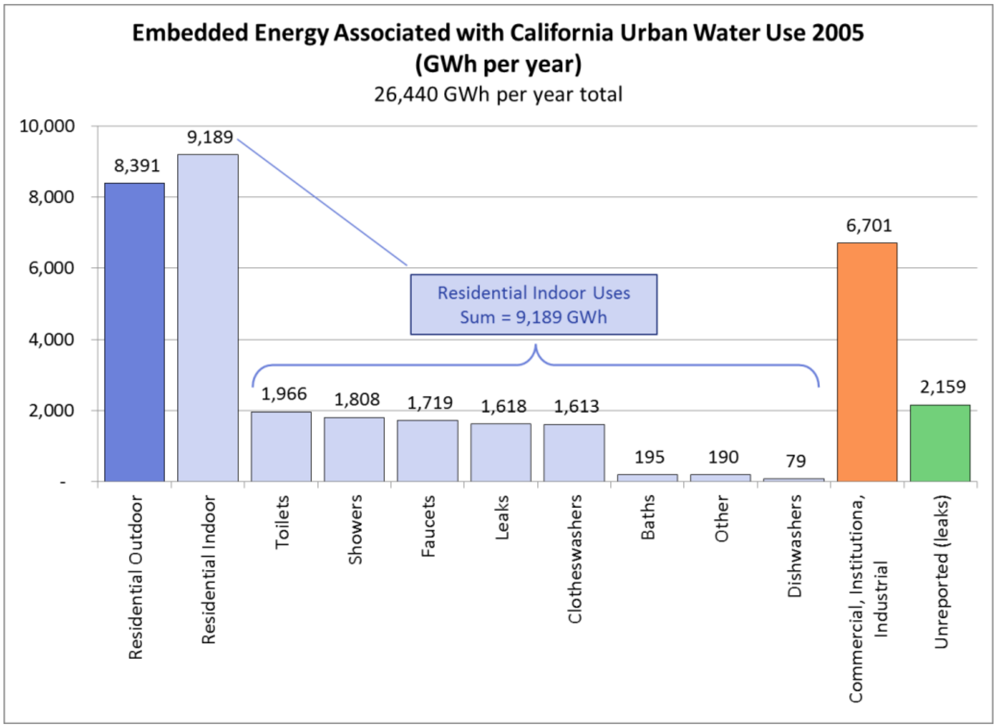



**Figure 2.2 California Urban Water Uses (2005)**

Source: Christian-Smith, Heberger, Luch (2012).

Assumptions: Embedded energy factor of 8,134 kWh/MG for residential outdoor water use and unreported (leaks); embedded energy factor of 10,045 kWh/MG for residential indoor; embedded energy factor of 9,090 kWh/MG for commercial, institutional, industrial.

# 3 Product Description

Toilets (also known as water closets) and urinals are sanitation fixtures used to dispose of human waste. In urban areas, toilets and urinals are connected to sewage lines that carry waste from the toilet to a wastewater treatment facility. In rural areas that do not have sewage collection systems and centralized wastewater treatment facilities, toilets and urinals may be connected to a septic system.

## 3.1 Toilets

Most modern flush toilets found in residential and small commercial applications in the United States are siphoning toilets. In siphoning, the bowl and the tube that leads from the bowl to the sewage line are carefully designed to create a siphon that pulls waste from the bowl when the toilet is flushed. Water must enter the bowl rapidly to trigger the siphoning effect. When all of the water is evacuated from the bowl, air enters the tube and the siphon action is halted (see Figure 3.1 for an example of tank-type siphoning toilet). If water is added to the bowl slowly, as is the case with leaking toilets, water in the siphon tube will also rise slowly and excess water will spill over the bend in the siphon tube and drain into the sewage line.

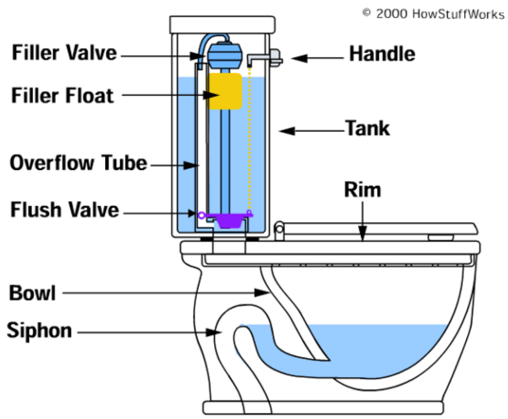



**Figure 3.1 Schematic of Tank-type Siphoning Toilet**
Source: Marshall 2013

Blowout toilets do not employ siphoning technology. These non-siphoning toilets rely on high water pressure and high water volume to remove waste from the bowl. Figure 3.2 illustrates the differences between siphon and blowout bowls. 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 valve toilets are best suited for heavy use applications like in airports, stadiums, and prisons because they are more durable and less susceptible to clogging. They are the only type of toilet exempt from the federal 1.6 gpf limit; federal regulations allow blowout toilets to use as much as 3.5 gpf. The California investor owned utilities (CA IOUs) are not recommending changes to the existing minimum efficiency standards from blowout toilets.


**Figure 3.2 Siphon Jet and Blowout Bowls**
Source: Jay R. Smith Mfg. Co

As water efficiency has become increasingly more important to consumers, manufacturers have responded by developing various toilet designs that aim to reduce water use while maintaining the ability of the toilet to effectively deliver waste to the sewage collection system. Several types of high-efficiency toilets, such as pressure-assist, power-assist, and vacuum-assist toilets, have emerged to provide a low-flush volume option for customers that have atypical waste collection piping configurations. These various types of toilets are explained in more detail below.

#### 3.1.1 Tank-type Toilets

Tank-type toilets employ a tank to hold flush water and are common in residential applications as well as light to medium usage commercial applications. When the flush lever is depressed, water from the tank quickly enters the bowl, pushing water into the siphon tube, and triggering the siphon action. Gravity-assist toilets are the most common and least expensive kind of tank-type toilet. Flush water is not pressurized in gravity-assist toilets. Tank-type toilets are the most common toilets in residential applications.

Pressure-assist toilets, also known as pressurized tank toilets or flushometer tank toilets, are becoming more common. Pressure-assist toilets are useful in applications where water pressure from gravity alone is not sufficient to carry waste from the bowl to the municipal wastewater collection system. The toilet contains a pressurized tank, which is pressurized using pressure from the water supply line, within the exterior porcelain tank facade. Since the water pressure within the pressurized tank is higher than the pressure that can be achieved through gravity alone, flush water in a pressure-assist toilet has more force than flush water in a gravity-assist toilet. Pressure-assist toilets require a minimum water supply pressure of 25-40 pounds per square inch (psi) to operate well. The trapway between the bowl and the wastewater collection line is a larger diameter than that of gravity-assist toilets, thereby minimizing the likelihood of clogs. The downsides of pressure-assist toilets are that they are louder when they flush, and they are more expensive than gravity-assist toilets. Figure 3.3 illustrates gravity-assist and pressure-assist toilets.

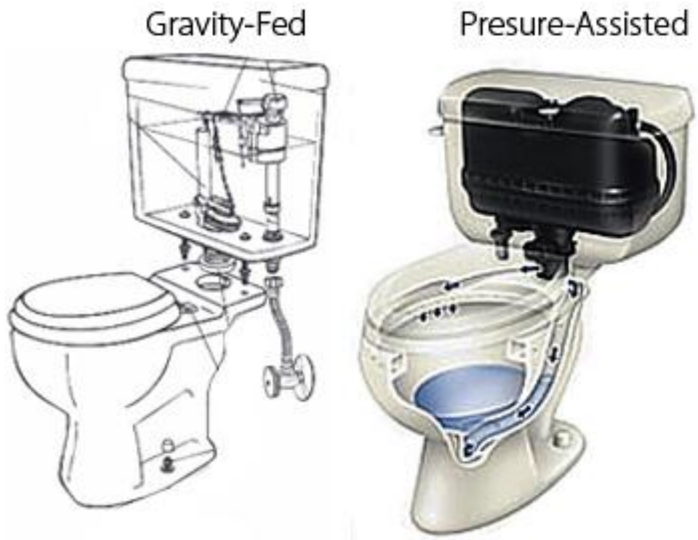



**Figure 3.3 Gravity and Pressure-assist Tank-type Toilets**
Source: Upland Plumber 2013

Power-assist (electromechanical hydraulic) and vacuum-assist toilets are less common tank-type toilet designs. Power-assist toilets are similar to pressure-assist toilets in that the water in the tank is pressurized, but power-assist toilets are pressurized using electricity instead of water line pressure. The downside of power-assist toilets is that they need to be plugged into an electricity outlet. They are also more expensive than gravity-fed toilets. Title 20 currently defines electromechanical hydraulic toilets as toilets 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 toilet bowl.

Vacuum-assist toilets are designed such that the water in the bowl is suspended by a pressurized air pocket within a trapway between the bowl and the exit to the sewage line. When the toilet is flushed the air in the trapway depressurizes and creates a suction force that pulls wastewater out of the bowl. Water enters the bowl from holes in the rim of the bowl; there is no siphon-jet hole. The downsides of vacuum-assist toilets are that they tend to be less powerful than other types of toilets, and they sometimes require a second flush to clear all waste. They are also more expensive than gravity-assist toilets. In addition, plunging is more difficult, as one must remove the lid and cover an opening in order to create suction for successful plunging. Figure 3.4 provides a schematic of a vacuum-assist toilet.

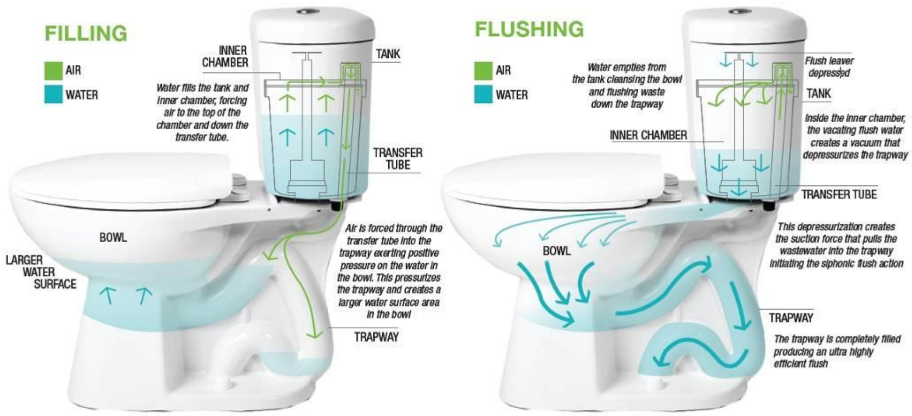



**Figure 3.4 Schematic of Vacuum-assist Toilet**
Source: Niagra Conservation

### 3.1.2 Valve-type (Flushometer Valve) Toilets

Valve-type toilets, also known as flushometer valve toilets, are common in medium to high usage commercial applications as well as industrial applications. These toilets do not have a tank, but the flush process is very similar to that of a flushometer-tank toilet (pressure-assist toilet). Instead of flush water coming from the tank, water comes directly from the water supply for the building. The valve controls the volume of water that enters the bowl per flush, and flush water is pressurized using water pressure from the main supply line. Water pressure typically needs to be between 20 and 80 psi for this type of toilet, and the toilet has to be supplied by a 1-inch (25 mm) plumbing line. Valve-type toilets provide a quick flush and rapid recovery but they are also quite noisy. As shown in Figure 3.5, valve-type toilets can be wall mounted or floor mounted. Blowout toilets, which as mentioned above are not covered in this CASE Report, are valve-type.

**Figure 3.5 Wall-mounted and Floor-mounted Flushometer Valve-type Toilets**
Source: American Standard

### 3.1.3 Dual-Flush Toilets

Dual-flush toilets have the ability to flush at full-volume or low-volume. Users can select the full-volume flush to remove solid waste or low-volume option to remove liquid waste. Most dual-flush toilets use 1.6

gpf for the full-volume flush and between 0.8 and 1.1 gpf for the reduced-volume flush. However, there are several models such as those offered by Caroma that use 1.28 gpf and 0.8 gpf, respectively. The effective flush volume of dual-flush toilets varies based on usage patterns (i.e., how often the toilet is flushed at the full and reduced volumes). Dual-flush toilets achieve an effective flush volume that is lower than the current federal maximum flush volume of 1.6 gpf. Dual-flush toilets are available for tank-type and valve-type toilets.

## 3.2 Urinals

Urinals are fixtures designed for male users to dispose of liquid waste. Urinals are most commonly found in public places, but on occasion they can be found at private residences. Some urinals, like blowout urinals, designed for heavy-duty commercial applications do not rely on siphoning principles, but most urinals employ the same siphoning principles used in toilets. Flush water can be pressurized water that comes directly from the water line or water that comes from a storage tank. Tank-type urinals, which utilize gravity to create water pressure, are less common. Urinals can be manual-flush, automatic-flush, or constant drip. Most urinals are wall-mounted, though floor-mounted urinals are also available.

Waterless urinals have emerged as a reliable alternative to flushing urinals. While this report does not focus on waterless urinals, the fact that waterless urinals are emerging as a viable alternative to flushing urinals is pushing the market towards higher-efficiency products. Most major manufacturers offer waterless urinals as well as premium-efficiency flushing urinals that only use 0.125 gpf. Waterless urinals typically cost about $250-$300 more than the fixture (bowl) for 0.5 gpf flushing urinals. However, there may be cost savings because waterless urinals do not require a valve (flushing mechanism).

Blowout urinals use the same technology as blowout toilets, and like blowout toilets, are best suited for heavy use applications like airports, stadiums, and prisons because they are more durable and less susceptible to clogging. Blowout urinals are not covered by AB 715, and the CA IOUs are not recommending changes to the existing federal minimum efficiency standards for blowout urinals.

Trough and floor urinals are less common urinal designs. Trough urinals can be used by several men simultaneously. They provide less privacy than single-user urinals, but one trough fixture is typically less expensive than two or more single-user urinals. Cost savings come from the fixture as well as installation costs. The CA IOUs are not recommending changes to the existing minimum efficiency standards from blowout toilets. Floor urinals are larger and more expensive than traditional bowl fixtures, and more expensive to install. The CA IOUs are recommending that the standard for floor-mounted urinals be consistent with AB 715 efficiency standards. Figure 3.6 shows a trough urinal and a floor-mounted urinal.

**Figure 3.6 Trough Urinal and Floor Urinal**
Source: Kohler

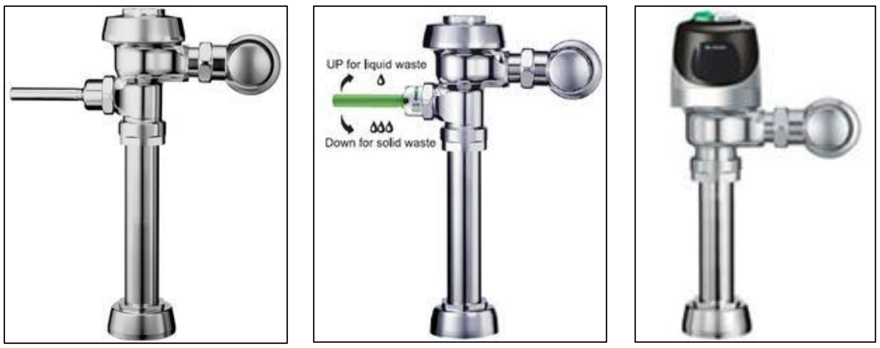
## 3.3 Flushing Devices (Valves)

Toilet and urinal valves are oftentimes sold separately from the fixtures themselves. Fixtures come in various shapes and sizes, and valves have a variety of features. Figure 3.7 shows one fixture design configured with four different valves. The flush volume can vary with every fixture-valve combination, so it is important that the every fixture-valve combination is able to achieve the rated flush volume.

**Figure 3.7 Urinal Fixture with Various Valve Options**
Source: Sloan Valve Company

### 3.3.1 Dual-Flush Valves

Dual-flush valves allow a toilet to be flushed using two different flush volumes. Dual-flush valves are available for tank-type toilets and valve-type toilets. Figure 3.8 shows a standard manual single-flush flushometer valve, a manual dual-flush flushometer valve, and a sensor-operated dual-flush flushometer valve. As demonstrated in the middle image in Figure 3.8, some dual-flush valves are designed such that pushing the valve down will result in a full-volume flush. Stakeholders have suggested that dual-flush valves should be designed so the default setting (i.e., pushing the lever down) will result in a low-volume flush. This design change will help improve savings from dual-flush toilets as users would not have to change behavior to select the low-flow option (Arocha & McCann 2013). The CA IOUs are not proposing a standard that specifically addresses the default settings for dual-flush valves.




a) Manual single-flush b) Manual dual-flush c) Sensor operated dual-flush

**Figure 3.8 Types of Flushometer Valves**

Sources: Sloan Valve Company

### 3.3.2 Automatic Flushing Devices and Phantom Flushes

Automatic flushing devices use sensors to flush toilets or urinals automatically. Widespread adoption of electronic, hands-free flushing operation for valve-type water closets and urinals has been accompanied by reports of phenomenon of the phantom flush – the unintended activation of the flush valve. One study has shown a significant increase in water consumption following the installation of hands-free water closets and urinals (Gauley & Keller 2010). When investigating this potential problem, the CASE Team learned from manufacturers that sensor technology has improved significantly, and that phantom flushes can usually be attributed to sensors being installed and/or commissioned incorrectly. At this time, the CA IOUs are not recommending standards that would address sensor accuracy. Additional data and a test procedure are needed however to fully determine and quantify the extent of this problem. The CASE Team will continue to monitor this issue.

# 4 Manufacturing and Market Channel Overview

Toilets and urinals are distributed through four primary outlets:

1. Direct sales (i.e., manufacturers sell directly to homebuilders or other volume purchases);
2. Retail sales (e.g., Home Depot, Lowes, or other retailer);
3. Wholesale plumbing suppliers; and
4. Decorator showrooms.

Manufacturers sell directly to entities that can purchase a large volume of products such as homebuilders, commercial builders, or water utilities. Distributors have a limited (or non-existent) role in direct manufacturer to installer sales, so the distributor mark-ups are minimal or eliminated completely. The price of units sold through direct sales can be 20 to 50 percent lower than typical retail prices (D&R International 2005).

Retail sales are common for do-it-yourself remodels. Large retailers such as Lowes, Home Depot, and Sears process a majority of the retail sales. These large retailers have a significant influence on which products reach the mainstream retail market. Retailers cannot stock a wide variety of models due, in part, to limited shelf space. The models that are stocked have a distinct advantage over models that are not stocked. Typically, water efficiency is not the primary factor retailers consider when making decisions about which products to carry; price, performance, and appearance are often weighed more heavily than efficiency.

Some manufactures have localized distribution channels that utilize wholesale distributors to deliver a tailored distribution strategy for different regions. Wholesale distributors may work with builders, water utilities, or retail stores. The wholesaler distribution model is most common for smaller manufactures that offer specialized products, including premium efficiency toilets and urinals. Sales representatives from the wholesaler can offer personalized messaging to interested customers. Wholesalers tend to target markets with high sales or markets that have an appetite for the specialty products they carry.

Showrooms are also a distribution channel. Manufacturers that offer high-efficiency products may target green building showrooms or choose to market their products at green building trade shows.

# 5 Energy Usage

## 5.1 Test Methods

### 5.1.1 Current Test Methods

***Efficiency***

Current Title 20 and federal efficiency standards require water closets and urinals to be tested and labeled according to procedures described in American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) A112.19.6-1995 – Hydraulic Performance Requirements for Water Closets and Urinals. This test procedure has undergone several revisions since 1995 to adjust for changes in toilet designs and to improve the accuracy of performance tests. In 2003 A112.19.6 was combined with A112.19.2. The current version of the test is ASME/ANSI A112.19.2-2008/Canadian Standards Association (CSA) B45.1-08 – Ceramic Plumbing Fixtures. Currently, DOE has a rulemaking in progress to update the federal test procedure for toilets and urinals to ASME/ANSI A112.19.2-2008/CAS B45.1-08 (77 Fed. Reg. 104, 30 May 2012, 78 Fed. Reg.67, 8 April 2013).

In 2001, ASME published ASME A112.19.14 – Six Liter Water Closets Equipped with a Dual Flushing Device, which established requirements for dual-flushing toilets. The tests specified in A112.19.14 are for removal of liquid waste and toilet tissues that are expected in a reduced volume flush and uses a ratio of two reduced-volume flush to one full-volume flush to calculate the effective flush volume of dual-flush toilets. WaterSense uses ASME A112.19.14 for dual-flush toilets. DOE has indicated that they do not plan on using ASME A112.19.14 for dual-flush toilets because there is not sufficient documentation to justify or verify the 2:1 flush ratio.

The CA IOUs reviewed seven studies that assessed usage patterns of dual-flush toilets in residential and nonresidential buildings. The studies indicate that the 2:1 ratio is likely too high. The studies also suggest that (1) building type (residential or nonresidential), (2) whether the toilet is installed in a restroom that also has a urinal, (3) education on proper use of dual-flush toilets, and (4) the design of the flush valve itself are some of the variables that need to be considered when determining an appropriate ratio for dual-flush toilets. See 12Appendix E: for a summary of results from the literature review.

When water closets or urinals with electronic flushing devices are being tested, Section 7.4.3 of ASME A112.19.2-2008/CAS B45.1-08 directs the test operator to "trip the actuator" to initiate the flush being measured. This allows the test operator to use the mechanical actuator on a hands-free valve rather than the electronic sensor. The efficacy of the sensor in the electronic flush device is never subjected to testing under the ASME procedure, even though the sensor feature can contribute to excessive water consumption of the tested unit if the sensor in the flushing device is not installed or commissioned properly and the flushing mechanism triggers phantom flushes. The CASE Team is not aware of any existing methodology to test the sensor accuracy.

***Performance***

As toilets become more water efficient it is important that they maintain their utility (that is, their ability to move waste from the bowl to the drainline). A toilet with a low gpf rating does not achieve the rated flush volume if it takes more than one flush to effectively eliminate solid waste. Uncertainty resulting from not knowing a toilet's waste extraction capability may result in consumers opting for higher volume toilets as a proxy for the assumed waste extraction capability being a function of flush volume.

Federal law requires performance tests for flushing urinals. ASME A112.19.2/CBA B45.4 includes performance tests, but WaterSense and others have expressed concern that the ASMW performance tests are not sufficient.

There are a number of voluntary test procedures for toilets that are designed to confirm quality performance and thereby help ensure high consumer satisfaction. Many local water utilities require voluntary tests in order for products to qualify for rebate programs. There are a number of standards developed by water utilities or third parties. The most widely used voluntary test is the Maximum Performance (MaP) Testing: Toilet Fixture Performance Testing Protocol: Version 5 – March 2013, which classifies how well a toilet removes waste. The MaP test protocol is a result of a collaboration of 22 organizations from the United States and Canada. Since the test became available in 2003, the voluntary test has been widely accepted and used by toilet manufacturers, water utilities, and standards-setting bodies. As of May 2013, more than 2,900 toilet models have been tested by independent third-party MaP approved laboratories. Over 80 manufacturers representing over 100 brands are participating in the MaP program. This data suggests that most manufacturers are already voluntarily performing MaP testing on a wide range of products.

The Los Angeles Department of Water and Power (LADWP) Requirements for Ultra-Low-Flush-Toilets, Supplementary Purchase Specification to ASME A112.19.2 (LADWP SPS) is another voluntary test method that is widely used (Veritec Consulting Inc. & Koeller and Company 2010, LADWP 2005). The LADWP SPS establishes requirements for chemical-resistant flappers and a maximum flush volume under maximum adjustment conditions.

It is difficult and costly for manufacturers to develop products that meet multiple voluntary standards, especially when those standards lack uniformity and sometimes include contradictory requirements. By the early 2000s it became evident that voluntary performance standards needed to be more consistent. In 2004 the plumbing industry and water utilities combined the MaP and LADWP SAS standards to create the Uniform North American Requirements (UNAR) for Toilet Fixtures: Guidelines and Specifications. UNAR is a voluntary system to qualify toilets that achieve sustainable water savings and ensure a high level of customer satisfaction with flushing performance.

The WaterSense specification for tank-type toilets includes performance standards that are based on the UNAR specifications. Many utilities are now requiring that tank-type toilets be WaterSense labeled in order to receive rebates. The high-efficiency toilet standards in the states of Georgia and Texas require tank-type toilets to be WaterSense labeled. AB 715 mirrors the standards in Georgia and Texas in that tank-type toilets in California would also need to be certified according to the WaterSense specification.

Standards for stainless steel urinals are in ASME/ANSI A112.19.3, and standards for plastic urinals are in the International Association of Plumbing and Mechanical Officials (IAPMO) Z124.9. Pressurized flushing devices must comply with American Society of Sanitary Engineering (ASSE) #1037—*Pressurized Flushing Devices (Flushometers) for Plumbing Fixtures*.

Table 5.1 below lists the test procedures that are referenced in various federal and state codes and standards for toilets and urinals.

**Table 5.1 Test Procedures Currently Referenced in Federal and State Standards**

| Standard, Legislation, or Specification | Current Reference Test Procedure(s) |
|---|---|
| Federal Appliance Standards | ASME/ANSI) A112.19.6-1995 [1] |
| California Appliance Efficiency Standards (Title 20) | ASME/ANSI) A112.19.6-1995 |
| California Assembly Bill 715 | ASME/ANSI A112.19.2-2003<br>ASME/ANSI A112.19.14-2001, as applicable |
| California Green Building Standards (CALGreen / Part 11 of Title 24) | ASME A112.19.2/CBA B45.4<br>ASME/ANSI A112.19.14 |
| WaterSense High-efficiency Toilet Specification | ASME A112.19.2/CBA B45.4<br>ASME/ANSI A112.19.14<br>UNAR[2] |
| WaterSense High-efficiency Urinals Specification | ASME A112.19.2/CBA B45.4<br>ASME/ANSI A112.19.3<br>IAPMO Z124.9<br>ASSE #1037 |
| Georgia Standard | ASME/ANSI A112.19.2-2003<br>ASME/ANSI A112.19.14-2001, as applicable<br>WaterSense Listed |
| Texas Standard | ASME A112.19.2-2008/CBA B45.4-2008<br>ASME/ANSI A112.19.14-2006, , as applicable<br>WaterSense Listed |

1. DOE is currently considering revisions to the test procedure for toilets and urinals. It is likely that DOE will adopt ASME 112.19.2-2008 (Docket No. EERE–2011–BT–TP–0061).
2. The WaterSense Toilet Specification is based on UNAR, but made several significant changes to the water-efficiency and performance criteria (WaterSense 2007).

Source: CASE Team analysis 2013

### 5.1.2 Proposed Test Methods

The proposed test method to verify flush volume is ASME/ANSI A112.19.2-2008. Dual-flush toilets cannot use more than 1.28 gpf for the full-volume flush.

The CA IOUs are recommending that toilets sold in California achieve a MaP score for waste extraction performance. The MaP Waste Extraction Test would be required for every basic model combination that is submitted for certification. Consistent with the WaterSense Specification for Tank-Type Toilets, flush performance criteria should apply to single-flush toilets and to the full-volume flush option of dual-flush toilets.

## 5.2 Water and Energy Use per Unit for Non-Qualifying Products

Table 5.2 presents the water and energy use for non-qualifying products. Non-qualifying products are products that do not meet the proposed standard described in Section 10.1 of this report.

The methodology used to calculate these estimates is presented in the following sections.

**Table 5.2 Average Water & Energy Use for Non-Qualifying Products**

| Product Class | Unit Water Consumption (gal/yr) | Embedded Electricity Consumption (kWh/yr) |
|---|---|---|
| Residential Toilets | 4,313 | 43 |
| Commercial Toilets | 2,468 | 25 |
| Urinals | 3,323 | 33 |

Source: CASE Team analysis 2013

### 5.2.1 Residential Toilets

To calculate the amount of water non-qualifying product use in California, the CASE Team estimated how many times each toilet is flushed per day, on average. This was achieved by multiplying the total population of California by the estimated number of flushes per person per day, then dividing by the estimated number of toilets in California (see Equation 5.1 below). We used data from 2010 to establish the daily flushes per toilet value, and it was assumed that the daily flushes per toilet value would remain constant throughout the modeled time period. Using the values presented in Table 5.3, it was determined that residential toilets are flushed 7.4 times per day.

**Equation 5.1 Average Number of Flushes per Residential Toilet in California**

$$Daily\ Flushes\ per\ Toilet =$$

$$Population\ of\ California\ x\ Flushes\ per\ Person\ per\ Day\ \div Number\ of\ Toilets\ in\ California$$

**Table 5.3 Assumptions Used to Calculate Daily Flushes per Toilet for Residential Toilets**

| Metric | Value | Source |
|---|---|---|
| California Population in 2010 | 37.3 million | California Department of Finance population estimates, May 2012 |
| Flushes per Person per Day | 4.76 | Aquacraft 2011, 134 |
| Number of Toilets Installed in California in 2010 | 24.1 million | See Section 6.1of this report. |

Source: CASE Team analysis 2013

Next the daily flushes-per-toilet value was multiplied by water use per flush and the number of days the toilet is flushed per year (see Equation 5.2). It was assumed that newly installed toilets will consume 1.6 gpf (the minimum efficiency level that is currently included in Title 20) and that residential toilets will be flushed 365 days per year. Using these assumptions, the average non-qualifying residential toilet uses approximately 4,313 gallons of water per year.

**Equation 5.2 Average Annual Water Use per Residential Toilet in California**

$$Annual\ Water\ Use\ per\ Toilet =$$
$$Daily\ Flushes\ per\ Toilet\ x\ Baseline\ Flush\ Volume\ x\ Flush\ Days\ per\ Year$$

The non-qualifying product energy use is attributed to the energy embedded in water. That is, the amount of energy required to supply, convey, make water potable, deliver, collect, and treat wastewater. For this analysis, it was assumed that every million gallons of water used for an indoor application in California is attributable to 10,045 kWh of electricity use. Appendix A: describes the methodology for calculating the embedded energy value. It is estimated that the average non-qualifying residential toilet is associated with 43.3 kWh of embedded electricity use per year.

### 5.2.2 Commercial Toilets

The annual per unit non-qualifying flush volume from commercial toilets was calculated in a similar manner as the non-qualifying residential toilets. Instead of using the entire California population to determine flushes per toilet per day (see Equation 5.1), the calculation for commercial toilets relies on the employed population, which will result in a more realistic approximation of flush frequencies in commercial buildings. Recent studies have found that on average, females flush a commercial toilet three times per day whereas males flush one time per day (D&R International 2005). Using the values presented in Table 5.4, on average, commercial toilets are flushed 5.9 times per day.

Annual water use was calculated using Equation 5.2. For non-qualifying product, it is assumed that newly installed toilets would achieve 1.6 gpf (the minimum efficiency level that is currently included in Title 20). It is assumed that commercial fixtures will be flushed 260 days per year, the total number of non-weekend days in a year. Using these assumptions, an average non-qualifying commercial toilet consumes 2,468 gallons per year with an associated embedded electricity use of 24.8 kWh per year.

**Table 5.4 Assumptions Used to Calculate Daily Flushes per Toilet for Commercial Toilets**

| Metric | Value | Source |
|---|---|---|
| California Employed (non-farm) Population 2010 | 13.9 million | California Employment Development Department; Labor Market Information Division; Seasonally Adjusted; March 2011 Benchmark |
| Percentage of employed workers that are male and female | 55% male<br>45% female | U.S. Census |
| Flushes per Person per Day | 3 per female<br>1 per male | Aquacraft 2011, 134 |
| Number of Commercial Toilets Installed in California in 2010 | 4.5 million | See Section 6.1 of this report. |

Source: CASE Team analysis 2013

### 5.2.3 Urinals

The annual per fixture water use for non-qualifying urinals was calculated using the same methodology as residential and commercial toilets. It is assumed that the average urinal is flushed approximately 18 times per day and is in use 260 days per year (WaterSense 2009). It is also assumed that 42 percent of the non-qualifying urinals consume 1.0 gpf (the minimum efficiency level that is currently included in Title 20) and 58 percent of the non-qualifying urinals consume 0.5 gpf (the AB 715 minimum efficiency level). Using these assumptions, the average non-qualifying urinal consumes 3,323 gallons of water per year with an associated embedded electricity use of 33.4 kWh per year.

## 5.3 Efficiency Measures

A toilet is considered high-efficiency if it consumes no more than 1.28 gpf. Urinals are considered efficient if they consume no more than 0.125 gpf.

## 5.4 Water & Energy Use per Unit for Qualifying Products

Table 5.5 presents the water and energy use for qualifying products. Qualifying products are products that do meet the proposed standard described in Section 11.1 of this report. The impacts of the replacement valve standard are not included in the analysis because the replacement valve standard does not, in itself, result in savings. Enforcing Senate Bill 407 (2009) will result in water savings (see Section 9.2.2 for further discussion of Senate Bill 407). The proposed replacement valve standard will help improve compliance with the bill. The methodology used to calculate these estimates is described in the following sections.

**Table 5.5 Average Water & Energy Use for Qualifying Products**

| Product Class | Unit Water Consumption (gal/yr) | Embedded Electricity Consumption (kWh/yr) |
|---|---|---|
| Residential Toilets | 3,450 | 35 |
| Commercial Toilets | 1,974 | 20 |
| Urinals | 585 | 6 |

### 5.4.1 Residential Toilets

The per fixture water and energy use for the qualifying products was calculated in the same manner as the non-qualifying products' water and energy use with the exception that qualifying toilets consume 1.28 gallons per flush. Each qualifying residential toilet is expected to consume 3,450 gallons per year with an associated embedded energy use of 34.7 kWh per year.

### 5.4.2 Commercial Toilets

The per fixture water and energy use for qualifying products was calculated in the same manner as the non-qualifying products' water and energy use with the exception that qualifying toilets consume 1.28 gallons per flush. Each qualified commercial toilet is expected to consume 1,974 gallons per year with an associated embedded energy use of 19.8 kWh per year.

### 5.4.3 Urinals

The per fixture water and energy use for qualifying products was calculated in the same manner as the non-qualifying products' water and energy use with the exception that for the qualifying toilets would consume 0.125 gallons per flush. Each qualified urinal is expected to consume 585 gallons per year with an associated embedded energy use of 5.9 kWh per year.

# 6 Market Saturation & Sales

## 6.1 Current Market Situation

### 6.1.1 Total Stock and Shipments

Table 6.1 presents the estimated existing stock and annual sales of toilets and urinals. The projections include both qualifying and non-qualifying products. The sections below explain the methodology used to arrive at the sales and stock projections.

**Table 6.1 California Annual Sales and Stock (2012 – 2040)**

| | Residential Toilets | | Commercial Toilets | | Urinals | |
|---|---|---|---|---|---|---|
| Year | Annual Sales | Stock | Annual Sales | Stock | Annual Sales | Stock |
| 2012 | 1,250,866 | 24,597,887 | 393,539 | 4,525,964 | 99,073 | 1,139,411 |
| 2013 | 1,265,910 | 24,869,035 | 396,293 | 4,557,646 | 99,073 | 1,139,411 |
| 2014 | 1,281,279 | 25,144,533 | 399,067 | 4,589,549 | 99,767 | 1,147,387 |
| 2015 | 1,296,852 | 25,424,409 | 401,861 | 4,621,676 | 100,465 | 1,155,419 |
| 2016 | 1,312,744 | 25,708,800 | 404,674 | 4,654,028 | 101,168 | 1,163,507 |
| 2017 | 1,328,876 | 25,997,766 | 407,507 | 4,686,606 | 101,877 | 1,171,652 |
| 2018 | 1,345,289 | 26,291,399 | 410,359 | 4,719,413 | 102,590 | 1,179,853 |
| 2019 | 1,362,014 | 26,589,820 | 413,232 | 4,752,448 | 103,308 | 1,188,112 |
| 2020 | 1,378,992 | 26,893,089 | 416,124 | 4,785,716 | 104,031 | 1,196,429 |
| 2021 | 1,396,171 | 27,201,211 | 419,037 | 4,819,216 | 104,759 | 1,204,804 |
| 2022 | 1,413,626 | 27,514,266 | 421,971 | 4,852,950 | 105,493 | 1,213,238 |
| 2023 | 1,431,363 | 27,832,336 | 424,924 | 4,886,921 | 106,231 | 1,221,730 |
| 2024 | 1,449,386 | 28,155,502 | 427,899 | 4,921,129 | 106,975 | 1,230,282 |
| 2025 | 1,467,699 | 28,483,847 | 430,894 | 4,955,577 | 107,724 | 1,238,894 |
| 2026 | 1,486,307 | 28,817,456 | --- | --- | --- | --- |
| 2027 | 1,505,216 | 29,156,415 | --- | --- | --- | --- |
| 2028 | 1,524,430 | 29,500,813 | --- | --- | --- | --- |
| 2029 | 1,543,954 | 29,850,738 | --- | --- | --- | --- |
| 2030 | 1,563,794 | 30,206,280 | --- | --- | --- | --- |
| 2031 | 1,583,953 | 30,567,532 | --- | --- | --- | --- |
| 2032 | 1,604,439 | 30,934,587 | --- | --- | --- | --- |
| 2033 | 1,625,255 | 31,307,541 | --- | --- | --- | --- |
| 2034 | 1,646,408 | 31,686,490 | --- | --- | --- | --- |
| 2035 | 1,667,903 | 32,071,532 | --- | --- | --- | --- |
| 2036 | 1,689,746 | 32,462,767 | --- | --- | --- | --- |
| 2037 | 1,711,942 | 32,860,297 | --- | --- | --- | --- |
| 2038 | 1,734,497 | 33,264,225 | --- | --- | --- | --- |
| 2039 | 1,757,418 | 33,674,657 | --- | --- | --- | --- |
| 2040 | 1,780,709 | 34,091,698 | --- | --- | --- | --- |

***Residential Toilets***

It is estimated that 24.6 million toilets were installed in residential buildings in California in 2012. This estimate was derived using housing construction forecasts that were developed by the CEC for use in the 2013 Building Energy Efficiency Standards rulemaking (CEC 2012b). It is assumed that there were 2.12 toilets per single-family home (EBMUD 2002) and 1.4 toilets per multi-family housing unit or mobile unit

(D&R International 2005). The average number of toilets per housing unit is assumed to remain constant throughout the forecast period (2015 – 2040).

Annual sales are projected to be in the range of 1.3 and 1.4 million per year between 2015 and 2020. Total sales will be equal to toilets purchased for installation in newly constructed buildings and toilets purchased to replace existing toilets. Given the product lifetime of 25 years, it is assumed that four percent of existing toilets are replaced each year. These estimates of the California residential toilet stock are consistent with other recent estimates, which are summarized in a 2005 report from the California Urban Water Conservation Council (CUWCC). Figure 6.1 is an excerpt from the CUWCC report that compares results from three unique estimates of installed residential toilet stock. The stock projections used in the CASE analysis are consistent with projections from Mitchell-Calfed and Koeller (CUWCC 2005).

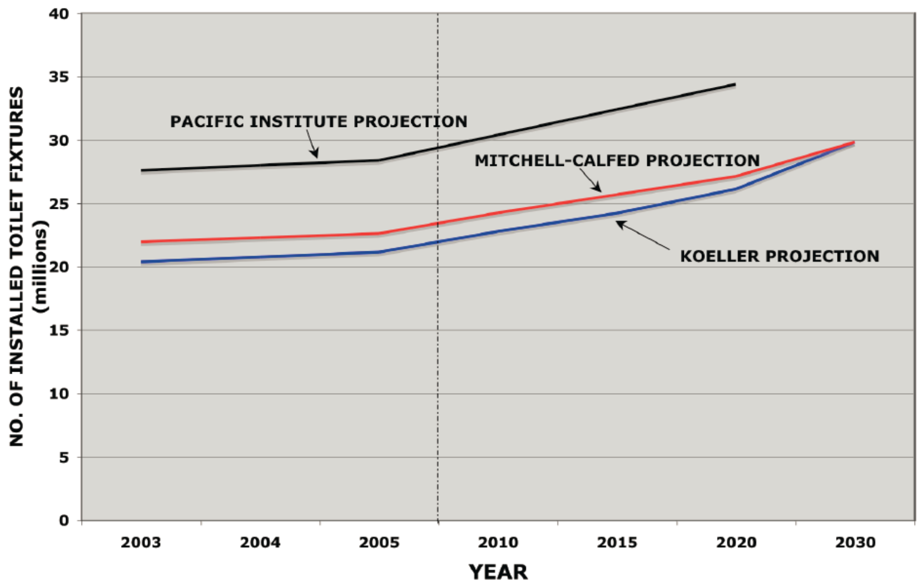



**Figure 6.1 Estimates of California Installed Residential Toilet Stock**
Source: CUWCC 2005, Figure 1

### *Commercial Toilets*

Prior to the effective date of EPAct 1992, it was estimated that 4.001 million toilets were installed in commercial, institutional, and industrial buildings. Recent estimates of the installed toilet stock reference this figure from the early 1990s and extrapolate based on employed population and toilet replacement rates (CUWCC 2005, D&R International 2005). The estimates prepared for this analysis followed a similar methodology. The count from 1992 was extrapolated out until 2007 based on employment rates. In 1992 there were 12.2 million non-farm employees in California and in 2007 there were 15.2 million non-farm employees (Cal EDD 2012). After 2007, it was assumed that the stock of commercial toilets would grow on average 0.7 percent per year, which is consistent with the projected nation-wide employment growth rates (USBLS 2012). Finally, it was assumed that 10 percent of the commercial toilets would actually be used for institutional applications that use blowout toilets and would therefore not be subject to the proposed standard.

Using this methodology it is estimated that there were approximately 4.5 million commercial toilets in California in 2012. Annual sales are projected to be in the range of 402,000 and 416,000 per year between

2015 and 2020. Given the product lifetime of twelve years in commercial settings, it is assumed that eight percent of existing toilets are replaced each year.

***Urinals***

As with commercial toilets there is no authoritative count of the existing stock of urinals. WaterSense and others have relied on estimating the number of urinals based the expected ratio of toilets to urinals installed at commercial facilities. The Uniform Plumbing Code currently requires specific ratios of toilets to urinals for buildings with 150 or more occupants. Using these ratios as a basis, one would expect to see one urinal for every three to four toilets. In other words, the total number of urinals is expected to be between 25 and 33 percent of the total commercial toilet count. To be conservative, it was assumed that the urinal count is 25 percent of the commercial toilet count (not including commercial toilets used for institutional purposes).

Using this methodology it is estimated that there were approximately 1.1 million urinals in California in 2012. Annual sales are projected to be in the range of 100,000 and 104,000 per year between 2015 and 2020. Given the product lifetime of twelve years, it is assumed that eight percent of existing toilets are replaced each year.

### 6.1.2 Market Share of High Efficiency Options

The market for plumbing fixtures is closely tied to the construction sector, so the housing market crisis and the subsequent recession have impacted toilet and urinal sales. Even though overall sales have not been as strong in recent years, high-efficiency products have been selling well.[2]

***Residential Toilets (Tank-type Toilets)***

The existing stock of residential toilets has a wide variety of products in terms of water efficiency. Between 2005 and 2010, Aquacraft Water Engineers Inc. used data loggers to meter actual water use of toilets installed in single-family houses located within the service territory of 11 water utilities in California. The water utilities were geographically representative of California's overall population. During the logging period, 122,869 unique toilet flushes were recorded. Water use per flush event ranged from less than 0.5 gpf to 6.75gpf. The average flush volume for all toilet flushes was 2.76 gpf, and 64 percent of all flushes were less than 2.75 gpf. The study found that about 67 percent of the installed toilets met the existing federal efficiency standard, having rated flush volumes of 1.6 or less. Thirteen percent of the installed toilets were classified as consuming 1.25 gpf or less, and three percent of the installed toilets consumed 1 gpf or less (Aquacraft 2011). This indicates that products that meet the proposed 1.28 gpf standard already held a significant market share before AB 715 took effect. Figure 6.2 presents some of the results from the study.

[2] As of May 2013 approximately 10 percent of the urinal models in CEC's Appliance Efficiency Database were waterless urinals (CEC 2013).

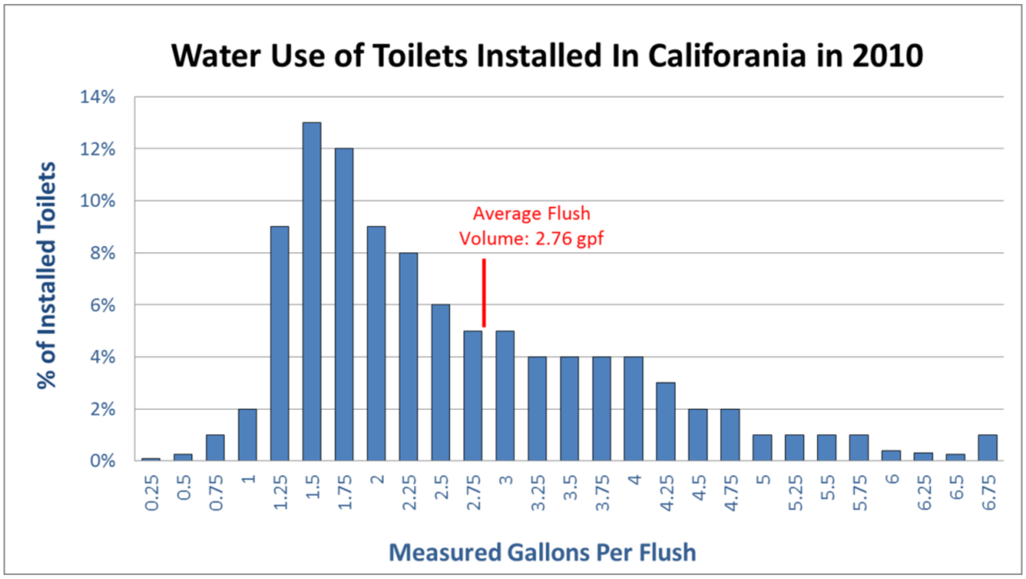



**Figure 6.2 Measured Water Use in Toilets Installed in California (2008)**
Source: Aquacraft 2011, 133-143.

Aquacraft found variability in the measured water use as compared to rated flush volume. Sixty percent of toilets rated at 1.6 actually use more than 1.6 gpf. The finding that toilets designed to consume no more than 1.6 gpf are actually consuming a higher volume of water is not a new discovery. In 2000, the City of Tucson conducted a study of residential customers who had received rebates for 1.6 gpf toilets in 1991 and 1992. The results indicated that nearly half of the aging high-efficiency toilets had high flush volumes, frequent double flushing, and/or flapper leaks. The average flush volume was 1.98 gpf, or about 24 percent higher than the 1.6 gpf design flush volume (Aquacraft. 2011, 52).

Aquacraft's finding that 1.28 gpf toilets are readily available is confirmed by the high number of WaterSense labeled tank-type toilets. As of July 2013, there were 1,805 unique WaterSense labeled residential toilets from 96 unique brand names. Manufacturers like American Standard Brands (brand names include American Standard, Crane, and Eljer), Kohler, Briggs, Gerber, and Toto offer a variety of tank-type toilets that use no more than 1.28 gpf or less. Nationwide it is estimated that about 50 percent of all tank-type toilets sold in the U.S. are Water Sense® labeled. [3]

***Commercial Toilets (Flushometer Toilets)***

A 2002 study performed by the East Bay Municipal Utility District (EBMUD) helped verify the water efficiency of the existing stock of commercial toilets. EBMUD surveyed the water efficiency of toilets installed in commercial toilets in its service territory. Though the survey only covers a small portion of the California building stock, it still provides useful insight into the water efficiency of the existing toilet stock. The results, which are presented in Figure 6.3, show that in 2002, 1.6 gpf rated toilets were the most common followed by toilets rated at 3.5 gpf.

[3] WaterSense®, a partnership program by the United States Environmental Protection Agency, has developed standards for high-efficiency toilets, urinals showerheads, irrigation controls, and faucets. WaterSense® maintains a list of WaterSense® Labeled Products that have undergone testing and certification by independent third-party entities.

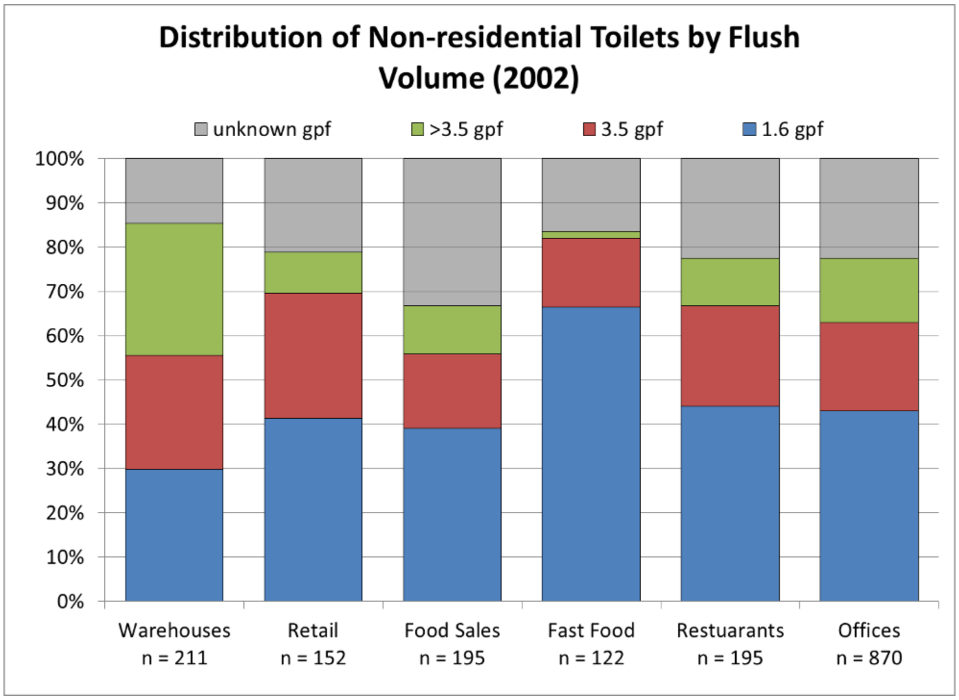



**Figure 6.3 Distribution of Non-residential Toilets by Flow Rate (2002)**
Source: EBMUD 2002.

### *Dual-flush Toilets*

Dual-flush toilets represent a growing market segment of high-efficiency toilets. The first dual-flush toilet was introduced to the U.S. market in 1998. By 2005, there were 44 dual-flush models available. As of July 2013 there are 624 WaterSense Labeled tank-type dual-flush models from 66 unique brand names. This represents 35 percent of all WaterSense Labeled toilets. In recent years, the number of dual-flush flushometer toilets available on the market has also increased.

### *Urinals*

As of July 2013, there were 256 unique WaterSense labeled urinal fixtures, valves and systems from 19 unique brand names. To be WaterSense labeled, urinals must consume no less than 0.5 gallons per flush. However, 35 percent of all WaterSense labeled urinal fixtures, valves, and systems far exceed the minimum efficiency standard and consumed just 0.125 gpf; 48 percent of the labeled urinal systems are rated at 0.125 gpf. The quantity and variety of high-efficiency urinals available for sale is an indication that qualifying products are readily available in California and throughout the United States.

The 2002 EBMUD survey referenced above also includes an analysis of the water efficiency of urinals installed in its service territory. As mentioned, the survey only covers a small portion of the California building stock, and researchers were not able to determine the flush volume of a significant portion of the urinals. Nonetheless, the survey provides some insight into the water efficiency of urinals currently installed in buildings. The results, which are presented in Figure 6.4, indicate that urinals that consume less than 2.0 gpf are more prevalent than inefficient (>2gpf) urinals. Considering the federal 1.0 gpf has been in effect since 1994, and the useful life of urinals is at least 12 years, it is not surprising that a fair number of urinals rated over 1.0 gpf were in use in 2002 – just eight years after the standard took effect.

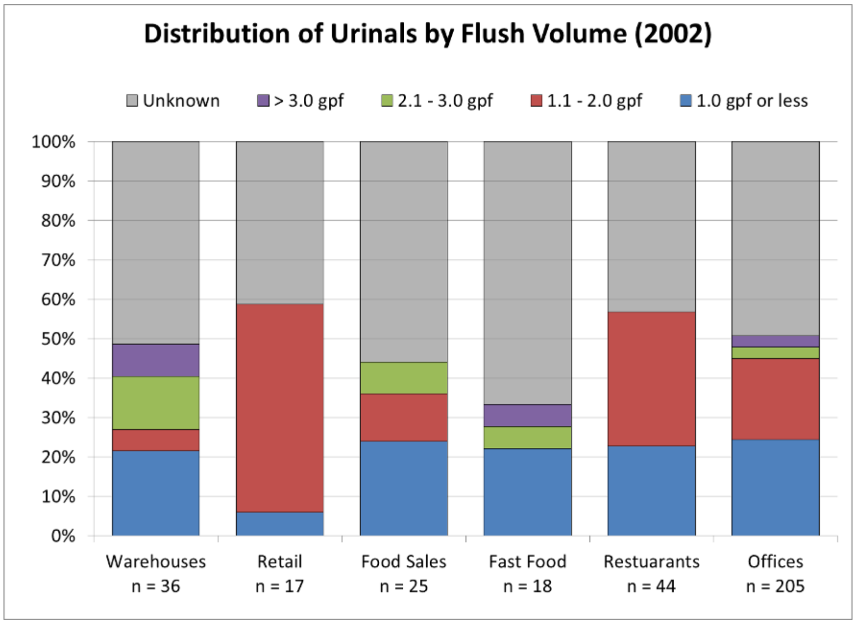



**Figure 6.4 Distribution of Urinals by Flush Volume (2002)**
Source: EBMUD 2002.

## 6.2 Future Market Adoption of High Efficiency Options

The future market adoption of high-efficiency toilets and urinals in California is influenced by the provisions of Senate Bill 407 (Padilla 2009) and Assembly Bill 715 (Laird 2007). SB 407 requires toilets and urinals installed in residential and commercial buildings constructed before 1994 to be replaced with more efficiency fixtures by 2017 (single-family buildings) or 2019 (multi-family and commercial buildings). According to SB 407, by 2019 all toilets and urinals installed in California will be at least 1.6 gpf and 1.0 gpf, respectively.

AB 715 requires all new toilets and urinals sold in California after January 1, 2014 to have a minimum efficiency rating of 1.28 gpf and 0.5 gpf. If a 100 percent compliance rate is achieved, all new toilets and urinals sold in California after 2014 will achieve these efficiency levels.

Provisions in AB 715 include a phase-in period between 2010 and 2014. During this period manufacturers must increase the percentage of compliant models available for sale in California according to the following schedule:

- Fifty percent in 2010
- Sixty-seven percent in 2011
- Seventy-five percent in 2012
- Eighty-five percent in 2013
- One hundred percent in 2014 and thereafter

Code compliance is an important factor to consider. Standards for toilets and urinals have not been updated since 1992, thus, manufacturers and code enforcement bodies have not been required to adapt to a new code in recent years. The standard was modified through legislation as opposed to the CEC's code adoption process. In general, stakeholders have more opportunity to participate in the standards setting process when the CEC adopts efficiency standards as opposed to the legislature. Participation in the standards setting rulemaking can also help compliance when the standards take effect as stakeholders are well informed about the standards before they take effect. Finally, AB 715 created a temporary compliance pathway that will be superseded when Title 20 is updated.[4,5] Generally speaking, temporary compliance pathways are not as effective as well established compliance and enforcement mechanisms. The CEC has a well-established code enforcement protocol that is applied to all products covered by Title 20, and temporary enforcement mechanisms are not as effective as the Title 20 enforcement mechanisms.

The savings values presented in this report assume 80 percent compliance with the AB 715 standards. To be consistent with other proposed Title 20 code changes, the savings estimates presented in this report assume the market share of AB 715 compliant products will remain constant at 2013 levels throughout the evaluation period. The savings are attributable to the incremental savings due to increased compliance and enforcement for the toilet and urinal standards and the more stringent 0.125 gpf urinal standard. Savings associated with moving from the pre-AB 715 efficiency standards to the post-adoption Title 20 standards at 100 percent compliance are much higher than the estimates presented in this report.

[4] To comply with AB 715, each manufacturer that sells water closets or urinals in California must disclose the percentage of high-efficiency toilets and urinal models offered for sale compared with the total number of toilet and urinal models offered for sale. Manufacturers have to report this information for each year between 2010 and 2013.

[5] AB 715 states: "… [Provisions of AB 715] would remain operative only until January 1, 2014, or until the date on which the California Building Standards Commission includes standards in the California Building Standards Code that conform to these requirements, whichever date is later."

# 7 Savings Potential

## 7.1 Statewide California Energy Savings

Revisions to the toilet standards will bring Title 20 language into conformity with existing California law, as enacted by AB 715. The proposed code change would set the efficiency level for toilets at the same level that was enacted by AB 715. The proposed efficiency standard for urinals in more stringent than the standard level adopted through AB 715.

Table 7.1 presents the estimated water energy use if the proposed changes are not adopted and the Title 20 standards remain unchanged (Non-standards Case). Table 7.2 presents the estimated water and energy use if the proposed standard is adopted (Standards Case). Table 7.3 presents the estimated water and energy savings if the proposed standards are adopted. As mentioned above, the savings estimates presented in Table 7.3 represent the savings achieved through improved compliance with AB 715 standards and improving the urinal standard from 0.5 gpf (AB 715 level) to 0.125 gpf.

The annual sales values represent the water or energy use (or savings) associated with products sold during a given year. The stock values represent the water or energy use (or savings) associated with all products that are *installed* and operational during a given year. Statewide savings estimates were calculated by applying the unit water and energy savings, which are presented in Section **Error! Reference source not found.** of this report, to the statewide stock and sales forecast presented in Section 6 of the report.

There are no demand savings associated with the proposed code change.

**Table 7.1 California Statewide Non-Standards Case Water & Energy Use**

| | **Annual Sales** | | **Stock** | |
|---|---|---|---|---|
| Product Class | Water Consumption (Mgal/yr) | Embedded Electricity Consumption (GWh/yr) | Water Consumption (Mgal/yr) | Embedded Electricity Consumption (GWh/yr) |
| 2015 (first year standard is in effect) | | | | |
| Residential Toilets | 4,832 | 49 | 116,859 | 1,174 |
| Commercial Toilets | 857 | 9 | 10,104 | 101 |
| Urinals | 268 | 3 | 3,165 | 32 |
| **Total** | **5,957** | **59.8** | **130,127** | **1,307** |
| 2026 (year commercial toilet and urinal stock turns over) | | | | |
| Commercial Toilets | 925 | 9 | 10,686 | 107 |
| Urinals | 290 | 3 | 3,347 | 34 |
| **Total** | **1,215** | **12.2** | **14,034** | **141** |
| 2038 (year residential toilet stock turns over) | | | | |
| Residential Toilets | 6,548 | 66 | 140,948 | 1,416 |

Source: CASE Team analysis 2013

**Table 7.2 California Statewide Standards Case Water & Energy Use**

| Product Class | Annual Sales: Water Consumption (Mgal/yr) | Annual Sales: Embedded Electricity Consumption (GWh/yr) | Stock: Water Consumption (Mgal/yr) | Stock: Embedded Electricity Consumption (GWh/yr) |
|---|---|---|---|---|
| 2015 (first year standard is in effect) | | | | |
| Residential Toilets | 4,474 | 45 | 116,501 | 1,170 |
| Commercial Toilets | 793 | 8 | 10,040 | 101 |
| Urinals | 59 | 1 | 2,955 | 30 |
| **Total** | **5,326** | **54** | **130,127** | **1,301** |
| 2026 (year commercial toilet and urinal stock turns over) | | | | |
| Commercial Toilets | 857 | 9 | 9,895 | 99 |
| Urinals | 63 | 1 | 733 | 7 |
| **Total** | **920** | **9** | **10,628** | **107** |
| 2038 (year residential toilet stock turns over) | | | | |
| Residential Toilets | 6,063 | 61 | 130,508 | 1,311 |

Source: CASE Team analysis 2013

**Table 7.3 California Statewide Water & Energy Savings Standards Case**

| Product Class | Annual Sales: Water Savings (Mgal/yr) | Annual Sales: Embedded Electricity Savings (GWh/yr) | Stock: Water Savings (Mgal/yr) | Stock: Embedded Electricity Savings (GWh/yr) |
|---|---|---|---|---|
| 2015 (first year standard is in effect) | | | | |
| Residential Toilets | 358 | 3.6 | 358 | 3.6 |
| Commercial Toilets | 63 | 0.6 | 63 | 0.6 |
| Urinals | 210 | 2.1 | 210 | 2.1 |
| **Total** | **631** | **6.3** | **631** | **6.3** |
| 2026 (year commercial toilet and urinal stock turns over) | | | | |
| Commercial Toilets | 69 | 0.7 | 792 | 8.0 |
| Urinals | 226 | 2.3 | 2,614 | 26.3 |
| **Total** | **295** | **3.0** | **3,406** | **34.2** |
| 2038 (year residential toilet stock turns over) | | | | |
| Residential Toilets | 485 | 4.9 | 10,441 | 104.9 |

Source: CASE Team analysis 2013

## 7.2 Other Benefits and Penalties

The estimated greenhouse gas emissions savings that would be achieved if the proposed standard were adopted are presented in

Table 7.4.

**Table 7.4 California Statewide Greenhouse Gas Savings for Standards Case**

| Product Class | Annual GHG Savings First-Year Sales (MTCO2e/yr) | Stock GHG Savings (MTCO2e/yr) |
|---|---|---|
| 2015 (first year standard is in effect) | | |
| Residential Toilets | 1,571 | 1,571 |
| Commercial Toilets | 279 | 279 |
| Urinals | 920 | 920 |
| **Total** | **2,770** | **2,770** |
| 2026 (year commercial toilet and urinal stock turns over) | | |
| Commercial Toilets | 279 | 2,243 |
| Urinals | 681 | 11,475 |
| **Total** | **960** | **13,718** |
| 2038 (year residential toilet stock turns over) | | |
| Residential Toilets | 1,331 | 45,831 |

Source: CASE Team analysis 2013

Note: Assumes 437 metric tons of $CO_2$ equivalents (MTCO2e) per GWh of electricity saved.

## 7.1 State or Local Government Costs and Savings

There are no known additional costs to state or local governments from the implementation of the standards proposal, given the CEC's existing authority for establishing appliance standards and staffing to administer the process. Energy savings are expected for local and state governments from the purchase of more efficient products as a result of the proposed standard, with the savings amount dependent on the volume of products purchased.

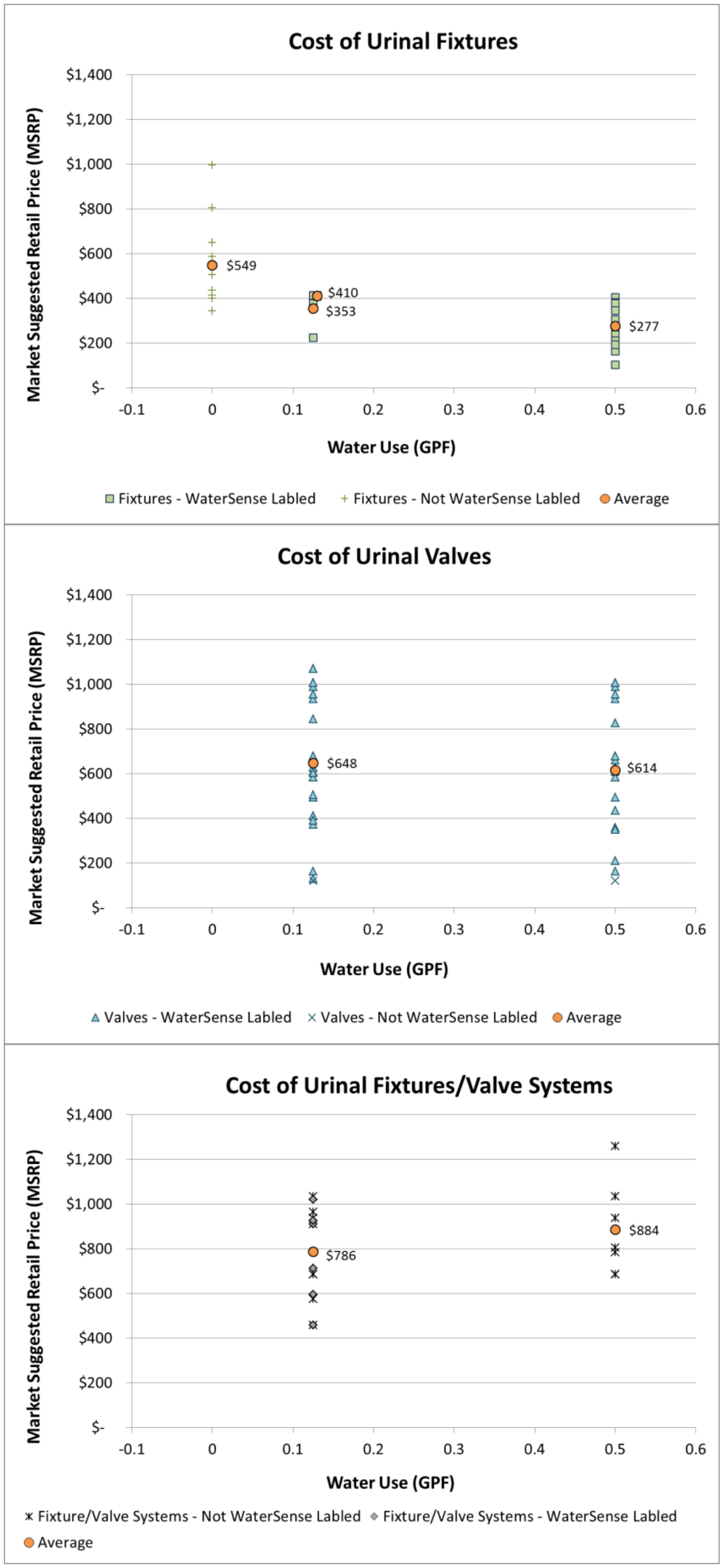
# 8 Economic Analysis

## 8.1 Incremental Cost

According to WaterSense, the incremental cost of a 1.6 gpf toilet and a 1.28 gpf toilet is minimal, as is the incremental cost between 1.0 gpf and 0.5 gpf urinals (WaterSense 2007, WaterSense 2009a). The price appears to be dominated by features, not by flush volume.

WaterSense did not evaluate the incremental cost of urinals that exceed 0.5 gpf. The CASE Team evaluated the cost of fixtures (bowls) and valves (flush mechanisms) rated between 0 gpf (waterless) and 0.5 gpf that are available on the market. Results of this analysis are presented in Figure 8.1. The average cost of 0.5 gpf fixtures, valves, and fixture-valve systems was $353, $648, and $786 respectively. The average cost of 0.125 gpf fixtures, valves, and fixture-valve systems was $277, $614, and $884 respectively. This analysis suggests that there is an overall price premium of $77 and $33 for 0.125 gpf fixtures and valves, respectively, over the 0.5 gpf alternatives. This represents a premium of about 12 percent. However, some manufacturers like American Standard offer 0.125 gpf, 0.5 gpf, and 1.0 gpf urinal systems with similar features for the same price.[6] These systems come with the fixture and the valve for one packaged price.

[6] For example, the American Standard Washbrook Urinals System with Selectronic Flush Valve is available in a 0.125 gpf, 0.5 gpf, or 1.0 gpf configuration; all three packages retail for $938. Model numbers are: 6590.525, 6590.505, and 6501.61.




(a)

(b)

(c)

**Figure 8.1 Cost of 0 gpf – 0.5 gpf Urinal Fixtures (a), Valves (b), and Fixture/Valve Systems (c)**

Source: CASE Team analysis 2013

## 8.2 Design Life

The analysis presented in this report assumes that residential toilets have a lifetime of 25 years and commercial toilets and urinals have a lifetime of 12 years. These lifetime estimates are conservative, as there is evidence the toilets and urinals often last for significantly longer.

In 2011, Aquacraft, Inc. Water Engineering and Management published a study of water use trends in California single-family homes. The study found that 24 percent of all registered toilet flushes consumed 3.5 gallons or more. This indicates that many toilets installed in California during the study period (2005-2010) were rated at 3.5 gpf or more. Considering the 1.6 gpf minimum efficiency standard took effect in 1978 and all toilet sold after that time had to be rated at 1.6 gpf or less, these 3.5 gpf toilets that were identified in the 2005-2010 time period were well over 25 years old (Aquacraft 2011).

A 2002 study performed by East Bay Municipal Utility District (EBMUD) sheds light on the lifetime of commercial toilets. In 2002, EBMUD surveyed the water efficiency of toilets and urinals installed in commercial buildings in its service territory. The survey only covered a small portion of the California building stock, but the survey provides some insight into the water efficiency of the existing toilet stock. The results, which are presented in Figure 6.2 and Figure 6.3, indicate a significant number of toilets (between 17 and 56 percent depending on building type) consume 3.5 gpf or more. Considering that toilets sold in California after 1978 had to consume 1.6 gpf or less, it is likely that the 3.5 gpf toilets that were still installed in commercial buildings in 2002 were over 25 years old (EBMUD 2002).

In 2005, D&R International developed a report for the U.S. EPA that assumes a replacement rate of 5 percent for residential toilets and 8 percent for urinals and commercial toilets. This corresponds to a product lifetime of 20 years and 12.5 years, respectively. Findings from the D&R International report were used in support of WaterSense standards (D&R International 2005).

## 8.3 Lifecycle Cost / Net Benefit

The lifecycle cost and benefits of the proposed standards are presented in

Table 8.1 and Table 8.2. Since there is no cost premium on high-efficiency toilets, adopting the standard will not result in any economic burden to consumers. Qualifying urinals do cost more than non-qualifying products, but it is estimated that over the lifetime of the product consumers will save money through reduced water costs.

**Table 8.1 Costs and Benefits per Unit for Qualifying Products**

| | | **Lifecycle Costs per Unit (Present Value $)** | | | **Lifecycle Benefits per Unit (Present Value $)** | | |
|---|---|---|---|---|---|---|---|
| Product Class | Design Life (years) | Incremental Cost | Add'l Costs | **Total PV Costs** | Water Savings [a] | Add'l Benefits | **Total PV Benefits** |
| 2015 (first year standard is in effect) | | | | | | | |
| Residential Toilets | 25 | $0 | $0 | **$0** | $121 | $0 | **$121** |
| Commercial Toilets | 12 | $0 | $0 | **$0** | $49 | $0 | **$49** |
| Urinals | 12 | $92 | $0 | **$92** | $274 | $0 | **$274** |
| **Total** | | **$92** | **$0** | **$92** | **$444** | **$0** | **$444** |

PV = Present Value

a. Calculated using the CEC's average statewide present value statewide energy rates that assume a 3% discount rate (CEC 2012a).

**Table 8.2 Lifecycle Costs and Benefits for Qualifying Products**

| Product Class | Lifecycle Benefit / Cost Ratio[a] | Net Present Value ($)[b, c] | | |
|---|---|---|---|---|
| | | Per Unit | First Year Sales ($million) | Stock Turnover [d] ($ million) |
| Residential Toilets | n/a | $121 | $50 | $744 |
| Commercial Toilets | n/a | $49 | $6 | $68 |
| Urinals | 2.98 | $182 | $14 | $145 |
| **Total** | | **$352** | **$70** | **$957** |

a. Total present value benefits divided by total present value costs.
b. Positive value indicates a reduced total cost of ownership over the life of the appliance.
c. Cost savings will be realized through lower water bills. See Appendix B: for more details on water rate assumptions. The analysis does not include cost savings associated with embedded energy savings.
d. Stock Turnover NPV is calculated by taking the sum of the NPVs for the products purchased each year following the standard's effective date through the stock turnover year, i.e., the NPV of "turning over" the whole stock of less efficient products that were in use at the effective date to more efficient products, plus any additional non-replacement units due to market growth, if applicable. For example, for a standard effective in 2015 applying to a product with a 5 year design life, the NPV of the products purchased in the 5th year (2019) includes lifecycle cost and benefits through 2024, and therefore, so does the Stock Turnover NPV.

# 9 Acceptance Issues

## 9.1 Infrastructure Issues

### 9.1.1 Potential Barriers and Compliance Issues

***Fixture and Valve Configurations for Test Procedure***

California currently uses the federal test procedure for toilets and urinals. Stakeholders have expressed concern that the DOE's definition of a "basic model," which must be tested to ensure compliance with the standard, is not clear enough. Manufacturers do not always know which combination of fixtures (bowls) and valves (flushing mechanism) should be tested, and the confusion has complicated testing, reporting, labeling, and overall compliance of toilets and urinals standards. In its recent Notice of Proposed Rulemaking, DOE offered a new interpretation of the existing definition of a "basic model," but DOE does not intend to change the definition that appears in the code language (77 Fed. Reg. 104, 30 May 2012).

The proposed revision to Title 20 does not include an alternative definition of "basic model." To avoid confusion, it is recommended that the CEC take steps in its compliance efforts, including phone calls and workshops with manufacturers, to clearly state which combinations of fixtures and valves need to be tested.

***Interaction with Federal Standard***

California is one of three states that have adopted toilet standards that are more stringent than the federal standard. Texas enacted standards for toilets and urinals in June 2009 and Georgia enacted standards for toilets, urinals, and faucets in March 2010. With more states setting their own standards, manufacturers have an increased burden of ensuring that products they sell in each state meet the appropriate standard. To help minimize the burden on manufacturers, the proposed changes to Title 20 have been developed taking the federal, Texas, and Georgia standards into account, and aim to use similar compliance pathways (test procedures, etc.) as the existing standards.

### *Perception that High-Efficiency Toilets Perform Poorly*

In the early 1990s, several models of high-efficiency toilets did not perform as well as consumers had hoped. These poorly performing models marred public perception of high-efficiency toilets. Many high-efficiency toilets on the market today perform just as well as the higher-flush-volume models. Several industry players are resolute in their commitment to repair public perception of the performance of high-efficiency toilets. As described in Section 5.1.1 of this Report, several third-party performance standards exist. Many water agencies require toilets to meet these voluntary performance standards in order to qualify for rebate programs.

WaterSense and others have expressed concern that the performance requirements in the ASME/ANSI standards referenced in the DOE test procedure are not stringent enough. It is important that the more stringent water efficiency standard does not inadvertently lead to a decline in toilet performance. Since some high-efficiency models perform very well, whereas other models lag behind in performance, it is important that the revised water efficiency standard be coupled with a performance standard, thereby ensuring that poor-performing models will not be available for sale.

To address this concern, the CA IOUs are recommending that the Title 20 toilet standards include a performance requirement for waste extraction. Georgia and Texas have partially addressed this concern by requiring tank-type toilets to be WaterSense Labeled. To be awarded a WaterSense Label, the toilet must demonstrate an ability to extract at least 350 grams of solid MaP test substance, which is equivalent to achieving a MaP score of 350 grams. WaterSense derived the 350 gram minimum performance standard based on a medical study that classified variability in "colonic function in health subjects" and found that 350 grams is a typical loading for healthy men with a 99.5 percent confidence level (WaterSense 2007).

Requiring tank-type toilets to be WaterSense Labeled does not address performance issues for valve-type toilets. Instead of requiring the WaterSense Label, the IOUs are recommending that all toilets (regardless of type) are able to achieve a MaP score of 350 grams or higher.

### *Concerns About Low-flow Urinals and Trap Seal Failure*

Some stakeholders have expressed concern that trap seals will fail on low-flow urinals. Water in the trap prevents sewage gasses from entering the building. If there is not enough water in the trap gases can move freely from the drainline to the building. Urinal trap seals can fail if the urinal is not used for a long period of time and water in the trap evaporates. Some stakeholder have expressed concern that since low flow urinals have less water in the trap, then trap failure will occur more quickly than in urinals that use more water. Trap seals would likely fail more quickly in hot, dry climates.

A 2012 study from the University of Texas, entitled *A Study of Water Evaporation in Urinal Traps*, investigates the relationship between low flush urinals and trap seal failure due to water evaporation. The study concluded that 0.125 gpf urinals are approaching the technical limit for urinals that comply with the existing plumbing code trap seal dimension requirements and that urinals using less than 0.125 gpf may be more vulnerable to trap seal failure and residue buildup (Bardet 2012).

If trap seal failure is a concern, low-flush urinals can be installed with valves that automatically flush the urinal after a given period of time. This periodic flush will replenish the water in the seal and prevents trap seal failure. Typically, valves with an automatic flush function would flush after 24 hours of non-use.

### *Impact of Low-flow Toilets and Urinals on Building Drainlines*

A 2012 study from the Plumbing Efficiency Research Coalition (PERC), entitled *The Drainline Transport of Solid Waste in Buildings*, investigated the relationship between toilet flush volume and solid waste transport within building plumbing pipes. The study confirms that 1.28 gpf toilets are effective at removing waste from the building (i.e. moving waste from the toilet to the municipal wastewater collection system or septic system). Toilets that use 0.8 gpf are not effective at removing waste from buildings. Another important finding is that toilet paper selection has a significant impact on how effectively waste moves thorough building pipes. As toilet paper tensile strength increases, waste movement decreases. While the Title 20 standards cannot influence toilet paper selection, this information is valuable for building managers that wish to optimize building's plumbing system performance (PERC 2012).

In some cases, buildings with waterless urinals have caused damage to building piping. To our knowledge, there is no evidence that low-flow 0.125 gpf urinals cause damage to building pipes. Several years ago, some consumers were concerned that low-flow or waterless urinals could cause build-up in pipes. When WaterSense was developing their specification for high-efficiency urinals many stakeholders urged that the flush volume should be lower than 0.5 gpf. At the time, 0.125 gpf urinals and waterless urinals were available but they were less prevalent than they are today. Waterless and low-flow urinals have now been installed at many locations for a period of several years. Issues with pipe build-up that some speculated would occur, have not yet occurred. Concerns about the adverse impacts on pipes are quickly diminishing, and consumers have embraced low-flow urinals.

### *Impact of Low-flow Toilets on Wastewater Collection Systems*

Some stakeholders have expressed concern that reducing water use in buildings, and particularly from toilets, will lead to major problems with the wastewater collection system, including clogging, odors, and pipe corrosion. Water use from toilets is of particular concern because toilets release water into the collection system at a high flow rate, and these high flows can help move solids through the collection system. Many wastewater collection systems were designed over 100 years ago when water use in buildings was higher than it is today (Environment Agency 2008). In California, engineers typically design

As California pursues water efficiency and conservation goals, such as the statewide 20x2020 goal,[7] urban water use will continue to decline, in turn, decreasing the amount of water in wastewater collection systems. If the amount of water in the collection system continues to decline and sewer system designs remain unchanged, at some point there will not be enough water in the wastewater collection system to effectively move solid waste through the system.

The solution is not to slow down efforts to achieve water conservation and water efficiency goals. Rather, California should evaluate the systematic impacts of water conservation and the wastewater collection and treatment systems and develop a strategy to achieve water conservation goals without compromising the reliability of wastewater collection and treatment systems. Many of California's wastewater collection systems are antiquated, and it is important that wastewater collection system design practices improve as water use patterns change.

[7] On February 28, 2008 Governor Schwarzenegger outlined key elements of a comprehensive water conservation plan to address water issues in the Sacramento-San Joaquin Delta. From this effort, the 20x2020 Water Conservation Plan was established, calling for a 20 percent reduction in per capita urban water use by 2020. In addition, the plan laid the foundation for Senate Bill X7 7. Passed by the Legislature in 2009, this bill incorporated the goal to achieve a 20 percent reduction in urban per capita water use in California by 2020. In February 2010, the California Environmental Protection Agency State Water Resources Control Board released the Final 20x2020 Water Conservation plan, which details how the State could achieve a 20x2020 goal. More information available here: http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/.

The proposed changes to Title 20 will not lead to an imminent failure. Wastewater collection systems in California typically see flows at about 200 gallons per capita per day (gpcd). The proposed standards for toilets and urinals will reduce water use by no more than 2 gallons per person per day. This represents a 1-2 percent reduction in water in the collection system. Reducing water use by 1-2 percent will not cause clogging in pipes.

One widely cited example of wastewater collection problems due to low-flow fixtures is from the City of San Francisco. This example is not representative of what would occur if the proposed Title 20 standards took effect, and the San Francisco example is often cited incorrectly. In 2009, the City of San Francisco experienced an odor issue. A media article claimed the odor issue was caused by low-flush toilets. The San Francisco Public Utilities Commission (SFPUC) refuted this claim in a letter submitted to the CEC in June 2013 (SFPUC 2013). In this letter, the SFPUC argued that odor issues cannot be attributed to low-flow fixtures. It should also be noted that San Francisco's wastewater collection system combines stormwater and municipal waste water into one collection system. Combined systems have larger pipes that require more water to move solids than traditional wastewater collection systems that do not combine stormwater and wastewater. San Francisco and sections of Old Town Sacramento are the only places in California that have combined wastewater collection systems. As such, the San Francisco wastewater collection system is not representative of typical wastewater collection systems in California.

Another widely cited example is from Melbourne Australia in which the wastewater collection system was stressed during a severe drought. During this event, potable water used dropped over 60 percent from 90 gpcd to 30 gpcd.[8] The baseline flows in California (200 gpcd) are much higher than baseline flows in Melbourne. Realizing 30 gpcd flow rates in California would require an 85 percent reduction in water use, which would be very unlikely. As a rule of thumb, many wastewater engineers in the United States assume between 75 and 100 gpcd will be enter wastewater collection systems with water conservation measures in effect. This 75 to 100 gpcd estimate is still significantly higher than flow rates in Melbourne.

A recent academic study explored how various water efficiency and conservation practices could contribute to odor and corrosion issues in a wastewater collection system in Melbourne (Marleni et al. 2011). The study concluded that aggressive water conservation practices can lead to odor and corrosion problems. In the most aggressive water conservation scenario, it was estimated that the useful life of the wastewater collection system could be reduced by 40 years due to pipe corrosion. While this is an alarming finding, the water conservation scenarios evaluated in the analysis are substantially more aggressive than the water efficiency measures being considered for California. The baseline scenario assumes 30 percent of households have rainwater collection tanks and 3 percent have graywater systems. Rainwater collection and graywater systems are not as prevalent in California. The aggressive water management scenario assumes water entering the collection system will be reduced by 43 percent from the already efficient baseline scenario. As mentioned above, the proposed Title 20 standards would reduce water entering the collection system by 1-2 percent. While the study did find that extraordinary reductions in water use can lead to odor issues and premature pipe degradation, the amount of water reductions achieved through the Title 20 proposals will not produce similar outcomes.

As mentioned above, the IOUs recommend that California complete a systematic review of water efficiency and conservation goals and the potential impacts on wastewater collection systems. This systematic review should occur outside the Title 20 rulemaking process, and should be a collaborative effort amongst all state agencies charged with implementing the 20x2020 water conservation and efficiency plan and all agencies that have a stake in regulating or overseeing wastewater collection systems.

[8] Flow rates are now back up to 40 – 50 gpcd.

The evaluation should include a review of the impacts of water efficiency codes and standards as graywater reuse and recycled water (purple pipe) options. The review should include a comprehensive research effort to identify and categorize all potential wastewater collection and wastewater treatment issues that might occur as urban water use continues to decrease. It should also include potential solutions for each issue. One wastewater expert that the CASE Team spoke with suggests that the standards used by wastewater engineers when designing wastewater collection systems are outdated and that the standards might need to be updated to account for a lower volume of water coming from buildings.[9]

***Effective Flush Volume of Dual-flush Toilets***

Current standards, including the WaterSense specification for Tank-type Toilets and ASME A112.19.14, allow dual-flush toilets to consume as much as 1.6 gallons per full-volume as long as the average flush volume for two full-volume flushes and one half-volume flush is 1.28 gpf or less (WaterSense 2007). Despite the fact that the WaterSense Specification only applies to tank-type toilets, efficiency standards in Texas and Georgia, and AB 715 standards in California have applied the 2:1 flush ratio for all types of toilets. This is of concern since there is evidence that the 2:1 ratio is not an accurate estimate of how the dual-flush feature is used in real buildings. Using a 2:1 ratio underestimates flow rates, particularly in non-residential buildings. The CA IOUs reviewed seven studies that assessed usage patterns of dual-flush toilets in residential and non-residential buildings. The studies indicate that the 2:1 ratio is likely too high. The studies also suggest that (1) building type (residential or nonresidential), (2) whether the toilet is installed in a restroom that also has a urinal, (3) education on proper use of dual-flush toilets, and (4) the design of the flush valve itself are some of the variables that need to be considered when determining an appropriate ratio for dual-flush toilets. (See the Appendix E: for a summary of results from the literature review.)

Since there is inadequate evidence that the 2:1 ratio is representative of how dual-flush toilets are actually used, the CA IOUs recommend that the Title 20 standard require that dual-flush toilets use no more than 1.28 gpf for the full-volume flush. Model codes such as *American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 189.1 Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings* are also moving away from using an effective flush volume and are requiring dual-flush toilets to use no more than 1.28 gpf for the full-volume flush.

### 9.1.2 Voluntary Programs

Most water utilities offer rebates to customers that replace standard efficiency toilets with toilets that do not exceed 1.28 gpf. The definition of standard efficiency toilets varies by utility, but common definitions are 3.5 gpf or more, 3.0 gpf or more, and 1.6 gpf or more.

Many utilities also offer rebates to customers that replace standard efficiency urinals with high-efficiency urinals. Some utilities, such as the LADWP and Metropolitan Water District of Southern California, only offer rebates for premium efficiency that consume less than 0.25 gpf and waterless urinals. Other utilities offer rebates for urinals that consume as much as 0.5 gpf.

In 2008 and 2009, the IOUs participated in the Embedded Energy in Water Pilot Program. Collectively the IOUs ran nine programs that aimed to reduce water consumption, and in effect reduce embedded energy use as well. One program offered financial incentives to detention facilities for installing high-efficiency toilets, urinals and showers. Two programs offered direct install services to low income customers to install high-efficiency toilets (CPUC, 2011).

[9] Personal communication with Michael Read, General Manager of Oak Lodge Sanitary District and former president of The Water Environment Federation, on May 15, 2013.

The CPUC conducted an Evaluation Measurement and Verification (EM&V) analysis on the IOU pilot programs. The EM&V studies and the IOU Pilot Programs provided an opportunity for the CPUC to explore how they might evaluate the effectiveness of water conservation programs at achieving embedded energy saving. However, to date the CPUC has not adopted a methodology for quantifying the embedded energy in water. The CPUC has not established guidance on what portion of the total embedded energy might effectively be saved through end-use water efficiency measures. Embedded energy in water is discussed in more detail in Appendix A:.

## 9.2 Existing Standards and Standards under Development

### 9.2.1 Federal Appliance Standards

Prior to 1970, most toilets consumed 6 gpf or more. Effective January 1, 1978 California law required all toilets to consume no more than 3.5 gpf. In the 1980s and early 1990s, several states including California had established water efficiency standards for toilets and urinals. Congress used these state-level standards as the basis for the first federal standards that were enacted with the EPAct 1992, took effect in 1994, and set the maximum flush volumes at 1.6 gpf for toilets and 1.0 gpf for urinals. In addition, all low-flush water closets and urinals must be labeled with specified language by the retailer identifying the fixtures as low-flush models. The federal standards have not been revised since EPAct 1992 was enacted.

EPAct 1992 stated that if the American Society of Mechanical Engineers (ASME) revises its standards for plumbing fixtures and fittings, the U.S. Department of Energy (DOE) must review ASME's action and consider adjusting the federal standards. If ASME does not revise its standards within five years, states are allowed to set more stringent state-level standards. To date, ASME has not revised the toilets or urinal standards. Since ASME did not revise the standard within five years of the first effective date, states were eligible to set their own standard after 1999.

On December 22, 2010, the DOE officially waived Federal preemption for energy conservation standards with respect to 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 their own standards for the relevant plumbing products as long as the state standard is more stringent than the federal standard.

As mentioned in section 5.5, DOE is in the process of updating the test procedures for showerheads, faucets, water closets, urinals, and commercial pre-rinse spray valves. In a Supplemental Notice of Proposed Rule (SNOPR) issued April 8, 2013, DOE provided its interpretation that valves shipped separately from a toilet bowl are not federally covered products, and are therefore not subject to federal standards (78 Fed. Reg.67, 8 April 2013).

### 9.2.2 California Standards

***Current Title 20 Standards***

Standards for toilets and urinals appear in Title 20. The current version of Title 20 includes standards that are consistent with the federal standards, or 1.6 gpf for toilets and 1.0 gpf for urinals. These standards are not consistent with the legislated standards enacted by AB 715 in 2007.

***Requirements Enacted by SB 407 (2009)***

In 2009, the California Legislature enacted Senate Bill 407 (Padilla 2009). This bill requires plumbing fixtures installed in residential and commercial buildings constructed before 1994 to be replaced with more efficiency fixtures by 2017 (single-family buildings) or 2019 (multi-family and commercial buildings). Toilets, urinals, showerheads, and faucets are the plumbing fixtures subject to the rules SB 407 established.

#### *Standards Enacted by AB 715 (2007)*

In 2007, the California Legislature enacted Assembly Bill 715 (Laird 2007), which established modified minimum efficiency standards for toilets and urinals sold or installed in California. By 2014, toilets must have an effective flush volume of 1.28 gpf or less and urinals must have an effective flush volume of 0.5 gpf or less. From an implementation perspective, AB 715 temporally adds the toilet and urinal efficiency standards to the California Health and Safety Code. The standards in the Health and Safety code will remain operative only until January 1, 2014, or until the California Building Standards Commission includes the standards in the Building Standards Code, whichever date is later (AB 715, 2007).

As discussed below, the 2010 California Plumbing Code does include the AB 715 water efficiency requirements, but the standards do not apply to all building types and the Plumbing Code only applies to newly constructed buildings and modifications/alterations/repairs to existing buildings; the building code cannot establish standards for all products offered for sale in California as AB 715 intended. To codify the portion of AB 715 that sets standards for products offered for sale in California, Title 20 standards must be updated.

#### *California Plumbing Code Standards (Part 5 of Title 24)*

The 2010 California Plumbing Code (§ 401.2) includes toilet and urinal water efficiency standards that are consistent with the efficiency levels enacted by AB 715. As a building code, the Plumbing Code establishes standards for products installed during new construction or alterations, but the standards do not apply to all products offered for sale in California – as intended by AB 715.The standards in Title 20 are what dictate the efficiency level for all products that are offered for sale in California.

#### *CalGreen (Part 11 of Title 24) Standards*

The California Green Building Code, which is also known as CALGreen or Part 11 of Title 24, includes mandatory water efficiency standards for toilets and urinals. The 2013 CalGreen standards, which were adopted in January 2013 and will take effect in January 2014, require toilets and urinals installed in newly constructed residential and nonresidential buildings to meet the minimum energy efficiency standards of 1.28 gpf or less for toilets and 0.5 gpf for urinals (CalGreen 2010).

#### *California Health and Safety Code*

As required by AB 715, the California Health and Safety Code currently includes standards for toilets and urinals that are consistent with AB 715 requirements (§17921.3). The standards appear in the Health and Safety Code as a temporary implementation strategy for AB 715. The standards are only effective until BSC includes standards in the Building Standards Code.

### 9.2.3 Local Standards

In 2009, the City of Los Angeles passed an ordinance that established water efficiency requirements for newly constructed buildings and renovations of existing buildings (City of Los Angeles 2009). The ordinance added Article V to Chapter XII of the City's Municipal Code. Among other provisions, the code now requires all toilets installed in new buildings or during retrofits to have an effective flush volume of 1.28 gpf or less. The maximum flush volume for urinals installed after October 1, 2010 cannot exceed 0.125 gpf (City of Los Angeles 2009).

Similarly, in 2010 New York City adopted a local law to revise the water efficiency standards in the local plumbing code. Local Law 57 set the maximum flush volumes of 1.28 gpf for toilets and 0.5 gpf for urinals (City of New York 2010).

### 9.2.4 Other Standards

***Other State Standards***

California is one of three states that have adopted toilet standards that are more stringent than the federal standard. In June 2009, Texas enacted standards that would require toilets and urinals sold or offered for sale to achieve 1.28 gpf and 0.5 gpf, respectively (Texas HB 2667, 2009). In March 2010, Georgia enacted standards that required toilets and urinals installed in newly constructed buildings to achieve 1.28 gpf and 0.5 gpf, respectively (Georgia SB 370, 2010).

Two bills currently being considered in Oregon would require toilets and urinals sold in Oregon to achieve 1.28 gpf and 0.125 gpf, respectively. Senate Bills 692 and 840 both passed the senate in April 2013 and upon writing have been sent to the House Committee on Energy and Environment for review (Oregon SB 692, Oregon SB 840).

A bill currently being considered in Washington would require toilets and urinals sold in Washington to achieve 0.5 gpf. House Bill 1017 passed house in March 2013 and currently sits with the Senate Committee on Energy and Environment & Telecommunications (Washington HB 1017).

***Model Codes***

Water efficiency standards already appear in the following "reach" codes:

- 2012 International Green Construction Code: Water Efficiency Provisions
- ASHRAE 189.1-2011: Standards for the Design of High-Performance Green Buildings (Except Low-Rise Residential Buildings)
- International Association of Plumbing and Mechanical Officials (IAPMO) 2012 Green Plumbing and Mechanical Code

The International Code Council (ICC) and IAPMO are considering proposals that suggest moving the toilet and urinal efficiency provisions to the "base" codes on which many states' plumbing or efficiency codes are modeled. The ICC is considering including the plumbing efficiency standards in the International Residential Code (IRC). IAPMO is considering moving the toilet and urinal standards that appear in the Green Plumbing and Mechanical Code into the Uniform Pluming Code (UPC).

## 9.3 Stakeholder Positions

Toilet and urinal manufacturers have expressed a preference that Title 20 standards align with standards in CalGreen, the California Plumbing Code, and the WaterSense Specification for Tank-type Toilets. Responses to CEC's Invitation to Participate (ITP) as well as the transcript from the ITP Workshop on May 31, 2013 provide some insight into stakeholder positions.[10]

[10] Documents from CEC's ITP process are available on the CEC's Appliance 2013 Appliance Efficiency Pre-Rulemaking website: http://www.energy.ca.gov/appliances/2013rulemaking/index.html.

# 10 Environmental Impacts

## 10.1 Hazardous Materials

There are no known incremental hazardous materials impacts from the efficiency improvements as a result of the proposed standards.

## 10.2 Air Quality

This proposed measure is estimated to reduce total criteria pollutant emissions in California by 13,800 lbs/year in 2026, after the commercial toilet and urinal stock turnover and about half of the toilet stock has turned over as shown in Table 10.1 due to 80.4 GWh in reduced end user electricity consumption with an estimated value of $662,600.[11] Criteria pollutant emission factors for California electricity generation were calculated per MWh based on California Air Resources Board data of emission rates by power plant type and expected generation mix (CARB 2010). The monetization of these criteria pollutant emission reductions is based on CARB power plant air pollution emission rate data times the dollar per ton value of these reductions based on Carl Moyer values where available, and San Joaquin Valley UAPCD "BACT" thresholds for sulfur oxides (SOx). These dollar per ton values vary significantly for fine particulates, as discussed in Appendix C: (CARB 2011a, CARB 2013a and San Joaquin Valley UAPCD).

**Table 10.1 Estimated California Criteria Pollutant Reduction Benefits (lbs/year) After Stock Turnover**

| | lbs/year | Carl Moyer $/ton (2013) | Monetization |
|---|---|---|---|
| ROG | 2,215 | $ 17,460 | $ 19,336 |
| Nox | 7,554 | $ 17,460 | $ 65,950 |
| Sox | 794 | $ 18,300 | $ 7,265 |
| PM2.5 | 3,265 | $ 349,200 | $ 570,049 |
| **Total** | **13,800** | | **$ 662,600** |

## 10.3 Greenhouse Gases

Table 10.1 shows the annual and stock GHG savings for the first year the standard takes effect (2015) and the year of full stock turnover (2026 for commercial toilets and urinals, and 2038 for residential toilets). Table 10.1 also presents the range of the societal benefits as a result of the standard. The first year the standard is in effect, this standard would save 2,770 metric tons of CO2e, equal to between $129,000 and $370,000 of societal benefits. The total avoided CO2e is based on CARB's estimate of 437 MT CO2e/GWh of energy savings from energy efficiency improvements, and includes additional electrical transmission and distribution loses estimated at 7.8% (CARB 2008). The range of societal benefits per year is based on a range of annual $ per metric ton of CO2 (in 2013 dollars) sourced from the U.S. Government's Interagency Working Group on Social Cost of Carbon (SCC) (Interagency Working Group

[11] Electricity savings due to electricity embedded in water. It is estimated that 30.4 GWh of savings would come from commercial toilets and urinals that achieve full stock turn over in 2026, and 46.2 GWh of savings would come from residential toilets, which do not achieve full stock turnover until 2038. The CASE Team did not calculate air quality benefits in 2038 (the year of residential toilet stock turnover because emission rates may not be accurate and measure is fully justified based on other benefits.

2013). The low end uses the average SCC, while the high end incorporates SCC values which use climate sensitivity values in the 95th percentile, both with 3% discount rate. It is important to note that this range can be lower and higher, depending on the approach used, so policy judgments should consider this uncertainty. See Appendix D: for more details regarding this and other approaches.

**Table 10.2 Estimated California Statewide Greenhouse Gas Savings and Cost Savings for Standards Case**

| Product Class | Annual GHG Savings First-Year Sales (MTCO2e/yr) | Stock GHG Savings (MTCO2e/yr) | Value of Stock GHG Savings - low ($) | Value of Stock GHG Savings - high ($) |
|---|---|---|---|---|
| 2015 (first year standard is in effect) | | | | |
| Residential Toilets | 1,571 | 1,571 | $73,166 | $209,870 |
| Commercial Toilets | 279 | 279 | $12,994 | $37,272 |
| Urinals | 920 | 920 | $42,847 | $122,903 |
| **Total** | **2,770** | **2,770** | **$129,006** | **$370,044** |
| 2026 (year commercial toilet and urinal stock turns over) | | | | |
| Commercial Toilets | 279 | 2,243 | $134,152 | $404,105 |
| Urinals | 681 | 11,475 | $686,310 | $2,067,367 |
| **Total** | **960** | **13,718** | **$820,461** | **$2,471,472** |
| 2038 (year residential toilet stock turns over) | | | | |
| Residential Toilets | 1,331 | 45,831 | $3,314,049 | $10,245,465 |

# 11 Recommendations

## 11.1 Recommended Standards Proposal

The recommended code change will:

1. Align definitions in Title 20 with definitions in ASME and DOE standards.
2. Align the maximum flush volumes for toilets with those enacted by AB 715. The maximum flush volume for all water closets except blowout water closets will be 1.28 gpf. The maximum flush volume for blowout toilets will remain at 3.5 gpf.
3. Reduce the maximum flush volume for all urinals. The maximum flush volume for urinals will be as follows:
    a. Trough-type urinals – (no change proposed) maximum flush volume (gpf) = trough length (inches) ÷ 16.
    b. Floor-mounted urinals – 0.5 gpf
    c. All other urinals – 0.125 gpf
4. Establish a minimum performance standard for all toilets, requiring toilet to receive a MaP score of 350 grams or more.

5. Establish an efficiency standard for replacement valves for toilets and urinals. After January 1, 2019 replacement valves for water closets cannot exceed 1.6 gpf and replacement valves for urinals cannot exceed 1.0 gpf.

SB 407 (2009) requires that, on or before January 1, 2019, all noncompliant plumbing fixtures (i.e., toilets over 1.6 gpf and urinals over 1.0 gpf) in single-family residential, multifamily residential and commercial buildings built before 1994 be replaced with water-conserving plumbing fixtures. As such, after January 1, 2019 there would be no lawful purpose in shipping valve designed for more than 1.6 gpf for toilets and 1.0 gpf for urinals.

## 11.2 Proposed Changes to the Title 20 Code Language

**Section 1601. Scope**

(i) Plumbing fixtures, which are water closets~~, and~~ urinals, and replacement valves for water closets and urinals.

**Section 1602. Definitions**

**(a) General**

“MaP” means Maximum Performance.

**(i) Plumbing Fixtures**

“Anti-siphon fill valve” is a valve that is used to supply water to a flush tank and has, on its discharge side, an air gap, integral mechanical backflow preventer, or vacuum breaker. It is operated by a float or similar device.

“Blowout action” is a means of flushing a water closet whereby a jet of water directed at the bowl outlet opening pushes the bowl contents into the upleg, over the weir, and into the gravity drainage system.

“Blowout ~~type~~ bowl” means a non-siphonic ~~type~~ water closet bowl ~~that is designed for a blowout action, and that has~~ with an integral flushing rim, a trap~~way~~ at the rear of the bowl, and a visible or concealed jet that operates with a blowout action. ~~, a wall outlet, and, if wall mounted, a three bolt hole configuration.~~

“Flush tank” means a vessel that stores a predetermined quantity of water and includes a flushing device to discharge water (plus some through-flow from the water supply line) into a water closet bowl or urinal.

“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.~~ flushing device that effectively enlarges the water supply pipe immediately before the water closet bowl or urinal by being integrated within an accumulator vessel affixed and adjacent to the fixture inlet.

“Flush valve” means a valve for discharging water from a flush tank or from the building’s main water supply line into a water closet bowl or urinal.

“Flushometer valve” means a valve that is attached to a pressurized water supply pipe that, when actuated, ~~and that is designed so that when actuated it~~ opens the pipe ~~line~~ for direct flow into the fixture at a rate and in a p~~redetermined~~ quantity that enables the ~~to~~ proper~~ly~~ operat~~e~~ion the fixture, ~~and in order~~ to provide trap reseal in the fixture and to avoid water hammer. The pipe to which the ~~device~~ is connected should be large enough to enable delivery of water at a sufficient rate for proper operation. ~~is, in itself, of sufficient size that when open shall allow the device to deliver water at a sufficient rate of flow~~

"Flushing device" means a device for delivering water into a water closet bowl or urinal.

> "Pressurized flushing device" means a flushing device that is employed in non-gravity flushing systems and uses the water supply to create a pressurized discharge to flush fixtures. Flushometer tanks, flushometer valves, and electronically controlled pressurized devices are examples of pressurized flushing devices.

"Replacement urinal valve" means an anti-siphon fill valve, a flush valve, or a flushometer valve sold to replace an existing water closet valves.

"Replacement water closet valve" means an anti-siphon fill valve, a flush valve, or a flushometer valve sold to replace an existing water closet valves.

"Plumbing fixture" means a water closet, ~~or a~~ urinal, or a replacement valve for a water closet or urinal.

"Urinal" means a plumbing fixture that receives only liquid body waste and, on demand, conveys the waste through a trap seal into a gravity drainage system.

> "Floor-mounted urinal" means a urinal attached to the floor.
>
> "Non-water-consuming ~~Waterless~~ urinal" means a urinal ~~designed to be used without the application of water for flushing.~~ that conveys liquid body waste through a trap seal into a gravity drainage system without the use of water.
>
> "Prison-type urinal" means a urinal designed and marketed expressly for use in prison-type institutions.
>
> "Trough-type urinal" means a urinal designed for simultaneous use by two or more persons.
>
> "Vacuum-type urinal" means a urinal whose bowl is evacuated by the application of a vacuum.

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

> "Blowout water closet" means a water closet with a blowout ~~type~~ bowl.
>
> "Dual-flush water closet" means 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.
>
> "Electro~~mechanical~~ -hydraulic water closet" means a water closet with a non-mechanical trap seal incorporating an electric motor and controller to facilitate flushing. ~~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.~~
>
> "Gravity flush tank~~-type~~ water closet" means a water closet designed to flush the bowl with water supplied by gravity only. ~~that includes a storage tank from which water flows into the bowl by gravity.~~

"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.

"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 CFR part 430(2008).

**Section 1604. Test Methods for Specific Appliances.**

**(i) Plumbing Fixtures.**

(1) The test methods for plumbing fixtures are as follows: ~~is ANSI/ASME A112.19.6-1995~~

(A) ASME A112.19.2-2008/CSA B45.1-08, and

(B) MaP Testing Toilet Fixture Performance Testing Protocol Version 5 – March 2013

…

The following documents are incorporated by reference in Section 1604.

**AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)**

~~ANSI/ASME A112.19.6-1995 Hydraulic Performance Requirements for Water Closets and Urinals~~

ASME A112.19.2-2008 Ceramic Plumbing Fixtures

**MAXIMUM PERFORMANCE (MAP) TESTING**

MaP Testing Toilet Fixture Performance Testing Protocol Version 5 – March 2013

**Section 1605. Energy Performance, Energy Design, Water Performance, and Water Design Standards: In General.**

**Section 1605.1. Federal and State Standards for Federally-Regulated Appliances.**

**(i) Plumbing Fixtures.**

See Section 1605.2(i) for water efficiency standards for plumbing fixtures.

~~The water consumption of water closets and urinals shall be not greater than the values shown in Table I.~~

~~**Table I**~~

~~**Standards for Plumbing Fixtures**~~

| ~~*Appliance*~~ | ~~*Maximum Gallons per Flush*~~ |
|---|---|
| ~~Gravity tank-type water closets~~ | ~~1.6~~ |
| ~~Flushometer tank water closets~~ | ~~1.6~~ |
| ~~Electromechanical hydraulic water closet~~ | ~~1.6~~ |
| ~~Blowout water closets~~ | ~~3.5~~ |
| ~~Trough-type urinals~~ | ~~Trough length (inches) / 16~~ |
| ~~Other urinals~~ | ~~1.0~~ |

**Section 1605.2. State Standards for Federally-Regulated Appliances.**

**(i) Plumbing Fixtures.**

<u>(1) The water consumption of water closets and urinals shall not greater than the values shown in Table I-1.</u>

<u>**Table I-1.**</u>

<u>**Standards for Water Closets and Urinals**</u>

| <u>*Appliance*</u> | <u>*Maximum Gallons per Flush*</u> |
|---|---|
| <u>Blowout water closets</u> | <u>3.5</u> |
| <u>Dual-flush water closet (full-volume flush)</u> | <u>1.28</u> |
| <u>Other water closets</u> | <u>1.28</u> |
| <u>Trough-type urinals</u> | <u>Trough length (inches) / 16</u> |
| <u>Blowout urinals</u> | <u>1.0</u> |
| <u>Floor-mounted urinals</u> | <u>0.5</u> |
| <u>Other urinals</u> | <u>0.125</u> |

<u>(2) Water closets shall achieve a MaP score of no less than 350 grams.</u>

~~See Section 1605.1(i) for water efficiency standards for plumbing fixtures that are federally-regulated consumer products.~~

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

**(i) Plumbing Fixtures.**

Replacement valves shall not be designed to deliver flush volumes greater than the values shown in Table I-2.

**Table I-2.**

**Standards for Water Closet and Urinal Replacement Valves**

| ***Appliance*** | ***Maximum Gallons per Flush*** *(Effective January 1, 2019)* |
|---|---|
| Water closet replacement valve | 1.6 |
| Water closet replacement valve | 1.0 |

~~See Section 1605.1(i) for water efficiency standards for plumbing fixtures that are federally-regulated consumer products.~~

**Section 1606. Filing by Manufacturers; Listing of Appliances in Database.**

**Table X - Data Submittal Requirements**

| | ***Appliance*** | ***Required Information*** | ***Permissible Answer*** |
|---|---|---|---|
| I | Plumbing Fixtures | *Type | Blowout water closet, dual-flush water closet, gravity flush tank ~~type~~ water closet, electro~~mechanical~~-hydraulic water closet, flushometer tank water closet, prison-type water closet, flushometer valve water closet, vacuum-type water closet, urinal, floor-mounted urinal, non-water-consuming~~waterless~~ urinal, prison-type urinal, trough-type urinal, vacuum-type urinal, replacement urinal valve, replacement water closet valve |
| | | Water Consumption (full-flush volume for dual-flush water closets) | |
| | | Reduced flush-volume Water Consumption (dual-flush water closets only) | |
| | | MaP Score | |
| | | Trough Length (trough-type urinals only | |

## 11.3 Implementation Plan

The expected implementation for this standards proposal is for the CEC to proceed with its appliance standards rulemaking authority, from pre-rulemaking and rulemaking through adoption, and for manufacturer compliance upon effective date.

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# Appendix A: Embedded Energy in Water

The embedded energy value used in the analysis is 10,045 kWh/million gallons of water (MG). This value was derived from a California Energy Commission PIER study (CEC 2006), which states the embedded energy values shown in the table below "are sufficient for informing policy and prioritization of research and development investments."

**Table A.1 Recommended Embedded Energy Estimates**

| | Indoor Uses | | Outdoor Uses | |
|---|---|---|---|---|
| | Northern California kWh/MG | Southern California kWh/MG | Northern California kWh/MG | Southern California kWh/MG |
| **Water Supply and Conveyance** | 2,117 | 9,727 | 2,117 | 9,727 |
| **Water Treatment** | 111 | 111 | 111 | 111 |
| **Water Distribution** | 1,272 | 1,272 | 1,272 | 1,272 |
| **Wastewater Treatment** | 1,911 | 1,911 | 0 | 0 |
| **Regional Total** | 5,411 | 13,022 | 3,500 | 11,111 |

Source: CEC 2006. Table 7.

The total regional values shown in Table A.1 were weighted based on the population in Northern and Southern California in 2011 (U.S. Census Bureau).[12] All water used in toilets and urinals is used indoors, so only the indoor embedded energy values apply.

The California Public Utilities Commission (CPUC) has conducted additional research on embedded energy since the CEC's 2006 report was released. However, the values presented in the CEC's 2006 report are still the most up-to-date values recommended for use to inform policies the CASE Team has used the CEC's 2006 embedded energy values for this analysis.

The CPUC has made notable progress in improving understanding of the relationship between water and energy in California. CPUC's Decision 07-12-050, issued December 20, 2007, authorized the largest electricity utilities to partner with water utilities and administer pilot programs that aimed to save water and energy (CPUC 2011c). The Decision also authorized three studies to validate claims that saving water can save energy and explore whether embedded energy savings associated with water use efficiency are measurable and verifiable. The pilot programs succeed at demonstrating that water conservation measures also result in energy savings.

The CPUC studies were effective at obtaining a more granular understanding of how energy use varies based on a number of factors including supply, (i.e. surface, ground, brackish, or ocean desalination), geography, and treatment technology. The authors found "that the value of energy embedded in water is higher than initially estimated in the CEC's 2005 and 2006 studies." Although the data collected for the studies is the most comprehensive set of data on energy used to meet water demand, the data is still just a small sampling of all the potential data points in California. Since the authors did not find strong patterns within the sample data and there was no strong evidence that the sample data was representative for a particular region, process, or technology type, the authors did not have a strong basis to estimate the

[12] Northern and Southern California populations are 39.1% and 60.9% of total California population, respectively.

embedded energy values for specific geographic regions. Further, the CPUC studies did not recommend changes to the embedded energy values presented in the CEC's 2006 report.

While the CASE Report analysis uses the embedded energy values associated with water supply and conveyance, there is no evidence that reducing water use at the building level will impact water supply and conveyance activities. Thus water efficiency standards may result in reductions to energy used to supply and convey water.

# Appendix B: Cost Analysis Assumptions

The cost analysis presented in this CASE Report assumes that cost savings will be realized through lower water bills. The analysis does not include cost savings associated with embedded energy savings.

The potable water rates used in the analysis presented in this CASE Report are based on water rate data from Raftelis Financial Consultants Inc. (Raftelis 2008, Raftelis 2011). The residential potable water rate was derived using data from a 2011 study of rates from 216 water utilities in California. The commercial rates are derived from the 2008 American Water Works Association Water and Wastewater Survey using values from the western region.

Wastewater rates are based on data from Black & Veatch on rates in the eight largest cities[13] in California (Black & Veatch 2010). About 30 percent of Californians live in one of these eight cities, and it is assumed that these city's rates are representative of rates throughout the state. The CASE analysis uses the population-weighted wastewater rate from the eight cities. The 2009 residential rate is based on cost data that assumes customers use 15,000 gallons per month. The 2009 commercial wastewater rates were derived from cost data that assumes customers use 100,000 gallons per month.

Future potable water and wastewater rates were projected based on the Consumer Price Index (CPI) for Water and Sewer Maintenance and assuming a 3 percent annual discount rate. In recent years water rates have been increasing faster than CPI projections (Black & Veatch 2010, Raftelis 2011). It is likely that water rates will increase faster than the CAES analysis predicts, and it follows that the cost savings presented in this report could understate the true potential savings.

The analysis uses the residential rates for the residential toilets analysis and the commercial rates for the commercial toilets and urinals analyses.

See the rates by year below in Table B.1.

[13] The eight largest cities in California are: Fresno, Long Beach, Los Angeles, Oakland, Sacramento, San Diego, San Francisco, and San Jose.

**Table B.1 Statewide Average Potable Water and Wastewater Rates 2015 - 2040 in 2013$/1000gal**

| Potable Water and Wastewater Rates (2013$ / 1000 gal) | | | | | | |
|---|---|---|---|---|---|---|
| | Residential Rate | | | Commercial Rates | | |
| Year | Potable Water | Waste-water | Total | Potable Water | Waste-water | Total |
| 2015 | $2.82 | $4.66 | $7.49 | $2.58 | $4.84 | $7.42 |
| 2016 | $2.88 | $4.77 | $7.66 | $2.52 | $4.72 | $7.25 |
| 2017 | $2.95 | $4.88 | $7.83 | $2.58 | $4.83 | $7.41 |
| 2018 | $3.01 | $4.98 | $8.00 | $2.64 | $4.94 | $7.58 |
| 2019 | $3.08 | $5.09 | $8.17 | $2.70 | $5.05 | $7.75 |
| 2020 | $3.14 | $5.20 | $8.34 | $2.76 | $5.16 | $7.92 |
| 2021 | $3.21 | $5.30 | $8.51 | $2.81 | $5.27 | $8.09 |
| 2022 | $3.27 | $5.41 | $8.68 | $2.87 | $5.38 | $8.26 |
| 2023 | $3.33 | $5.51 | $8.85 | $2.93 | $5.49 | $8.43 |
| 2024 | $3.40 | $5.62 | $9.02 | $2.99 | $5.60 | $8.59 |
| 2025 | $3.46 | $5.73 | $9.19 | $3.05 | $5.71 | $8.76 |
| 2026 | $3.53 | $5.83 | $9.36 | $3.11 | $5.82 | $8.93 |
| 2027 | $3.59 | $5.94 | $9.53 | $3.17 | $5.93 | $9.10 |
| 2028 | $3.65 | $6.04 | $9.70 | $3.22 | $6.04 | $9.27 |
| 2029 | $3.72 | $6.15 | $9.87 | $3.28 | $6.15 | $9.44 |
| 2030 | $3.78 | $6.26 | $10.04 | $3.34 | $6.26 | $9.61 |
| 2031 | $3.85 | $6.36 | $10.21 | $3.40 | $6.37 | $9.77 |
| 2032 | $3.91 | $6.47 | $10.38 | $3.46 | $6.48 | $9.94 |
| 2033 | $3.98 | $6.57 | $10.55 | $3.52 | $6.59 | $10.11 |
| 2034 | $4.04 | $6.68 | $10.72 | $3.58 | $6.70 | $10.28 |
| 2035 | $4.10 | $6.79 | $10.89 | $3.64 | $6.81 | $10.45 |
| 2036 | $4.17 | $6.89 | $11.06 | $3.69 | $6.92 | $10.62 |
| 2037 | $4.23 | $7.00 | $11.23 | $3.75 | $7.03 | $10.79 |
| 2038 | $4.30 | $7.10 | $11.40 | $3.81 | $7.14 | $10.95 |
| 2039 | $4.36 | $7.21 | $11.57 | $3.87 | $7.25 | $11.12 |
| 2040 | $4.42 | $7.32 | $11.74 | $3.93 | $7.36 | $11.29 |

# Appendix C: Criteria Pollutant Emissions and Monetization

## C.1 Criteria Pollutant Emissions Calculation

To calculate the statewide emissions rate for California, the incremental emissions between CARB's high load and low load power generation forecasts for 2020 were divided by the incremental generation between CARB's high load and low load power generation forecast for 2020. Incremental emissions were calculated based on the delta between California emissions in the high and low generation forecasts divided by the delta of total electricity generated in those two scenarios. This emission rate per MWh is intended to provide a benchmark of emission reductions attributable to energy efficiency measures that could help achieve the low load scenario instead of the high load scenario. While emission rates may change somewhat over time, 2020 was considered a representative year for this measure.

## C.2 Criteria Pollutant Emissions Monetization

Avoided ambient ozone precursor and fine particulate air pollution benefits were monetized based on avoided control costs rather than damage costs due to the availability of emission control cost-effectiveness thresholds, as well as challenges in quantifying a specific value for damages per ton of pollutants.

Two sources of data for cost-effectiveness thresholds were evaluated. The first is Carl Moyer cost-effectiveness thresholds for ozone precursors and fine particulates (CARB 2011a, CARB 2013a and 2013b). The Carl Moyer program has provided incentives for voluntary reductions in criteria pollutant reductions from a variety of mobile combustion sources as well as stationary agricultural pumps that meet specified cost-effectiveness cut-offs.

The second is the San Joaquin Valley UAPCD Best-Available Control Technology ("BACT") cost-effectiveness thresholds study. Pollution reduction technologies that are not yet demonstrated in practice (in which case they are required without a cost-effectiveness evaluation) can be required at new power plants and other sources if technologically feasible and within cost-effectiveness thresholds. San Joaquin Valley UAPCD conducted a state-wide study as the basis for updating their BACT thresholds in 2008.

This CASE report relies primarily on the Carl Moyer thresholds due to their state-wide nature and applicability to combustion sources[14]. In addition, the Carl Moyer fine particulate values for fine particulate apply to combustion sources with specific health impacts, while BACT thresholds include both combustion sources and dust. The Carl Moyer values are somewhat more conservative for ozone precursors than San Joaquin Valley UAPCD BACT thresholds, and significantly higher for fine particulate[15].The Carl Moyer program does not address sulfur oxides, however, thus the San Joaquin BACT thresholds were used for this pollutant.

Price reports for California Emission Reduction Credit (ERCs, i.e. air pollution credits purchased to offset regulated emission increases) for 2011 and 2012 were also compared to the values selected

[14] Further evaluation of the qualitative impacts of combustion fine particulate emissions from power generation and transportation sources may be beneficial.

[15] We note that both the Carl Moyer and San Joaquin Valley UAPCD BACT cost-effectiveness thresholds for fine particulates fall within the wide range of fine particulate ERC trading prices in California in 2011 and 2012.

in this CASE report. For each pollutant there is a wide range of ERC values per ton that are both higher and lower than the values per ton used in this CASE report [CARB 2011b and 2012]. Due to wide variability and low trading volumes, ERC values were evaluated for comparative purposes only.

# Appendix D: Greenhouse Gas Valuation Discussion

The climate impacts of pollution from fossil fuel combustion and other human activities, including the greenhouse gas effect, present a major risk to global economies, public health and the environment. While there are uncertainties of the exact magnitude given the interconnectedness of ecological systems, at least three methods exist for estimating the societal costs of greenhouse gases: 1) the Damage Cost Approach 2) the Abatement Cost Approach and 3) the Regulated Carbon Market Approach. See below for more details regarding each approach.

## D.1 Damage Cost Approach

In 2007, the U.S. Court of Appeals for the Ninth Circuit ruled that the National Highway Transportation Traffic Safety Administration (NHTSA) was required to assign a dollar value to benefits from abated carbon dioxide emissions. The court stated that while there are a wide range of estimates of monetary values, the price of carbon dioxide abatement is indisputably non-zero. In 2009, to meet the necessity of a consistent value for use by government agencies, the Obama Administration established the Interagency Working Group on the Social Cost of Carbon to establish official estimates (Johnson and Hope).

The Interagency Working Group primarily uses estimates of avoided damages from climate change which are valued at a price per ton of carbon dioxide, a method known as the damage cost approach.

## D.2 Interagency Working Group Estimates

The Interagency Working Group SCC estimates, based on the damage cost approach, were calculated using three climate economic models called integrated assessment models which include the Dynamic Integrated Climate Economy (DICE), Policy Analysis of the Greenhouse Effect (PAGE), and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) models. These models incorporate projections of future emissions translated into atmospheric concentration levels which are then translated into temperature changes and human welfare and ecosystem impacts with inherent economic values. As part of the Federal rulemaking process, DOE publishes estimated monetary benefits using Interagency Working Group SCC values for each Trial Standard Level considered in their analyses, calculated as a net present value of benefits received by society from emission reductions and avoided damages over the lifetime of the product. The recent U.S. DOE Final Rulemaking for microwave ovens contains a Social Cost of Carbon section that presents the Interagency Working Group's most recent SCC values over a range of discount rates (DOE 2013) as shown in

Table D.1. The two $ metric ton of values used in this CASE report were taken from the two highlighted columns, and converted to 2013 dollars.

**Table D.1 Social Cost of $CO_2$ 2010 – 2050 (in 2007 dollars per metric ton of $CO_2$) (source: Interagency Working Group on Social Cost of Carbon, United States Government, 2013)**

| Discount Rate | 5.0% | 3.0% | 2.5% | 3.0% |
|---|---|---|---|---|
| Year | Avg | Avg | Avg | 95th |
| 2010 | 11 | 33 | 52 | 90 |
| 2015 | 12 | 38 | 58 | 109 |
| 2020 | 12 | 43 | 65 | 129 |
| 2025 | 14 | 48 | 70 | 144 |
| 2030 | 16 | 52 | 76 | 159 |
| 2035 | 19 | 57 | 81 | 176 |
| 2040 | 21 | 62 | 87 | 192 |
| 2045 | 24 | 66 | 92 | 206 |
| 2050 | 27 | 71 | 98 | 221 |

The Interagency Working Group decision to implement a global estimate of the SCC rather than a domestic value reflects the reality of environmental damages which are expected to occur worldwide. Excluding global damages is inconsistent with U.S. regulatory policy aimed at incorporating international issues related to resource use, humanitarian interests, and national security. As such, a regional SCC value specific to the Western United States or California specifically should be at similarly inclusive of global damages. Various studies state that certain values may be understated due to the asymmetrical risk of catastrophic damage if climate change impacts are above median predictions, and some estimates indicate that the upper end of possible damage costs could be substantially higher than indicated by the IWG (Ackerman and Stanton 2012, Horii and Williams 2013).

## D.3 Abatement Cost Approach

Abating carbon dioxide emissions can impose costs associated with more efficient technologies and processes, and policy-makers could also compare strategies using a different by estimating the annualized costs of reducing one ton of carbon dioxide net of savings and co-benefits. The cost of abatement approach could reflect established greenhouse gas reduction policies and establish values for carbon dioxide reductions relative to electricity de-carbonization and other measures. (While recognizing the potential usefulness of this method, this report utilizes the IWG SCC approach and we note that the value lies within the range of abatement costs discussed further below.)

The cost abatement approach utilizes market information regarding emission abatement technologies and processes and presents a wide-range of values for the price per ton of carbon dioxide. The California Air Resources Board data of the cost-effectiveness of energy efficiency measures and emission regulations would provide one source of potential data for an analysis under this method. To meet the AB 32 target, ARB has established the “Cost of a Bundle of Strategies Approach” which includes a range of cost-effective strategies and regulations (CARB 2008b). The results of this approach within the framework of the Climate Action Team Macroeconomic Analysis are provided for California, Arizona, New Mexico, the United States, and a global total identified in that same report, as shown in Table D.2 below.

**Table D.2 Cost-effectiveness Range for the CAT Macroeconomic Analysis**

Exhibit 3: Cost-effectiveness Range for the CAT Macroeconomic Analysis, Selected States, United States, Global -

| State | Cost-effectiveness Range $/ ton $CO_2$eq | Tons Reduced MMt$CO_2$e/yr | Percent of BAU |
|---|---|---|---|
| California 2020 (CAT[1], CEC[2]) | - 528 to 615 | 132 | 22 |
| Arizona[3] 2020 | - 90 to 65 | 69 | 47 |
| New Mexico[4] 2020 | - 120 to105 | 35 | 34 |
| United States (2030)[5] | -93 to 91 | 3,000 | 31 |
| Global Total (2030) | -225 to 91 | 26,000 | 45 |

Source: 1. Climate Action Team Updated Macroeconomic Analysis of Climate Strategies, Presented in the March 2006 Climate Action Team Report, September 2007.
2. California Energy Commission, *Emission Reduction Opportunities for Non-CO2 Greenhouse Gases in California*, July 2005, ICF ($/MT$CO_2$eq).
3. Arizona Climate Change Advisory Group, *Climate Change Action Plan*, August 2006, ($/MT$CO_2$eq).
4. New Mexico Climate Change Advisory Group, Final Report, December 2006.
5. McKinsey & Company, *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* December 2007.
6. The McKinsey Quarterly, McKinsey & Company, *A Cost Curve for Greenhouse Gas Reduction*, Fall 2007.

Source: CARB 2008b

Energy and Environmental Economics (E3) study defines the cost abatement approach more specifically as electricity de-carbonization and is based on annual emissions targets consistent with existing California climate policy. Long-term costs are determined by large-scale factors such as electricity grid stability, technological advancements, and alternative fuel prices. Near-term costs per ton of avoided carbon could be$200/ton in the near-term (Horii and Williams 2013), thus as noted earlier the value used in this report may be conservative.

## D.4 Regulated Carbon Market Approach

Emissions allowance markets provide a third potential method for valuing carbon dioxide. Examples include the European Union Emissions Trading System and the California AB32 cap and trade system as described below. Allowances serve as permits authorizing emissions and are traded through the cap-and-trade market between actors whose economic demands dictate the sale or purchase of permits. In theory, allowance prices could serve as a proxy for the cost of abatement. However, this report does not rely on the prices of cap-and-trade allowances due to the vulnerability of the allowance market to external fluctuations, and the influence of regulatory decisions affecting scarcity or over-allocation unrelated to damages or abatement costs.

### D.4.1 European Union Emissions Trading System

The European Union Emissions Trading System (EU ETS) covers more than 11,000 power stations, industrial plants, and airlines in 31 countries. However, the market is constantly affected by over-supply following the 2008 global recession and has seen prices drop to dramatic lows in early 2013, resulting in the practice of "back-loading" (delaying issuances of permits) by the European parliament. At the end of June 2013, prices of permits dropped to $5.41/ton, a price which is well below damage cost estimates and sub-optimal for encouraging innovative carbon dioxide emission abatement strategies.

### D.4.2 California Cap & Trade

In comparison, California cap-and-trade allowance prices were reported to be at least $14/ton in May of 2013, with over 14.5 million total allowances sold for 2013 (CARB 2013b). However, cap-and-trade markets are likely to cover only subsets of emitting sectors of the industry covered by AB 32. In addition, the market prices of allowances are determined only partly by costs incurred by society or industry actors and largely by the stringency of the cap determined by regulatory agencies and uncontrollable market forces, as seen by the failure of the EU ETS to set a consistent and effective signal to curb carbon dioxide emissions.

# Appendix E: Summary of Studies that Evaluated Usage Patterns of Dual-flush Toilets in Residential and Nonresidential Buildings

The CA IOUs reviewed seven studies that evaluate usage patterns of dual-flush toilets in residential and nonresidential buildings.[16] Key conclusions in regards to flush ratio for residential and nonresidential buildings are presented in Tables E.1 and E.2, respectively. The studies indicate that the 2:1 ratio is likely too high. The studies also suggest that building type (residential or nonresidential), whether the toilet is installed in a restroom that also has a urinal, education, and the design of the flush valve itself are some of the variables that need to be considered when determining an appropriate ratio for dual-flush toilets.

Collectively, the five residential studies evaluated use patterns of 200 toilets installed in the United States and Canada. The lowest average ratio was 0.5:1. The highest average ratio of 1.9:1 was observed from a toilet replacement program that was coupled with an extensive education campaign comprising organized community events and hands-on interactive school curriculums focused on energy and water efficiency.

The three nonresidential studies present factors that impact the flush ratio in nonresidential settings. As evident from the Veritec Consulting study, usage patterns vary significantly when the toilet is installed in a women's restroom versus a men's restroom that also has a urinal. The average ratio for dual-flush toilets installed in women's restrooms was 2.7:1, and the ratio of toilet in a men's restroom that also has a urinal was 1.1:1. While there are differences in how the toilets installed in the men's and women's restrooms are used, the overall average ratio for all toilets in the building was 1.7:1.

Arocha 2013 found a very low ratio of 0.4:1 in women's restrooms. This ratio increased slightly to 0.6:1 after instructional signs were posted in the stalls. Arocha concluded that although installing signage increases the flush ratio, behavior plays a significant role in how dual-flush toilets are actually used as does the design of the flush valve itself. For example, according to the Arocha and Harrison studies, dual-flush toilets with buttons are more effective because the user has to consider the options (choosing a button rather than pushing down a handle) since toilets with buttons do not produce an automatic human response.

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[16] Seven studies that evaluate usage patterns of dual-flush toilets:

Arocha, Jade and Laura McCann. *Behavioral Economics and the Design of a Dual-Flush Toilet.* 2013. American Water Works Association Journal. 105 Number 2. pg E73-E83.

Aquacraft, Inc. Water Engineering and Management. *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-family Homes in the East Bay Municipal Utility District Service Area.* 2003. Prepared for East Bay Municipal Utility District and the United States Environmental Protection Agency.

Aquacraft, Inc. Water Engineering and Management. *Seattle Home Water Conservation Study: the Impacts of High Efficiency Plumbing Fixture Retrofits in Single-family Homes.*2000. Prepared for Seattle Public Utilities and the United States Environmental Protection Agency.

Harrison, Masaye. *Flush: Examining the Efficacy of Water Conservation in Dual Flush Toilets.* 2010. American Solar Energy Society SOLAR 2010 Conference Proceedings.

Mohadjer Paula. *Jordan Valley Water Conservancy District Residential Ultra-Low-Flow Toilet Replacement Program*.

Pacific Northwest National Laboratory. *The Save Water and Energy Education Program: SWEEP Water and Energy Savings Evaluation.* 2001. Prepared for the U.S. Department of Energy Office of Building Technology State and Community Programs. PNNL-13538.

Veritec Consulting Inc. *Canada Mortgage and Housing Corporation Dual-flush Toilet Project.* 2002.

In other words, dual-flush button design educates and re-enforces users to choose between a large or a small flush.

It is hypothesized that user behavior and intuitive valve design plays a larger role in nonresidential buildings where a user might use a toilet one time. In residential buildings users have the opportunity to learn how to use the dual-flush function correctly – even if the valve design is not intuitive. In addition, users are more likely to choose the appropriate volume flush at residential sites because the decision directly affects them through their monthly utility bills.

DOE should conduct additional research to ensure that an appropriate ratio is established. When determining the ration, DOE should consider developing a different ratio for tank-type toilets, which are typical found in residential buildings and small commercial buildings, and flushometer toilets, which are typically found in nonresidential buildings. It is also recommended that DOE consider the variables discussed above, among other factors.

**Table E.1 Summary Findings from Studies Evaluating Usage Patterns of Dual-flush Toilets in Residential Buildings**

| Study ID | Description | Educational Component | Toilet Flush Volumes (gpf) | Ratio (reduced-volume flushes: full-volume flushes) | Average Effective Flush Volume [A] (gpf) |
|---|---|---|---|---|---|
| **Aquacraft 2000** | Evaluate usage patterns of 40 dual-flush toilets installed in 20 single-family homes in Seattle.<br>Study duration: 975 days post-retrofit | No | 0.8 / 1.6 | 0.8 : 1 | 1.25 |
| **PNNL 2001** | Evaluate usage patterns of more than 100 dual-flush toilets installed in 50 single-family homes in two communities in northern Oregon.<br>Study duration: 2 months post-retrofit | Yes [B] | 0.8 / 1.6 | 1.9 : 1 | 1.3 [C] |
| **Veritec Consulting 2002** | Evaluate usage patterns of 10 dual-flush toilets installed in single-family homes in 7 Canadian provinces.<br>Evaluated usage patterns of15 dual-flush toilets installed in a single multi-family apartment building in Canada.<br>Study duration: 1-2 months post-retrofit | No | 0.8 / 1.6 | 1.6 : 1 | 1.11 |
| **Aquacraft 2003** | Evaluate usage patterns of 35 dual-flush toilets installed in 17 single-family homes in East Bay Municipal Utility District service territory.<br>Study duration: 923 days post-retrofit | No | 0.8 / 1.6 | 0.5 : 1 | 1.34 |
| **Mohadjer 2003** | Evaluate usage patterns of 13 dual-flush toilets installed in single-family homes in Utah.<br>Study duration: 1-2 months post-retrofit (average of 50 days) | No | 0.8 / 1.6 | 1.5 : 1 | 1.12 |

Notes:

A. Effective flush volume calculated using rated flush volumes (e.g., 0.8 gpf reduced-volume and 1.6 gpf full-volume), not measured flush volume. Measured flush volume is often larger than rated flush volume.

B. Education campaign included programs in elementary and middle schools as well as community water end energy conservation fairs.

C. There is a discrepancy in the results presented in the PNNL 2001 report. The report claims that "on average the liquid flush was used about 65% of the time," which results in a flush ratio of 1.9:1 However, the report also claims the effective flush volume is 1.3 gpf. To achieve an effective flush volume of 1.3 gpf with a 0.8 gpf/1.6 gpf dual-flush toilet, the flush ratio must be 0.75:1.

**Table E.2 Summary Findings from Studies Evaluating Usage Patterns of Dual-flush Toilets in Nonresidential Buildings**

| Study ID | Description | Educational Component | Toilet Flush Volumes (gpf) | Ratio (reduced-volume flushes: full-volume flushes) | Average Effective Flush Volume [A] (gpf) |
|---|---|---|---|---|---|
| **Veritec Consulting 2002[B]** | Evaluate usage patterns of 31 dual-flush toilets installed in offices, golf courses, schools, and coffee shops in 7 Canadian provinces.<br>Study duration: 1-2 months post-retrofit | No | 0.8 / 1.6 | Office (all): 1.7 : 1<br>Office (female): 2.7 : 1<br>Office (male): 1.1 : 1<br>Coffee Shop: 1.3 : 1 | Office (all): 1.16<br>Office (female): 1.09<br>Office (male): 1.24<br>Coffee Shop: 1.20 |
| **Harrison 2010** | Evaluate usage patterns of dual-flush toilets on one floor of a mixed-occupancy commercial building in Portland Oregon.<br>Study duration: 12 hours during weekday<br>370 unique flush events | No | 0.8 / 1.6 | 1.6 : 1 | 1.29 |
| **Arocha 2013** | Evaluated usage patterns of 8 dual-flush toilets installed in female restrooms in a LEED certified office building in a small city in the American Midwest.<br>Study duration: 7 weeks total; 4 weeks post retrofit with no signage plus an additional 3 weeks after signs were posted.<br>1,870 unique flush events prior to sign installation and 1,222 unique flush events after sign installation. | Yes, signs installed after 4 weeks | 1.6 | Office (female)<br><br>before signs: 0.4 : 1<br>after signs: 0.6 : 1 | Office (female)<br><br>before signs: 1.46<br>after signs: 1.41 |

Notes:

A. Effective flush volume calculated using rated flush volumes (e.g., 0.8 gpf reduced-volume and 1.6 gpf full-volume), not measured flush volume. Measured flush volume is often larger than rated flush volume.

B. The study looked at usage patterns in golf courses and schools, but results were not presented in the report.